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Microbiological Water Quality Disparities among Tribal and Non-tribal Farm Households in Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study examines and compares potable water quality among tribal and non-tribal farm households in the Jorhat district of Assam. Despite similar socio-economic challenges, disparities exist in water access, usage practices, and microbiological safety.While water quality encompasses a range of parameters—chemical, physical, and heavy metal contamination—this study specifically focuses on microbiological aspects due to their direct implications for public health. Based on data from 100 farm households across four villages and microbiological analysis of 36 water samples,

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the study reveals that tube wells are the primary water source for both groups, yet inadequate treatment and unsafe storage practices persist. Notably, only 40% of tribal farm households covered their water containers, compared to 78% of non-tribal ones. Microbiological tests found bacterial counts exceeding safe limits, especially in filtered and raw water, while boiled water showed better results. These findings highlight the urgent need for improved rural water infrastructure, targeted hygiene education, and integration of water safety into housing and public health policies. Addressing these gaps is vital for reducing health risks and supporting the Sustainable Development Goals (SDG 6 and SDG 11).

Keywords: Potable water quality; waterborne diseases; water storage hygiene; microbial contamination; rural public health, sustainable development goals (SDGs).

1. INTRODUCTION

Housing continues to be recognized not only as a basic human need but also as a fundamental human right that significantly influences health, social equity, and quality of life. Housing serves not only as a physical shelter but also as a foundation for human dignity, safety, and overall well-being. Adequate housing with proper ventilation, sanitation, and space significantly reduces the risk of communicable diseases, injuries, and mental stress among the farming community. Equally crucial is the provision of safe and potable drinking water, which directly affects their health. Contaminated water is a major source of water-borne illnesses such as diarrhoea, cholera, and typhoid, especially in low-income farm households in rural areas. While water quality can deteriorate due to physical, chemical, and heavy metal contamination, the presence of pathogenic microorganisms is particularly dangerous, as it poses an immediate risk to human health. When both secure housing and clean drinking water are ensured, individuals—particularly women and children—experience better health outcomes, improved productivity, and enhanced quality of life (Rangaswami & Bagyaraj, 2004). Therefore, housing interventions must be holistically planned for the farming community to include access to clean water and sanitation, as these are essential for promoting sustainable health and supporting a robust agricultural production system. According to the United Nations (2021), adequate housing is central to achieving Sustainable Development Goal 11, which emphasizes making cities and human settlements inclusive, safe, resilient, and sustainable. Inadequate housing—characterised by overcrowding, poor construction, or lack of water and sanitation—has been linked to a higher prevalence of respiratory diseases, mental stress, and increased vulnerability to disasters (Rolnik, 2020). Post-pandemic studies have highlighted how access to basic household infrastructure —especially safe water, sanitation, and hygiene - was vital in reducing exposure to COVID-19 and maintaining physical and mental well-being. In particular, inadequate water storage, irregular supply, and poor water quality posed serious health risks for families, especially in low-income or informal settlements. While secure housing plays a role in protecting populations, it is the availability of essential services such as clean water within these homes that truly determines health outcomes (WHO, 2017). The pandemic has thus reinforced the need to integrate household water security into broader housing, health, and development policies. Assam is home to a rich mosaic of ethnic communities, including a significant tribal population. The Scheduled Tribes (STs) constitute about 12.4% of the state's total population (Office of the Registrar General & Census Commissioner, India, 2013). These communities are concentrated in rural and forested areas and are predominantly dependent on agriculture, forest produce, and traditional crafts for their livelihood. Many tribal households function as farm households, where subsistence farming forms the backbone of daily sustenance. Despite various welfare schemes, tribal populations still face challenges such as limited access to quality education, healthcare, and clean drinking water—factors that also impact their agricultural productivity and overall well-being. On the other hand, the non-tribal population—which includes various caste groups—forms the majority. This group is more urbanised and generally has better access to social services, economic opportunities, and political representation. However, rural non-tribal farming communities also grapple with poverty, under-employment, and resource-based conflicts in some regions, highlighting the shared vulnerabilities of farm households across ethnic lines.

Drinking water—also referred to as potable water—is essential for human survival and must be free from contaminants that pose health risks. Safe drinking water is not only crucial for hydration but also for cooking, food preparation, and hygiene. As of 2022, approximately 5.8 billion people worldwide had access to safely managed drinking water services, while about 2 billion people still relied on sources contaminated with faeces and other pollutants (WHO & UNICEF, 2023). Unsafe drinking water remains a major source of water-borne illnesses such as cholera, dysentery, hepatitis A, and typhoid, particularly in low-income and rural areas.

Rapid urbanisation, climate change, and inadequate infrastructure exacerbate the challenge of providing safe and equitable water access, especially in the Global South. Additionally, marginalised communities, including indigenous populations and people in informal settlements, are disproportionately affected by water insecurity (UN-Water, 2023). Contaminated water can carry pathogens including Escherichia coli, Vibrio cholerae, and Salmonella typhi, all linked to serious disease outbreaks. Efforts to improve water quality and accessibility have been linked to major reductions in child mortality and improvements in public health (World Bank, 2022). Studies from Northeast India also support this, as poor water quality has been linked to diarrhoeal outbreaks and high bacterial contamination in Assam (Bhattacharjee et al., 2022; Singh & Borthakur, 2021; Baruah & Dutta, 2023) [updated].

Occurrence of cholera in different parts of India and the outbreaks were ascribed to contaminated water. It is obvious that life expectancy is reduced by the use of contaminated water and community health is greatly affected. People in developing countries suffer most from water-borne diseases. High mortality from such diseases is being taken with great concern at various levels all over the world, as narrated by Bhattacharya et al. (2000).

High frequency of diarrhoeal episodes in children leads to environmental enteropathy, which is the decreased ability of the intestine to absorb nutrients. This leads to malnutrition, which has even more implications such as stunting and decreased intelligence (Korpe & Petri 2012).

Therefore, in light of these challenges, the present study was conducted to assess the quality of potable water used by tribal and non-tribal farm households in the Jorhat district of Assam. The study aims to understand variations in water sources, storage practices, and microbiological safety across these socio-cultural groups.

2. MATERIALS AND METHODS

2.1 The Study Area

This study was conducted in the Jorhat district of Upper Assam during the year 2021–22. The sampling design involved a combination of purposive and simple random sampling techniques. Two Agricultural Development Officer (ADO) circles located in the Titabar and Jorhat development blocks were selected for the study. From each block, two villages were randomly chosen, making a total of four villages. A sample of 100 farm households—comprising both tribal and non-tribal families—was selected.

2.2 Data Collection and Sampling Procedure

Data collection involved a combination of interview and observational methods. Interviews were conducted with selected households to obtain demographic information, identify primary sources of potable water, and document household water storage and handling practices. In total, 36 potable water samples were collected aseptically from different households, including both tribal and non-tribal groups. The water samples were collected in sterile bottles and stored in ice boxes to maintain cold chain conditions. They were then transported within 4–6 hours to the Microbiological laboratory, Department of Pathology, College of Agriculture, Assam Agricultural University, Jorhat, Assam, where analysis was conducted promptly to prevent microbial degradation.

2.3 Determination of Bacterial Load (Standard Plate Count Method)

The total bacterial population in water samples was assessed using the standard plate count technique, as outlined by Mukherjee and Ghosh (2002). Nutrient agar was prepared using 28 g of commercially available medium dissolved in 1000 ml distilled water, sterilized at 121°C (15 lbs pressure) for 15 minutes. One millilitre of each thoroughly mixed water sample was inoculated into sterile Petri plates, followed by the addition of melted and cooled nutrient agar (45–50°C). Plates were gently rotated for uniform distribution and incubated at 20–22°C for 72 hours. Colonies were counted, and bacterial load was calculated as colony-forming units (CFU) per ml. Water samples with <100 CFU/ml were considered of acceptable quality, while samples exceeding this limit were classified as microbiologically unsafe.

3. RESULTS AND DISCUSSION

A perusal of Table 1 reveals that the majority (55 %) of the tribal respondents belonged to the age group of 25-35 years. On the other hand, the majority of the non-tribal respondents (50 %) belonged to the age group of 35-45 years, and an equal percentage of the respondents (7.5 %) belonged to the age group of 45 and above.

Concerning educational qualification, 17.5 % of the tribal respondents were illiterate, whereas all non-tribal respondents had received some formal education. The highest education level attained by both tribal and non-tribal respondents was higher secondary (40% in tribal and 50% in non-tribal groups). Very few were graduates, and none held post-graduate degrees.

Regarding occupation, nearly equal proportions of heads of tribal (58%) and non-tribal (54%) farm households were engaged solely in farming. A small percentage were servicemen (2% and 10%, respectively), while others were involved in petty business, often related to agriculture (16% tribal and 18% non-tribal), indicating a mix of livelihood strategies.

With respect to monthly family income, 77.5% of the tribal respondents and 65% of the non tribal respondents fell in the ₹20,000–40,000 category, while 22.5% of the tribal and 35% of the non tribal households earned ₹40,000–60,000. These figures suggest that the majority of farm households were part of the lower-middle-income group.

Table 2 shows that a majority of tribal respondents (74%) and a slightly lower percentage of non tribal respondents (68%) accessed tube wells located within their premises. Government-supplied water was available to only 26% of both tribal and non tribal households. In addition to tube wells, pond water was occasionally used; notably, 6% of respondents used pond water for drinking—raising potential health concerns. A study by Ravichandran and Balasundaram (2000) revealed that the drinking-water supply in rural Tamil Nadu was severely contaminated, thus, it affirms that, contaminated drinking water is a problem in other places as well.

The findings also show that 76% of all respondents used filtered water for drinking, while 15% of tribal and 14% of non tribal households consumed raw water. Boiled water was used by just 8% of tribal and 10% of non tribal households. Despite improvements in access, the reliance on untreated or improperly stored water increases the risk of microbiological contamination. Storage of drinking water in clean and covered containers significantly reduces contamination risk by preventing contact with vectors and suppressing microbial regrowth (Kumpel & Nelson, 2016). However, inappropriate storage—including uncovered or infrequently cleaned vessels—continues to compromise water safety, particularly in rural and peri urban areas (Shields et al., 2015). Such issues are particularly relevant in the study area, where microbial contamination may reoccur post-collection due to household-level handling.

As shown in Table 3, although both tribal and non tribal respondents stored drinking water in plastic or iron buckets and jars, only 40% of tribal households covered these containers, compared to 78% of non tribal ones. Regular cleaning of storage vessels was also low—46% among tribal and 58% among non tribal households. These gaps in hygiene practices directly contribute to higher microbial loads in household-stored water, as supported by findings from Sangameshwar& Dhananjaya (2008). In fact, poor hygiene practices have been identified as primary causes of household-level contamination (Sangma et al., 2020), with Bain et al. (2014) estimating that up to 53% of contamination occurs due to unsafe storage conditions.

Microbiological analysis of 36 household water samples (Table 4) revealed that the average bacterial count in raw tube-well water was 126 CFU/mL in tribal and 124.33 CFU/mL in non tribal households—exceeding the WHO-recommended safety limit of 100 CFU/mL (Aneja, 2006). Filtered water samples also exceeded this threshold, though slightly lower than raw water. By contrast, boiled water samples showed significantly lower bacterial counts—97.33 CFU/mL (tribal) and 96.00 CFU/mL (non tribal)—falling within or close to the safe range. These results reinforce the effectiveness of boiling in reducing bacterial loads, although the practice remains uncommon.

High levels of coliform contamination in drinking water have been strongly linked to increased incidences of water-borne diseases such as dysentery, diarrhoea, and typhoid fever, particularly in low resource and rural settings (Bain et al., 2014 [updated]). The presence of faecal coliforms, especially *Escherichia coli*, serves as a reliable indicator of faecal contamination and a predictor of disease outbreaks in populations relying on untreated or poorly stored water.

Table 1. Distribution of the respondent households according to the personal and demographic characteristics (N=100)

Characteristics	Tribal farm Households		Non-tribal farm households	
	f	%	f	%
1.Age of the responders(in years)				
i) 25 to 35 years	27	54	21	42
ii) 35 to 45 years	18	36	25	50
iii) 45 years and above	5	10	4	8
Total	50	100	50	100
2.Educational qualification of the respondents				
i) Illiterate	8	16	0	0
ii) Who are able to read and write	1	2	6	12
iii) Passed primary school	6	12	8	16
iv) Passed secondary school	13	26	8	16
v) Passed higher secondary school	20	40	25	50
vi) Graduate	2	4	3	6
Total	50	100	40	100
3.Occupation of the head of the family				
i) Farming	29	58	27	54
ii) Farming and service	5	10	7	14
iii) Service	1	02	5	10
iv) Business and farming	7	14	2	04
v) Business (Petty trading)	8	16	9	18
Total	50	100	50	100
4. Family income of the respondents/month(Rs.)				
i) 20000-40000	38	78	32	64
ii) 40000-60000	12	24	17	34
Total	50	100	50	100

Table 2. Distributions of the respondent households according to the source and form of potable water

Source of potable water within the premises.	Tribal Households (n=50)		Non-Tribal Households (n=50)	
	f	%	f	%
a) Pond water	0	0	3	6
b) Tube well	37	74	34	68
c) Government water distribution system	13	26	13	26
Total	50	100	50	100
Form of water				
a) Raw	15	30	14	28
b) Filtered drinking water through ceramic candles	31	62	31	62
c) Boiled	4	8	5	10
Total	50	100	50	100

Table 3. Distribution of the respondent households according to the practice followed for keeping the potable water in the house

Practices	Tribal households				Non- tribal households			
	Yes		No		Yes		No	
	f	%	f	%	f	%	f	%
i)Storage structure for keeping drinking water- Plastic bucket, Iron bucket, Jar etc.	50	100	0	0	50	100	0	0
ii)Regularly cleaned storage for drinking water	23	46	27	54	29	58	21	42
iii)Properly covered storage	20	40	30	60	39	78	11	22

Table 4. Assessment of the quality of potable water using standard plate count technique for determination of total bacterial population

Source and form of water	Tribal households				Non-tribal households			
	72 hour				72 hour			
1. Tube well	Colony Forming Unit(CFU)/ml				Colony Forming Unit(CFU)/ml			
	S_1	S_2	S_3	Average	S_1	S_2	S_3	Average
a. Raw form	126.00	127.00	125.00	126.00	123.00	125.00	125.00	124.33
b. Filtered form	107.00	105.00	106.00	106.00	101.00	106.00	103.00	103.33
c. Boiled form	95.00	98.00	99.00	97.33	96.00	98.00	94.00	96.00
2. Govt. water distribution system								
a. Raw form	102.00	103.00	105.00	103.33	102.00	106.00	103.00	103.66
b. Filtered form	50.00	46.00	49.00	48.33	46.00	47.00	52.00	48.33
c. Boiled form	23.00	26.00	28.00	25.66	19.00	21.00	24.00	21.33

Water samples from the government distribution system also showed elevated bacterial loads—103.33 CFU/mL and 103.66 CFU/mL for tribal and non tribal households respectively—likely due to leaky or poorly maintained plumbing systems. This aligns with Cruez et al. (2000), who reported bacterial contamination in bore-well systems. However, when this government-supplied water was filtered, bacterial counts reduced to 48.33 CFU/mL in both groups. Boiled government water was the safest, with bacterial counts as low as 25.66 CFU/mL (tribal) and 21.33 CFU/mL (non tribal), suggesting a compounded effect of treatment at source and household boiling.

The results thus showed that water from tube wells—even after filtration—remains bacteriologically unsafe, aligning with previous studies in Assam and other NE states (Bhattacharjee et al., 2022; Baruah and Dutta, 2023). This suggests that filtration systems in rural households may be ineffective or poorly maintained. Moreover, improper storage practices among tribal households (e.g., low vessel coverage) significantly increased microbial loads. These findings highlight the urgent need for community-based hygiene education and low-cost water purification strategies.

The health implications are substantial. High levels of coliform bacteria, particularly *Escherichia coli*, are reliable indicators of faecal contamination and have been associated with increased cases of diarrhoea, typhoid, and dysentery in low-resource settings (Bain et al., 2014). In the present study, the widespread presence of unsafe bacterial levels in both raw and filtered water confirms the need for better water treatment and hygiene practices. This is especially urgent for households that rely on groundwater sources and do not regularly boil their drinking water (Plates 1–3).

Plate 1. Preparation of nutrient agar media

Plate 2. Transferring of water samples into the petri plates Inside a Laminar

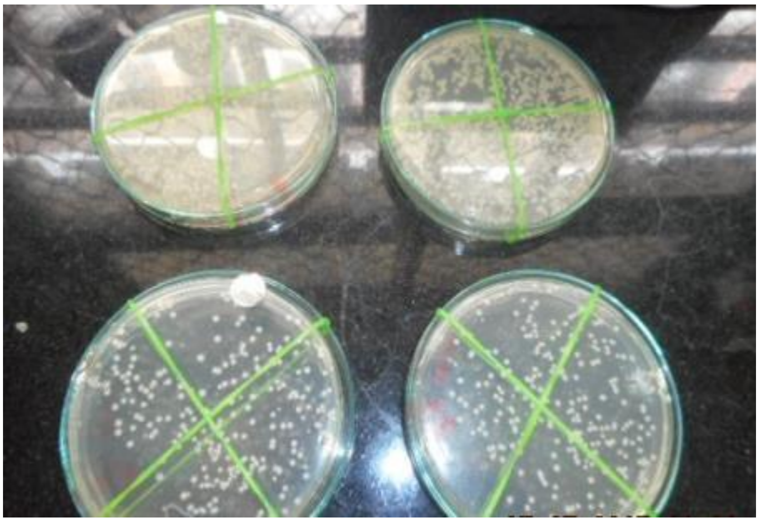

Plate 3. Bacterial count of potable water samples

4. CONCLUSION

This study highlights significant differences in water quality and hygiene practices between tribal and non-tribal farm households in Jorhat district. Both groups rely heavily on tube wells for drinking water, with slightly higher dependence observed among tribal households. Despite widespread use of filtration, themicrobiological analysis revealed that raw and filtered water samples frequently exceeded safe bacterial levels, posing considerable public health risks. Boiled water consistently showed lower bacterial counts, yet the practice of boiling remains limited in both groups, particularly among tribal households. Water from government distribution systems exhibited slightly better quality but still exceeded microbial safety limits in its raw form—raising questions about the maintenance of these systems.

While microbial contamination poses an immediate and widespread threat, chemical pollutants such as fluoride, arsenic, and nitrate remain equally concerning in India. For example, Choubisa (2022; erratum 2023) reported fluoride levels up to 34 mg/L in rural Rajasthan tube wells, contributing to a fluorosis rate as high as 84% (dental) and ~33% (skeletal) in adults. A Pan-India assessment (2024) further identified Rajasthan, Gujarat, and Odisha as fluoride hotspots, with 8–9% of groundwater samples exceeding WHO safety limits.

Thus, while fluoride and arsenic contamination remain long-term hazards, microbial contamination continues to be the most immediate health risk, especially where poor household storage and hygiene practices persist. These findings highlight the urgent need for low-cost, community-based water treatment solutions, routine monitoring, and educational interventions on safe storage and boiling practices—particularly in marginalized tribal regions where infrastructure is weak.

Government programs like theJal Jeevan Mission (2019) have aimed to provide universal water access, but implementation challenges and quality issues persist. Public health interventions that integrate microbial risk management with chemical water quality monitoring can significantly reduce waterborne diseases and support broader rural development and health equity goals.

5. LIMITATIONS OF THE STUDY

This study was limited to assessing microbiological parameters of drinking water. Physical and chemical analyses—such as turbidity, pH, fluoride, nitrate, and arsenic content—were beyond the scope of the present work due to time and budget constraints. Future studies should incorporate a more comprehensive set of parameters to better understand rural water quality challenges.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

As per international standards or university standards, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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