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Original Article

A Comparative Study of Filter Water and Bore Water Samples for Assessment of Fecal Contamination of Total Coliform and Fecal Coliform

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ABSTRACT

Background: Despite comprising a large portion of the Earth's surface, accessible fresh water is limited, and its quality is critical to human health. In many regions, particularly in developing countries, the availability of uncontaminated drinking water remains a significant concern. Previous studies have highlighted the prevalence of waterborne pathogens in such water supplies, leading to a considerable public health burden.

Objective: This study aimed to assess fecal contamination in bore and filter water samples by quantifying total coliforms, fecal coliforms, and total viable counts, and to compare these findings with established health standards.

Methods: A total of 50 water samples were collected from rural and urban settings in Islamabad, with 25 samples each from bore wells and filter water plants. Samples were collected, processed, and analyzed using Standard Operating Procedures (SOPs) to ensure the integrity of results. Bacteriological analyses were conducted using Most Probable Number (MPN) tests, along with Peptone water tests for Enterobacteriaceae analysis. Physical analysis included evaluation of appearance, color, and odor. Data were statistically analyzed using SPSS version 25.

Results: Analysis revealed that 54% of water samples were satisfactory, with filter water (76%) exhibiting better quality than bore water (32%). Unsanitary samples accounted for 46%, with bore water constituting the majority of this group (68%). Bore water samples showed a 68% prevalence of total coliforms and 44% for fecal coliforms. Filter water samples were lower, with 24% for total coliforms and 20% for fecal coliforms. The total viable count was 68% in bore water and 24% in filter water.

Conclusion: The study highlighted a critical public health issue with a substantial portion of bore water samples being contaminated, underscoring the need for urgent improvements in water treatment and public health infrastructure to prevent waterborne diseases.

Keywords: Water Quality, Bore Water, Filter Water, Fecal Contamination, Total Coliforms, Fecal Coliforms, Total Viable Count, Public Health, Waterborne Pathogens, Drinking Water Standards.

INTRODUCTION

Approximately 70% of the Earth's surface is covered by water, yet less than 3% of this is freshwater, with a mere 0.01% held in glaciers and ice caps (1). Access to safe drinking water, defined as water that does not pose significant health risks over a lifetime, is crucial (2). Ideal drinking water should be free from odors, colors, turbidity, and microbial contaminants, ensuring it is both aesthetically pleasing and safe for consumption (3). The necessity for water to be devoid of microbes and other harmful contaminants such as parasites is underscored by the World Health Organization (WHO), which highlights the severe impact of infectious diseases from contaminated water sources (4, 5). Contamination of drinking water can be categorized into three types: physical, chemical, and biological. Physical contamination, often caused by sewage, waste, animals, and human excrement, is a prevalent risk (6). Chemical contaminants include harmful substances like pesticides, mercury, and biotoxins such as endotoxins and

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exotoxins (7). Biological contaminants encompass pathogens such as Entamoeba histolytica, Cryptosporidium parvum, and viruses like Hepatitis A and Poliovirus, which are significant agents of waterborne diseases (8-11).

Among biological contaminants, total coliforms and their subgroup, fecal coliforms, are critical indicators of water quality. Fecal coliforms, particularly Escherichia coli, are present in the intestines and feces of warm-blooded animals and provide a more precise measure of fecal contamination (12). While many E. coli strains are harmless, pathogenic strains such as E. coli O157:H7 can cause severe illnesses (13). The presence of E. coli and total coliforms in water is a globally recognized indicator of microbial contamination, and their absence in any 100-ml sample of drinking water is a standard set by WHO (14, 15). Despite the critical importance of safe drinking water, a significant portion of the global population, especially in developing countries, lacks access to this essential resource. In these regions, only a small fraction of the population has access to clean drinking water and adequate sanitation facilities, exacerbating the risk of water-related diseases (16-22).

Water pollution not only poses a severe health risk but also has profound environmental implications. Each year, millions of deaths in poorer nations are attributed to preventable diseases caused by contaminated water (17, 19). Recent findings indicate high levels of coliform bacteria in water samples from various provinces, highlighting the widespread issue of water contamination in developing regions (21). Furthermore, groundwater, which serves as the primary water source in many cities, often contains pathogens that contribute to the high incidence of diarrheal diseases, leading to significant mortality, particularly among children under five years of age (24, 25). In fact, diarrheal diseases remain one of the leading causes of death among young children globally, despite the availability of simple treatment options (25).

In response to these challenges, cost-effective water treatment methods such as solar disinfection, chlorination, boiling, safe storage, and the use of domestic mini filters are suggested. However, these methods are not widely adopted or known in many affected areas (23). Recent studies in 2022 reported that in Rawalpindi, a significant majority of water samples were contaminated with total coliforms, and a substantial number also tested positive for fecal coliforms, underscoring the ongoing challenges in ensuring safe water access (26). This persistent issue calls for enhanced efforts towards improving water quality and accessibility, particularly in underserved communities.

MATERIAL AND METHODS

In the study, a total of 50 water samples were systematically collected, with equal representation from filtered and bore water sources. The filtered water samples were obtained from urban filtration plants in the G, F, and H sectors of Islamabad, while bore water was sourced from rural taps in Tramri, Alipur, Thand Pani, Charah. Each sample was meticulously collected in a 120ml Sterilized Plastic Container (SPC) and labeled distinctly with a laboratory number, for instance, 01-WM (Water Microbiology), to ensure precise identification and traceability (1).

The sampling procedure adhered strictly to a Standard Operating Procedure (SOP) to minimize contamination and ensure the integrity of the results. The water collection involved sterilizing the tap or faucet with a bleach-dipped swab, followed by flaming to eradicate residual bacteria. After letting the water run for 2-3 minutes to achieve a clear stream, the sample was collected in a sterilized container, leaving an air gap to facilitate subsequent shaking. The samples were then transported to the laboratory within 6-8 hours post-collection, and only those received within 24 hours were processed further, following stringent SOPs to ensure that the samples were free from leaks and correctly labeled (2).

The analytical phase commenced with a physical examination of the samples, assessing appearance, color, and odor to identify any overt physical contaminants. For bacteriological analysis, the Most Probable Number (MPN) test was executed in three stages: presumptive, confirmed, and completed tests. The presumptive test involved inoculating MacConkey broth under varying strengths and incubating the tubes to detect bacterial growth. Positive samples were further tested using Brilliant Green Lactose Bile Broth (BGLB) and subsequently streaked on selective media such as Eosin Methylene Blue agar to confirm the presence of fecal coliforms (3).

Additional analyses included the Peptone Water Test, where samples from positive MacConkey broth cultures were incubated to observe indole production, indicative of Enterobacteriaceae. The water samples were also serially diluted and cultured on Plate Count Agar to quantify viable bacteria, calculated using a standardized formula accounting for the dilution factor (4).

The ethical considerations of the study adhered to the Declaration of Helsinki principles, ensuring that all experimental protocols were approved by an institutional review board. Data collected from the study were anonymized and analyzed using SPSS version 25, employing appropriate statistical methods to ensure robust and valid results. This comprehensive methodology, combining meticulous sample collection with rigorous analytical techniques, provided a solid foundation for assessing the microbial quality of drinking water and addressing public health implications.

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RESULT

The analysis of water samples, as depicted in the study's figures and tables, yielded telling results that reflect the state of water safety in the surveyed regions. A critical evaluation of the bore water samples uncovered a concerning variation in microbial content, with total coliform counts oscillating significantly across different samples. Notably, fecal coliform levels were present in all samples, although the exact concentrations varied, underscoring potential inconsistencies in sanitation practices in rural areas (Figure 2A).

On the other hand, the assessment of filter water samples from urban localities exhibited a similarly troubling spectrum of microbial contamination. The data vividly highlighted instances where the total viable count far exceeded acceptable levels, pointing to lapses in filtration efficacy or post-filtration contamination. Both total and fecal coliforms were detected in all the filter water samples analyzed, with certain samples revealing alarmingly high counts that warrant immediate attention and action to safeguard public health (Figure 2B).

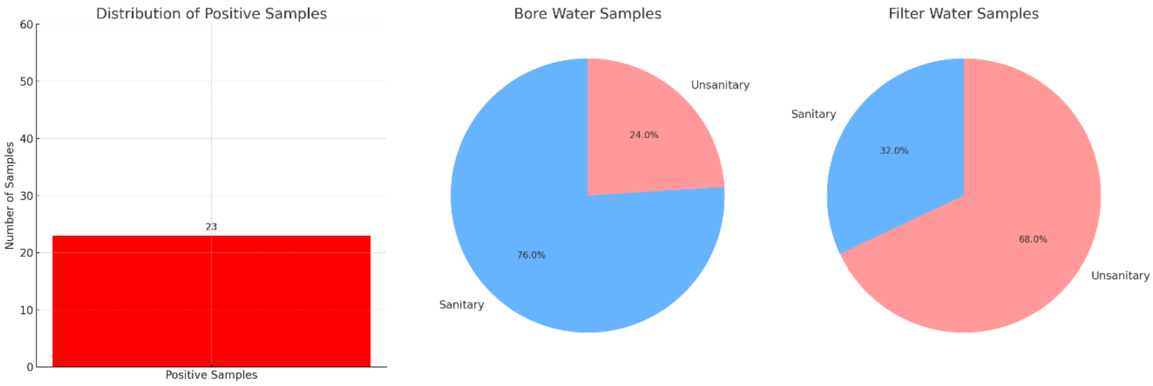

Figure 1 Distribution of positive samples, bore water samples, and filter water samples

Table 1: Bacterial Parameters representing Bore and Filter Water

A: Bacterial Parameters representing Bore Water			
Parameters	Total Samples	Satisfactory	Unsatisfactory
Total Coliforms	25	08 (32 %)	17 (68 %)
Fecal Coliforms	25	14 (56 %)	11 (44 %)
Total Viable Count	25	08(32 %)	17 (68 %)
B: Bacterial Parameters representing Filter Water			
Total Coliforms	25	19 (76 %)	6 (24 %)
Fecal Coliforms	25	20 (80 %)	5 (20 %)
Total Viable Count	25	19 (76 %)	6 (24 %)

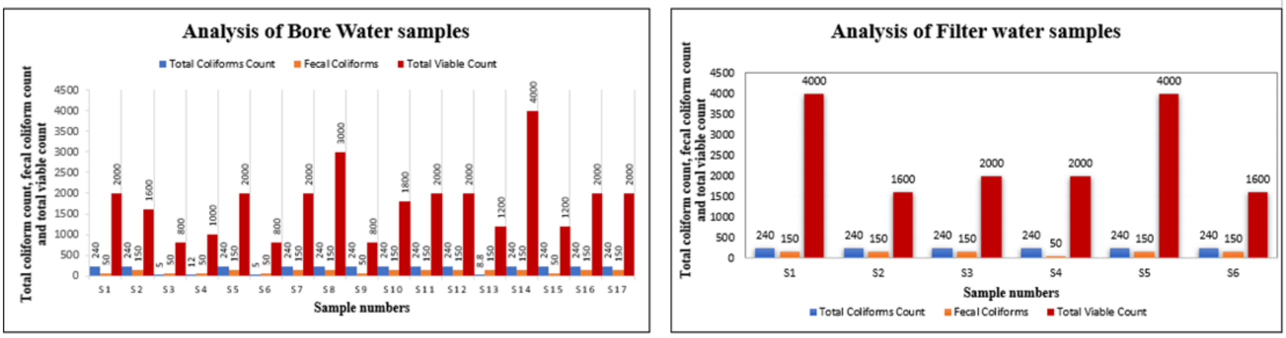

Figure 2 A and B, Bore Water Analysis and Filter Water Analysis

The comprehensive dataset presented in the tables captures the quantitative essence of the study, enabling a granular view of water quality metrics across the board (Table 1). The numerical values, when seen in conjunction with the graphical representations, not only enhance our understanding of the water quality but also underline the severity of the contamination issues faced. The graphical depictions in the figures serve as visual substantiations of the numerical data, offering an intuitive grasp of the scale and scope of the water quality concerns encountered in the sampled populations.

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DISCUSSION

In the conducted investigation, an assessment of 50 water samples—comprising an equal number of filter and bore water specimens—was undertaken. The analysis revealed a split in quality: 54% of the samples met satisfactory standards for potability, with bore water accounting for a lesser share of 32%, while filter water contributed a more commendable 76%. However, this also meant that nearly half, or 46%, of the samples did not satisfy the criteria for consumption, with 68% of bore water and 24% of filter water samples deemed unsatisfactory. When these findings were positioned against the backdrop of standards set by the Pakistan Standards and Quality Control Authority, the implications for public health became evident (17, 18).

The presence of total and fecal coliforms was notably higher in bore water samples from Islamabad, identified in 68% and 44% of cases, respectively. Filter water samples reflected lower contamination levels, with 24% for total coliforms and 20% for fecal coliforms. These figures align with the narrative of previous studies, such as the research conducted by Sami and colleagues in 1988, which showed that a significant majority of samples harbored total coliforms, and nearly a quarter contained fecal coliforms (17). Similar patterns of contamination were echoed in the findings of Hussain MF et al., in 2011, where bore water contamination was staggeringly high (25), and in subsequent studies that consistently reported high levels of both total and fecal coliforms in bore water samples (26).

The recurrent detection of high total viable counts, particularly in bore water, underscores the continuing challenge of bacterial contamination, suggesting a systemic issue in water supply management. The historical data corroborates that bore water samples frequently exhibit bacterial counts that far exceed those found in other water sources, indicating a pronounced susceptibility to contamination.

Considering these findings, it is imperative to address the root causes of contamination. In many instances, fecal contamination can be traced back to sewage leaks, which underscore infrastructural inadequacies. The comparative safety of filtered water points to the efficacy of treatment plants, though this does not completely absolve the filtered supply from scrutiny. The gradual deterioration of environmental and soil conditions, exacerbated by urbanization and population growth, poses a persistent threat to water quality, particularly in bore water sources (17).

The study's strengths lie in its comparative approach and the contextual alignment with previous research, lending weight to the argument for targeted interventions. Nevertheless, it is not without limitations; the scope of sampling, restricted to specific sectors within Islamabad, may not fully capture the heterogeneity of the urban and rural water supply systems. Furthermore, the reliance on bacteriological indicators, while instructive, does not encompass the full spectrum of potential chemical and physical contaminants (13).

Recommendations for future research include a broader survey of water sources across diverse geographic regions, coupled with a multidisciplinary approach that incorporates environmental assessments. From a public health standpoint, the impetus is on healthcare providers and policymakers to not only bolster water treatment facilities but also to enforce stringent monitoring to mitigate the risks of contamination. The ultimate goal remains clear: to ensure the accessibility of safe, clean drinking water for all, thereby curbing the incidence of waterborne diseases and fortifying community health (19).

CONCLUSION

The investigation found that a substantial proportion of drinking water samples, particularly bore water, in Islamabad are unfit for consumption, presenting significant public health risks due to bacterial contamination. This situation mandates immediate and sustained intervention from healthcare providers and authorities to improve water treatment and distribution infrastructures, reinforce environmental health practices, and ensure rigorous water quality monitoring, ultimately aiming to safeguard the community from waterborne diseases and enhance overall health outcomes.

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