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

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Abstract
Water quality is a critical yet often overlooked determinant of dairy productivity in semi-arid regions. Tonk district of Rajasthan experiences high summer temperatures, seasonal rainfall, and widespread reliance on groundwater—conditions that can elevate total dissolved solids (TDS), hardness, fluoride, nitrate, and microbial loads in livestock water. This paper examines how water quality interacts with climate, feed intake, and animal health to influence milk yield and composition in milch cows. We outline a field-appropriate study design for Tonk, present illustrative findings based on realistic ranges reported for semi-arid India, and translate evidence into practical recommendations for farmers and local agencies. The synthesis highlights that (i) elevated TDS (>3,000 mg/L), fluoride (>1.5 mg/L), or nitrate (>50 mg/L as NO_3^-) are associated with reduced water intake, lower dry matter intake (DMI), subclinical health issues, and decreased milk yield and fat%; (ii) microbial contamination significantly increases during the monsoon months; and (iii) low-cost interventions—source selection, trough hygiene, point-of-use disinfection, and defluoridation where indicated—can materially improve productive performance and welfare.

Keywords: dairy cattle, water quality, TDS, fluoride, nitrate, coliforms, semi-arid, Rajasthan, Tonk district

1. Introduction

In hot, semi-arid environments, water is both a nutrient and a regulator of thermoregulation, digestion, and endocrine function in dairy cattle. Daily water intake (DWI) in lactating cows scales with ambient temperature, milk yield, and dietary salt; poor water palatability or quality reduces DMI and milk production. In districts such as Tonk, where groundwater is the primary source and pre-monsoon heat is intense, dissolved solids, hardness, fluoride, and nitrate may exceed desirable limits, while monsoon runoff can drive episodic microbial contamination. Understanding these interactions is essential to protect milk yield, reproductive efficiency, and animal welfare, and to guide low-cost mitigation at farm scale. 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) 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). 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 (Bangaladesh) 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 2025al). 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).

2. Study Area: Tonk District

Tonk district lies in eastern Rajasthan and is characterized by a semi-arid climate with hot summers, a monsoon season typically from June–September, and cool, dry winters. Cattle watering points include borewells/handpumps, dug wells, ponds/talabs, and occasional canal or piped supplies. Hydrogeology (alluvium and hard-rock aquifers) and evaporative concentration during long dry spells can increase TDS and hardness; certain pockets in Rajasthan are known for elevated fluoride and nitrate in groundwater. Seasonal environmental loads and infrastructure constraints can affect microbial quality, especially in open storage and troughs.

3. Objectives and Hypotheses

Objectives

1. Characterize physicochemical and microbiological quality of cattle drinking water across major sources in Tonk district across seasons.
2. Quantify associations between water quality parameters and (a) DWI and DMI, (b) milk yield and composition, and (c) health indicators (fecal consistency score, mastitis incidence, fertility metrics).
3. Recommend practical, low-cost interventions suited to Tonk's climatic and socio-economic context.

Hypotheses

- H1: Higher TDS, fluoride, and nitrate levels are negatively associated with DWI palatability, DMI, milk yield, and fat%.

- H2: Total coliforms and *E. coli* counts rise during the monsoon and correlate with higher clinical diarrhea and subclinical mastitis incidence.
- H3: Basic on-farm measures (source selection, trough hygiene, shade + cooling, and point-of-use treatment) improve outcomes.

4. Materials and Methods

4.1 Study Design and Sampling

- **Design:** Cross-sectional panel across three seasons—pre-monsoon (April–June), monsoon (July–September), and post-monsoon/winter (November–January).
- **Sites:** 24 villages across all tehsils, stratified by predominant water source (borewell/handpump, open well/pond, canal/piped).
- **Farms & Animals:** ~10 smallholder farms per village; 1–2 lactating cows per farm (Holstein-Friesian crosses and indigenous/crossbreds). Record parity, days in milk, and ration.
- **Sample Size:** Power analysis targeting detection of a 1.0 L/day milk yield difference with α=0.05 and 80% power, accounting for clustering (intra-class correlation ~0.1), suggests ~400–450 cow-observations per season.

4.2 Water Quality Assessment

- **Field parameters:** Temperature, pH, electrical conductivity (EC), TDS.
- **Lab parameters:** Total hardness (TH as $CaCO_3$), Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, NO_3^{-} (as NO_3^{-}), fluoride (F^{-}), Fe (if iron staining observed).
- **Microbiological:** Total coliforms and *E. coli* by membrane filtration (CFU/100 mL).
- **Sampling:** Triplicate samples at source and at trough; sterile bottles for microbiology; cold chain within 6 h to lab.

4.3 Animal and Farm Measurements

- **Intake and production:** DWI (metered or bucket count), ambient THI (temperature–humidity index), DMI (ration weighing/estimation), daily milk yield (3-day average), milk fat% and SNF.
- **Health:** Fecal score (1–5), mastitis (CMT and SCC subset), reproductive records (services per conception, days open).
- **Management:** Shade availability, watering frequency, trough cleanliness score, distance to water, ration salt content.

4.4 Statistical Analysis

- Descriptive statistics by season and source.
- Mixed-effects linear models for continuous outcomes (milk yield, fat%), with random intercepts for farm/village; fixed effects for THI, parity, DIM, breed type, ration salt, and water parameters (TDS, F^{-}, NO_3^{-}, coliforms).
- Logistic/Poisson models for health outcomes.
- Sensitivity analyses: alternate cut-points for TDS (1,500/3,000/5,000 mg/L) and fluoride (1.0/1.5/2.0 mg/L).
- Interaction terms: season × water parameter; THI × TDS.

5. Illustrative Results (Realistic Ranges for Semi-Arid Settings)*

*These results are illustrative, constructed to demonstrate likely patterns consistent with literature and field experience in semi-arid India. They should be replaced with empirical values from the proposed study.

5.1 Water Quality by Source and Season

Parameter	Borewell (Median)	Pond/Open Well (Median)	Canal/Piped (Median)	Notes
TDS (mg/L)	2,200 (pre-monsoon); 2,600 (post-monsoon)	1,400 (monsoon)	800	High TDS in groundwater; dilution in monsoon surface

Parameter	Borewell (Median)	Pond/Open Well (Median)	Canal/Piped (Median)	Notes
				water
Fluoride (mg/L)	1.8	0.8	0.5	Groundwater pockets exceed 1.5 mg/L
Nitrate (mg/L as NO_3^-)	55	35	20	Elevated with fertilizer leaching
Total Hardness (mg/L as $CaCO_3$)	450	280	180	Hard to very hard, affects palatability
Total coliforms (CFU/100 mL)	15 (source), 120 (trough)	250 (source), 600 (trough)	20 (source), 80 (trough)	Monsoon rise; troughs accumulate biofilms

5.2 Production and Health Associations

- **Milk yield:** Every 1,000 mg/L increase in TDS associated with −0.6 L/day (95% CI −0.9 to −0.3) after adjusting for THI, parity, DIM, and ration salt.
- **Milk fat%:** Declined by 0.12 percentage points per 1 mg/L increase in fluoride above 1.0 mg/L threshold.
- **DWI & DMI:** At TDS >3,000 mg/L, DWI fell ~8–10%, with a parallel 4–6% drop in DMI.
- **Health:** Odds of positive CMT increased with higher *E. coli* counts at the trough (OR ~1.3 per $\log_{10}$ CFU/100 mL). Monsoon season had highest diarrheal episodes in calves and fresh cows.
- **THI interaction:** At THI >78 (hot–humid), the negative slope of TDS on yield was ~1.3× steeper, suggesting compounding heat stress and palatability effects.

6. Discussion

High ambient temperatures and seasonal water scarcity amplify the consequences of poor water quality. When TDS, hardness, or fluorides are high, cows reduce voluntary intake, impairing rumen function, fiber digestibility, and milk synthesis. During monsoon, microbial contamination spikes—particularly at troughs—raising subclinical disease burden and depressing performance.

6.2 Interpreting Key Parameters

- **TDS & EC:** Elevated TDS (>3,000 mg/L) reduces palatability; very high levels (>5,000 mg/L) can cause laxative effects and metabolic stress. Sodium salts are typically more tolerable than sulfate salts.
- **Fluoride:** Chronic intake >1.5 mg/L risks dental/skeletal fluorosis, lameness, lowered production and fertility.
- **Nitrate:** Levels >50 mg/L (as NO_3^-) may predispose to methemoglobinemia (more acute in young stock) and depress performance.
- **Microbiology:** Coliform contamination commonly arises from storage/handling rather than the source alone; trough biofilms are frequent in warm conditions.

6.3 Practical Recommendations for Tonk District

Source and Delivery

1. **Prefer lower-TDS sources** (canal/piped where available) for fresh cows, high-yielders, and calves.
2. **Blend waters**: Mix borewell and low-TDS surface or harvested rainwater to bring TDS <2,000 mg/L and fluoride <1.0–1.5 mg/L.
3. **Provide shade and coolers** near watering points; target water temperature <25–28 °C in summer to encourage intake.
4. **Increase watering frequency** (≥3×/day in summer); reduce walking distance to <200 m where possible.

Treatment and Hygiene

1. **Defluoridation where needed**: Nalgonda technique (alum + lime + settling), activated alumina units, or community RO for drinking water; reserve best-quality water for milch cows and young stock.
2. **Point-of-use disinfection**: Regular chlorination of storage tanks; for small farms, use measured chlorine tablets or solar disinfection (SODIS) for emergency use.
3. **Trough management**: Drain–scrub–rinse troughs at least 2×/week (daily in monsoon). Fix leaks and ensure overflow doesn't create mud/manure slurry.
4. **Sedimentation/filtration**: Simple cartridge or slow-sand filters to reduce turbidity before chlorination.

Diet and Monitoring

1. **Balance ration salt** (common salt ≤0.5–0.7% of diet DM when water salinity is high); monitor DCAD to avoid compounding cation load.
2. **Trace mineral support**: Provide chelated minerals and vitamin A–E during high-TDS periods; monitor urine pH and EC as field proxies.
3. **Routine testing**: Quarterly testing of TDS, F^-, NO_3^-, and coliforms; test at both
4. **Source and trough**. Maintain a simple logbook.
5. **Prioritize cohorts**: Fresh cows (−10 to +30 DIM), peak yielders, and calves should get the best water.

6.4 Implications for Policy and Extension

- **Village-level water maps** identifying safer sources for livestock.
- **Community defluoridation/RO** prioritized for high-risk hamlets.
- **Subsidies/credit** for on-farm storage, shade structures, and trough upgrades.
- **Training** on water testing, chlorination, and Nalgonda protocols via local veterinary and extension services.

7. Limitations

This paper's numerical results are illustrative. Actual parameter distributions and effect sizes must be measured empirically across Tonk's villages and seasons. Confounding by feed quality, disease status, and farm management requires careful adjustment in analysis.

8. Conclusion

Under Tonk's semi-arid, heat-stressed conditions, water quality is a decisive lever for dairy performance. Managing TDS, fluoride, nitrate, and microbial contamination—especially at the trough level—can safeguard water intake, stabilize rumen function, and improve milk yield and composition. Low-cost, targeted interventions coupled with regular testing are practical and impactful for smallholders. Implementing the proposed study will generate local evidence to fine-tune thresholds, intervention packages, and policy support for the district.

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