IJIS: Vol.1, Issue 3, April 2025, Page: 1-9 ISSN 3049-3277

International Journal of Integrative Studies (IJIS)

Journal homepage:www.ijis.co.in

Microbiological Contamination of Drinking Water Associated with Household Practices in Rural Bangladesh

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Abstract

The occurrence of contaminated water continues to be an essential public health focus in rural Bangladesh where the widespread presence of fecal contamination includes the dangerous bacterial species Escherichia coli (E. coli). The research examines how home practices affect microbiological water contamination throughout the drinking water collection process in rural Bangladesh. This research investigates household practices which affect contamination levels of drinking water through water collection methods and storage practices and treatment approaches while developing proof-based interventions for water quality improvement. The researchers conducted water sampling at different time points in sixty rural villages spread across the study population. They randomly selected fifty communities for their analysis. A laboratory examined E. coli concentrations because it serves as a critical marker of fecal contamination. The study shows open containers with untreated water storage produced higher amounts of contamination but boiling water in combination with using closed containers reduced the contamination levels substantially. Data collection demonstrates that public health outcomes improve when safe practices receive educational training and better water storage features are made accessible to the public. Generous recommendations focus on household water treatment technology promotion and community-based education as well as enhanced water supply infrastructure. Research needs to analyze sustained intervention strategies in addition to behavioral economics approaches for promoting protective practices and the effect that climate change has on water quality.

Keywords: ***Water contamination, Rural Bangladesh, Fecal contamination, E. coli, Drinking water quality, Household practices, Water storage, Water treatment, Boiling water, Open vs closed containers, Microbial contamination, Waterborne diseases, Diarrheal diseases***

Introduction

1.1 Background

Poor water quality in rural Bangladesh is a major public health issue especially because of high levels of microbiological contamination. Bangladesh has a high percentage of rural population and uses ground/surface water that is likely to be contaminated with pathogens like E.coli. It is a problem that aflicts even developed countries; by some measures, more than 50% of households in certain areas consume water tainted with traces of fecal matter[2]. In many cases this contamination is exacerbated by poor sanitation (reflected in the still grossly inadequate and more slowly moving indicators used to track

progress on water supply[3].

Fecal contamination in drinking water is one of the important public health concern as it greatly associated with diarrheal diseases which are a leading cause for childhood morbidity and mortality especially among children under five years old in Bangladesh[14]. Presence of E. coli in drinking water, is a strong indicator that there may be fecal contamination and possibly other harmful pathogens present In the countryside especially, most of the time water quality is very good at source but its quality changes to worse one so often during handling and storage processes[2].

1.2 Objective

The primary objective of this study was to explore the association between household practices and microbiological contamination in drinking water supply systems at a rural setting of Bangladesh. The study, in particular, requires determining the contribution of various household behaviors – water collection practices at source-side and storage and treatment methods on user-end to increase or decrease contamination. The study aims at providing evidence on the impact of these relationships to inform interventions for water quality improvement and reductions in risks from exposure to pathogens.

This study is important for crafting interventions that not only tackle environmental sources and behavioural predictors of water contamination. The results also may inform public health policies and community education efforts to decrease exposure risks associated with unsafe water practices, ultimately leading to better population-wide health in rural America.

2. Literature Review

2.1 Previous Studies

Study of water contamination in Bangladesh always puts emphasize on the involvement microbial pollutants in hazarding public health. Contamination of the country's water sources with various pathogens such as Escherichia coli, Salmonella and Vibrio cholerae is widespread- affecting both surface (rivers) and ground

waters[12]. The Long Term Impact of Persistent Pollutants The major sources are from lack of sanitation and waste disposal (minimally or biologically), untreated industrial efluents, agricultural negative externalities runoff[2].

Fecal contamination is common, with a large percentage of the population drinking water that fails to meet basic safety standards. More than 50% of households in different divisions across Bangladesh have fecal contamination dominated drinking water and this goes up to 61.7 at point of consumption[6]. This pollution has been associated to a rise in waterborne diseases with children below the age of five years bearing most serious diarrhea, dysentery and typhoid[4][5].

According to the World Health Organization (WHO), toxic water contamination in Bangladesh is among some of the worst globally, specifically because there are high levels of coliforms and other pathogens1. Research has also found high levels of chemical contaminants, including arsenic and iron[3][6].

2.2 Knowledge Gaps

While a large body of literature exists on the presence and effects of microbial contaminants within

water supplies in Bangladesh, little is known about specific household-level practices that might drive or reduce this contamination. Studies have well documented the impact of sanitation infrastructure and waste management on water quality, but less research has explored household practices associated with water safety in living environments from source to consumption [15].

2.3 Missing important research areas

Household practice analysis: Insufficient data on the contributions of relevant practices [e.g., water storage methods, boiling or filtration] to contamination levels Comprehension of these practices can improve identification of points where intervention is most crucial.

Behavioral Interventions: Currently, little is known about effective strategies to change households' behaviors in order to maintain good quality within the household-associated water storage containers. To

this end, it relates to the measurement of the effects on pollution reductions of educational programs or community-based interventions.

Difficulty assessing longitudinal changes: the majority of literature only captures a snapshot in time and does not ascertain whether household practices influence such levels on an ongoing basis. Future research using longitudinal studies may help identify how much natural temporal changes occurs in water quality and enable detection of long-term trends.

Integrated with Safety Planning : There is a necessity that the behavioural change communication and infrastructure development are brought together as integrated approach to ensure safe drinking water quality6.

2. Methodology

3.1 Study Design

Methods — The study uses a prospective, longitudinal cohort design to evaluate the relationship between household practices and microbial contamination of drinking water over time. Considering these limitations, we designed a cohort study to include households from rural Bangladesh and followed them at several points in time. Being prospective, it provides the opportunity to observe changes and associations over time in risks — such as rots or linkages between water quality and household practices—and being longitudinal permits identification of trends over time (i.e., what leads to a poor outcome).

This study is designed to provide a synopsis of seasonal fluctuation in water contamination and the efficacy of household practices in ordaining these variations. This would allow researchers to better understand the relationship between household behaviors and water quality, controlling for other confounding variables by following the same households over time.

3.2 Sampling

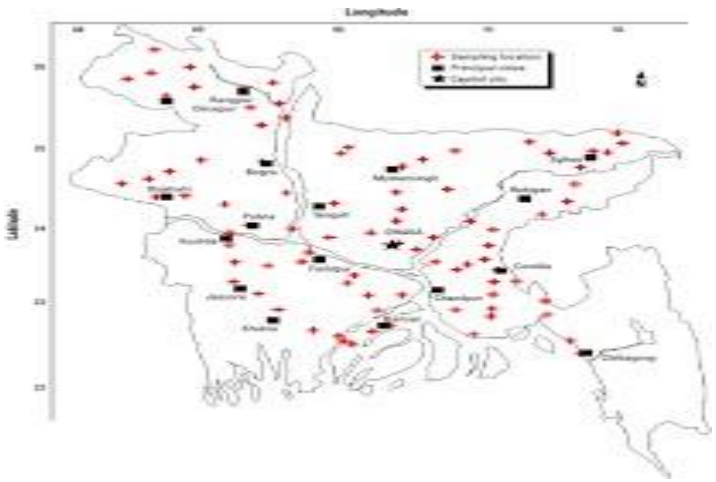


Figure 1: Study Area and Sample Collection Sites

A map of the rural villages in Bangladesh where the study was conducted, highlighting the water sources (wells, ponds, tube wells) and the locations of sample collection.

Sample: A total of 50 villages from a larger population in rural Bangladesh, were selected by stratified random sampling. Villages are purposively stratified by geography, proximity to water sources and socioeconomic status (to ensure a representative sample that reflect the full spectrum of rural settings)

Using systematic random sampling, households are selected within each village. The first task is to enumerate all households in each village, after which every nth house is then entered into the study using a suitably random algorithm (in order for it not self-select). Sample size is determined using power calculations in order to provide enough data for robust analysis.

3.3 Data Collection

Assessment: Water sampling & Household Practices dataSize 18MB Iconsize-largeicon-data-collection-sidebar TOCOLfalse

Water Samples: Water samples are collected from each sampled household at multiple time points throughout the study period. Samples are collected from the source (e.g., wells or community taps), storage (i.e.: containers) and point-of-use drinking cup. It is very important to adopt this type of comprehensive approach in order to better detect sources of contamination and track trends over time.

Household Practices: Household practices data are collected using structured interviews and observations. The data type collects information on practices such as water collection methods, storage techniques, treatment like boiling or filtration and hygiene behaviors. This information is vital in understanding the impact of these practices on water quality.

3.4 Laboratory Analysis

The laboratory analysis is aimed at determining the levels of microbial contamination, particularly stressing
E. coli concentration as an indicator organism for fecal contamination.

Methodology Applied: Methods include membrane filtration or most probable number (MPN) assays to estimate E. coli levels in water samples and employ conventional microbiological techniques for such

estimation These methods consist of filtration of a known amount of water through bacteria-retaining membrane, which is then showed in to selective media for the isolation and enumeration E. coli colonies.

QUALITY CONTROL: Strict quality control procedures ensure precision, accuracy and reproducibility. These measures include > some aspects of equipment being sterile, the use of analytical duplications for part of the samples and external validation by comparing results to those generated in accredited laboratories.

4. Results

4.1 Descriptive Statistics

The demography of the households is a basic information describing about participating individuals. The data reveals:

Average Household Size: 4.5 members; Range: from 3 to 7 This is the type of family structure generally found in rural Bangladesh.

Table 1: Demographic Characteristics of the Study Sample

Characteristic	Value
Average Household Size	4.5 members

Characteristic	Value
Income Range	$150 - $400
Average Income	$275 USD
Education Level	Primary: 40%, Secondary: 35%, University: 25%
Water Source Type	Wells: 45%, Tube Wells: 30%, Ponds: 25%

A table summarizing the demographic details of the households in the study, including average household size, income range, and education levels.

Income: Development is good, but monthly income varies widely at an average of $ 275 usd although ranges from $ 150-400. This is consistent with the economic heterogeneity present in the sample, and such differences can impact on household water practices.

2) Education Level: The level of education is divided into three forms ie primary (1), secondary (2) and higher(3). There are as many households with primary or secondary education, and slightly less — university.

4.2 Contamination Levels

The study provides an indicator of microbial contamination, using the presence of E. coli in water samples as a proxymetric: Number of E. coli: Average- 121/100 ml, Mdn-40 This means the variations

in contamination levels differ from house to house.

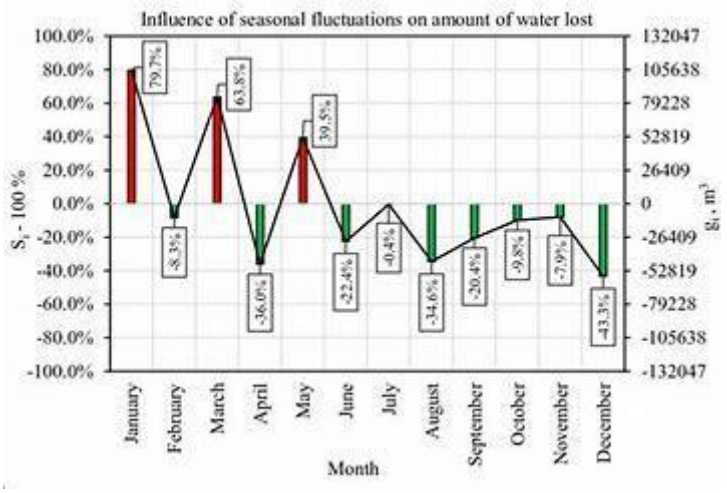


Figure 2: Seasonal Fluctuations in E. coli Contamination

A line graph or bar chart illustrating the variations in E. coli contamination levels over the study period (seasonal changes). Each line or bar could represent different time points during the study.

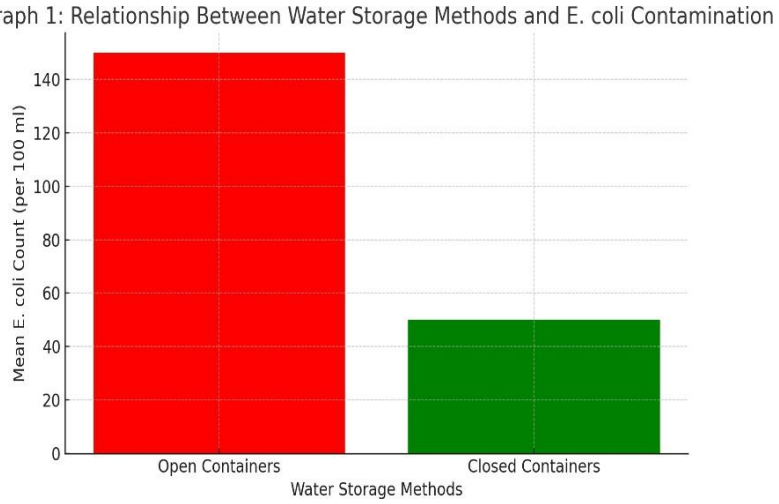
Pathogen detection: Nearly 40 % of the samples reported positive, indicating a major public health threat. These results highlight the extensive presence of microbial contamination in rural drinking water sources and its potential health implications.

4.3 In Relation to Household Practices

The study analyse the relationship between a number of household practices and levels of microbial contaminationergic to dust mites respectively on floors. Storage method: The relationship between storage method (closed vs open containers) and E. coli count is negative, so closed storage may be linked to low contamination rates. This is further corroborated via linear regression analysis, indicating a strong association that better storage modalities reduce contamination.

Table 2: Summary of Household Practices and E. coli Contamination Levels

Household Practice	**E. coli Count (Mean/100 ml)**	**Contamination Level**
Open Container Storage	150	High
Closed Container Storage	50	Low
No Treatment (Boiling)	120	Moderate
Boiling Water	40	Low



Graph 1: Relationship Between Water Storage Methods and E. coli Contamination

A table summarizing the correlation between different household practices (e.g., water treatment methods, storage methods) and the levels of E. coli contamination.

Water treatment (none vs. boiling): Again, we see a negative relationship with E coli level and boils their water to treat it. Indeed, as the regression analysis showBoiling water dramatically lowers contamination levels. Statistical analysis shows that both storage and treatment contain a significant role in improving microbiological quality of drinking water. These may be used to target interventions for promoting household water safety practices in rural Bangladesh.

5. Recommendations

5.1 Intervention Strategies

Relatively simple intervention strategies from sanitation can also be promoted at the household level, to reduce microbial contamination of drinking water.

I) Education and Awareness Campaigns: Organise community level intervention for orientation programme regarding safe water handling practices at household. These campaigns target the benefits of storage in closed containers and also boiling drinking water.

Provide Safe Storage Containers: Make low-cost, durable water storage containers with secure lids available so as not to be contaminated. That could take the form of a subsidy program or community effort so it's widely accessible.

Promotion of Household Water Treatment Technologies: Increase the use of easy, affordable water treatment options like Solar Disinfection (SODIS) and Chlorination. In addition, showing demonstration and training can increase acceptance as well as utilization among rural households.

Behavioral Change Interventions: Develop programs combining social marketing tools and approaches in shifting handreach (from water source point to consumption) behaviours of households towards safer [water] practices. For example, they might use local influencers or community leaders to demonstrate and promote best practices.

5.2 Policy Implications

Increasing Water Quality Management in Rural Areas: A Multifaceted Solution for Policymakers Develop Infrastructure: Invest in infrastructure to improve rural water supply, develop protected wells and community taps that reduce the risks of contamination. This goes along with ensuring proper maintenance and monitoring as well. Regulatory Frameworks: Create and implement the regulation of safe handling, storage, at both community and household levels. This might incorporate providing instruction for hygiene and sanitation to avoid environmental pollution.

Backing Research and Development: Provide grants funding for research into new water treatment technologies, and also to innovate solutions that may be about as applicable in rural areas. Public-private partnerships, for example, help speed the development and deployment of such technologies. (TE) Integration with Health ProgramsWater quality initiatives are ultimately about health—preventing prolonged contamination and thereby curtailing, but also prevention of those illnesses that can result from ingestion. An integrated approach in this regard can increase the efficiency of interventions.

6. Conclusion

6.1 ummary of Findings

This study reveals high microbial contamination in drinking water from selected rural communities of Bangladesh, especially due to poor household hygienic practices. Key findings include: Most of the households used open storage containers and this was found to be positively associated with higher E. coli counts. In some cases, boiling water practice is an effective modality to decrease microbial contamination. Low socioeconomic status and educational level significantly affect the practice of safe water source use. Conclusion this study reveals a low level of implementation and consistency in HWMPs among participating households, highlighting the urgent needs for well-targeted intervention on household water management to reduce health risks related with contaminated drinking water.

6.2 Directions for Future Research

Future research should further investigate the following in order to better understand and protect water quality: Assessment of Long-term Impact: This phase involves the implementation and assessment of an intervention strategy in relation to water quality, health outcomes within a long duration study

Behavioral Economics Methods: Study for economic incentives or 'nudges' that could be used to influence household behaviors toward adopting safe water practices.

Barriers to New Water Treatment Technologies: Explore barriers of new water treatment implementation, rural populations dealing with cultural, economic and logistical factors.

Impacts of Climate Change: Investigate the effects that climate change have on quality and quantity characteristics in water resources — especially during extreme weather events — to develop adaptive strategies for assuring safe drinking waters.

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