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FREQUENCY OF E. COLI IN WATER SAMPLES FROM FILTRATION PLANTS OF LAHORE DISTRICT

Original Article

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ABSTRACT

Background: Clean and safe drinking water is fundamental for public health and well-being. Globally, microbial contamination of water is a persistent issue, especially in urban areas with aging infrastructure and poor sanitation. Escherichia coli (E. coli), a fecal indicator organism, serves as a critical marker of contamination and potential pathogenic presence. In cities like Lahore, Pakistan, challenges such as unregulated urban expansion, outdated filtration systems, and limited maintenance have increased the vulnerability of water sources to fecal contamination.

Objective: To determine the frequency of *E. coli* contamination in water samples from public filtration plants in Lahore, assess associated environmental and operational factors, and evaluate the effectiveness of preventive measures.

Methods: A cross-sectional study was conducted over three months in Lahore, during which 178 water samples were collected from filtration plant outlets using simple random sampling. Each 100 mL sample was transported in sterile conditions to the Institute of Public Health, where *E. coli* detection was performed using the Multiple Tube Fermentation (MTF) method. Sanitary conditions around the plants were documented, and physical water characteristics (color, odor, pH, temperature) were recorded. Data were analyzed using SPSS version 20.0, with descriptive statistics and Chi-square tests applied. A p-value of ≤ 0.05 was considered statistically significant.

Results: Of the 178 samples, *E. coli* was detected in 54 (30.8%). Contamination was significantly higher in plants near sewerage lines (47.8%) compared to those without nearby sewerage infrastructure (6.3%) ($p < 0.001$). Plants with prior contamination history showed a 55.9% positivity rate. Preventive measures such as scheduled chlorination and sealing of open areas showed 0% contamination, while sediment filter-only systems had the highest contamination rate (54.1%). Community complaints were reported in 60.3% of locations, with 46.8% correlating with laboratory-confirmed contamination.

Conclusion: The study highlights substantial *E. coli* contamination in Lahore's public filtration systems, with strong links to inadequate maintenance, environmental exposure, and lack of effective preventive strategies. Policy-level interventions, infrastructure upgrades, community education, and strict adherence to testing and disinfection protocols are crucial to ensuring safe drinking water.

Keywords: Chlorination, Community Health, Drinking Water Standards, Escherichia coli, Fecal Contamination, Filtration Systems, Water Pollution.

INTRODUCTION

Water is fundamental to all forms of life, both in terms of quantity and quality. Its indispensable role in sustaining health, hygiene, and socioeconomic development is repeatedly emphasized, including in the Holy Quran, which states, “And Allah has created every animal from water...” (Surah 24:45). Despite covering approximately 71% of the Earth's surface, the availability of safe and clean water for human use remains alarmingly limited due to escalating pollution and unsustainable consumption patterns. As the global population grows and industrial demands increase, ensuring access to uncontaminated drinking water has become an urgent public health concern (1). Water pollution, driven by industrial effluents, agricultural runoff, and improper waste disposal, poses a serious threat to human health. Contaminated water sources serve as vectors for waterborne pathogens, leading to outbreaks of diseases such as diarrhea, hepatitis A, and gastroenteritis (2). In low- and middle-income countries like Pakistan, the impact of unsafe water is especially profound. Urban centers such as Karachi frequently experience outbreaks of E. coli-induced diarrhea, which is strongly linked to poor sanitation and inadequate access to clean water (3). Lahore, the capital of Punjab province, is similarly burdened. The city relies heavily on groundwater, with approximately 90% of its water supply derived from this source. However, over-extraction has led to a documented annual decline of 0.9 meters in the water table, while losses of up to 45.4% due to leakages and inefficiencies have been reported by the Water and Sanitation Agency (WASA) (4,5). This over-reliance, coupled with the discharge of untreated wastewater, has heightened the risk of groundwater contamination, including exposure to harmful agents like arsenic.

Children are disproportionately affected by the consequences of unsafe drinking water, with diarrhea ranking among the leading causes of under-five mortality in Pakistan. An estimated 53,000 child deaths occur annually, largely due to infections caused by pathogens like Rotavirus and E. coli, with contaminated water accounting for approximately 70% of these cases (6-8). Preventive strategies such as water purification, improved hygiene practices, maternal health education, and Rotavirus immunization can reduce disease burden; however, access remains limited due to high costs and infrastructural barriers (9,10). Against this backdrop, the current study was designed to assess the frequency of fecal contamination, specifically the isolation of Escherichia coli, in water samples collected from filtration plants across Lahore city. By investigating the microbial quality of treated water, this research aims to draw critical attention to the effectiveness of existing filtration systems, inform public health authorities, and support evidence-based policymaking to strengthen water safety regulations. Furthermore, it seeks to enhance public awareness regarding the health implications of waterborne pathogens and promote the broader goal of safeguarding community health through improved water management practices.

METHODS

This cross-sectional study was conducted over a period of three months in Lahore, Pakistan, targeting operational public water filtration plants across the city. The study aimed to evaluate the microbiological quality of drinking water by detecting fecal contamination, specifically Escherichia coli. A total of 208 water samples were collected using simple random sampling from the outlets (filter tips) of functional public filtration units. Only operational plants with accessible filtration taps were included in the study. Non-functional units, privately operated plants, or those under maintenance were excluded to ensure the accuracy and consistency of data collection (11,12). All samples were collected aseptically by trained laboratory personnel following standard procedures. Each sample was stored in sterilized, labeled containers and immediately transported in ice-packed coolers to the Water Testing Laboratory at the Institute of Public Health, Lahore. Sample processing was carried out within a few hours of collection to preserve the microbial integrity of the water. Physical characteristics such as color, odor, taste, and turbidity were noted at the time of collection. The pH and temperature of each sample were measured using calibrated portable devices to ensure standardized evaluation across sites.

Microbiological analysis was performed using the Multiple Tube Fermentation (MTF) technique to detect the presence of fecal E. coli, following standard WHO protocols. Lactose broth tubes were incubated to observe gas production as a presumptive indicator of coliform activity. Confirmatory tests were conducted to identify E. coli based on typical fermentation patterns and gas formation (6). All laboratory analyses were conducted under the supervision of the principal investigator to ensure methodological rigor. Data was recorded using a structured proforma developed for the study and later entered into SPSS version 20.0 for statistical analysis. Descriptive statistics were applied to summarize demographic and water quality variables. Frequencies and percentages were reported for categorical variables, while continuous variables were expressed as mean ± standard deviation. Chi-square tests were employed to assess associations between categorical variables, and independent samples t-tests were used to compare means. A p-value of ≤ 0.05 was considered statistically significant. The study received ethical approval from the Institutional Review Board of the Institute of Public

Health, Lahore. Informed consent was obtained verbally from plant supervisors or on-site personnel before sample collection, with strict adherence to ethical and biosafety protocols.

RESULTS

Out of 178 water samples collected from operational public filtration plants in Lahore, E. coli contamination was detected in 54 samples, representing 30.8%, while 123 samples (69.2%) showed no contamination, indicating microbiologically safe water. The presence of fecal contamination was confirmed using the Multiple Tube Fermentation method, which involved incubation and gas production as indicators of E. coli. A significant association was observed between the proximity of filtration plants to sewerage lines and the presence of E. coli. Among the 105 plants located near sewerage infrastructure, 47.8% exhibited contamination, whereas only 6.3% of plants without adjacent sewerage lines tested positive for E. coli ($P < 0.001$). Similarly, 43.6% of the plants had a history of previous contamination events, and among these, 55.9% showed current contamination. In contrast, only 11.4% of plants with no prior contamination history were found to be positive ($P < 0.001$). Community feedback also showed a strong correlation with laboratory findings. In localities where community members had raised concerns about water quality, 46.8% of filtration plants tested positive for E. coli, whereas in areas with no complaints, only 6.5% showed contamination ($P < 0.001$).

The impact of preventive practices was also analyzed. Filtration plants employing sealing of open areas and scheduled chlorination showed zero contamination. In comparison, plants using regular pipe inspection had 33.3% contamination, those practicing regular equipment cleaning had 10.6%, and the highest contamination (54.1%) was found in plants using only sediment filters ($P < 0.001$). Nearby sources of pollution were another critical factor influencing contamination. Among plants located close to such sources, 68.8% tested positive for E. coli compared to only 4.3% contamination in those without nearby pollution ($P < 0.001$). Waste management practices also affected water quality. Plants that disposed of waste via municipal services had a contamination rate of 59.4%, whereas those that recycled or used sealed containers showed significantly lower contamination rates of 8.7% and 13%, respectively ($P = 0.000$). Operational and testing parameters were also documented. The mean duration of filtration plant operation was 12.3 ± 5.89 months (range: 1–24 months). The frequency of water testing for E. coli ranged from every 7 to 120 days, with an average testing interval of 46.8 ± 41.13 days.

Table 1: Assessment of E. coli Contamination in Water Samples

Presence of E. coli	**Frequency**	**Percent**
Detected	54	30.8
Not Detected	123	69.2
Total	**178**	**100.0**

Table 2: Association of Sewerage Proximity and Community Complaints with E. coli Contamination in Water Samples

Variable		**Detected**		**Not Detected**	
		n	%	n	%
Is there any sewerage line passing near the filtration plant	Yes	50	47.8	55	52.2
	No	11	6.3	62	93.8
Association of Community Complaints About Water Quality with the Presence of E. coli in Water Samples					
Variable		Detected		Not Detected	
		n	%	n	%
Have there been any community complaints regarding water quality?	Yes	50	46.8	57	53.2
	No	**5**	**6.5**	**66**	**93.5**

*P < 0.001

Table 3: Association of Incidents of Contamination with the Presence of E. coli in Water Samples

Variable		Detected		Not Detected	
		n	%	n	%
Have there been any incidents of contamination in the past	Yes	43	55.9	34	44.1
	No	**11**	**11.4**	**90**	**88.6**

*P < 0.001

Table 4: Association of Preventive Measures for Fecal Contamination with the Presence of E. coli in Water Samples

Variable		Detected		Not Detected	
		n	%	n	%
	Sealing of open areas	0	0	10	100
Preventive measures	Scheduled chlorination	0	0	27	100
are implemented to avoid fecal	Regular inspection of pipes	5	33.3	9	66.6
contamination	Regular cleaning of equipment	5	10.6	38	89.4
	Installation of Sediment Filters	**45**	**54.1**	**39**	**45.9**

*P < 0.001

Table 5: Association of Nearby Pollution Sources with the Presence of E. coli in Water Samples

Variable		Detected		Not Detected	
		n	%	n	%
Are there any nearby sources of pollution that could affect water quality	Yes	50	68.8	23	31.3
	No	**5**	**4.3**	**100**	**95.7**

*P < 0.001

Table 6: Association of Waste Management Practices with the Presence of E. coli in Water Samples

Variable		Detected		Not	Detected
		n	%	n	%
waste management at the filtration plant to prevent contamination	Disposed via municipal services	43	59.4	30	40.6
	Recycled where possible	5	8.7	48	91.3
	Waste safely container	**7**	**13**	**45**	**87**

Table 7: Descriptive Statistics of Filtration Plant Operations and Water Testing Frequency

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Duration of filtration plant been operational in months	178	1	24	12.32	5.894
Days interval of water samples testing for fecal E. coli	**178**	**7**	**120**	**46.82**	**41.136**

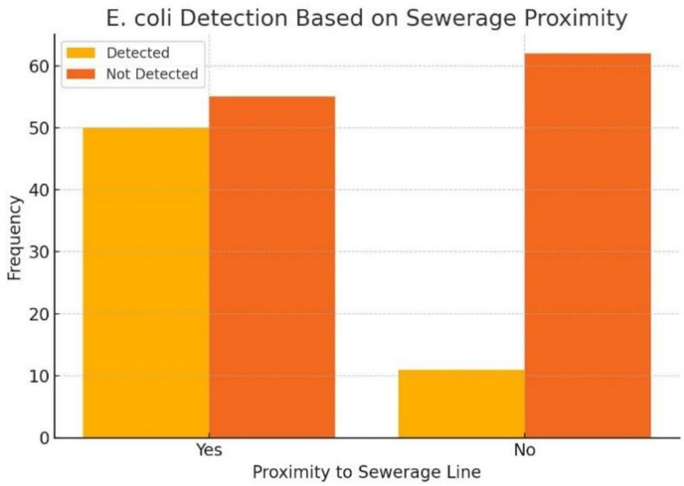

Figure 1 E. coil Detection Based on Sewerage Proximity

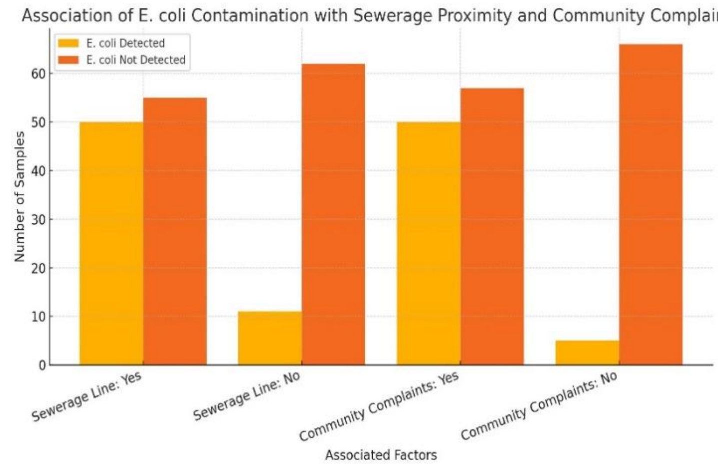

Figure 2 Association of E. coil Contamination with Sewerage Proximity and Community Complain

DISCUSSION

The findings of this study underscore the critical role of environmental and operational factors in determining the microbiological safety of drinking water in urban filtration systems. Proximity to sewerage lines emerged as a significant determinant of contamination risk, with 47.8% of filtration plants located near sewage systems testing positive for *E. coli*, compared to only 6.3% among those situated farther away. This pattern is consistent with existing literature, where studies have documented elevated *E. coli* levels in wells and water sources located near sanitation infrastructure, often attributed to leaks, overflow, and poor wastewater management (13,14). The microbial contamination in such cases is largely fecal in origin, reflecting the direct impact of infrastructural vulnerabilities on public health. A strong correlation was also observed between past contamination events and current microbial load, with 55.9% of previously affected plants exhibiting *E. coli* presence compared to just 11.4% of those with no known history. This association highlights the role of aging infrastructure, recurring leaks, and inadequate remediation following earlier contamination events. Previous studies have similarly emphasized how untreated sewage and deteriorating sewer systems facilitate the propagation of microbial communities, making them persistent sources of infection over time (15,16). This pattern reinforces the notion that water safety cannot be ensured through one-time interventions but requires sustained maintenance and monitoring.

The study also established a clear link between community-reported water quality concerns and the presence of contamination. Plants in areas with complaints showed a contamination rate of 46.8%, whereas those without complaints showed only 6.5%. Prior research supports these observations, demonstrating how consumer dissatisfaction often reflects real-time microbial or aesthetic deterioration in water quality, leading to behavior changes such as increased reliance on bottled water or alternative sources (17). Social monitoring tools have also been proposed to track such complaints systematically, offering an indirect but timely indicator of emerging water safety issues (18). These findings validate the importance of integrating community feedback into surveillance frameworks for water quality governance. Preventive practices at the plant level appeared inconsistent and inadequately implemented. While sediment filters were the most commonly adopted intervention, their presence alone did not prevent contamination, with a detection rate of 54.1% among such plants. In contrast, critical preventive strategies such as sealing open areas and chlorination schedules were entirely absent in several facilities, despite evidence supporting their effectiveness in eliminating microbial contaminants (18,19). The absence of such core practices highlights a gap between infrastructural installation and functional disinfection, underscoring the need for strict regulatory enforcement and accountability in plant operations.

The monitoring frequency and methodology also showed critical deficiencies. Although monthly testing was reported in 22.2% of plants and periodic inspections occurred in 80%, real-time or bi-weekly assessments were largely absent. This infrequency leaves significant windows for undetected contamination. Innovative tools such as paper-based point-of-care sensors have been proposed to address such gaps, offering low-cost and rapid alternatives for more frequent monitoring (19). Furthermore, countries with independent public health surveillance tend to report better compliance with water quality standards, emphasizing the importance of centralized oversight rather than plant-led self-assessments (20). Waste management practices at filtration sites were found to be suboptimal, with 59.4% relying solely on municipal disposal, while only 8.7% recycled waste and 13% employed safe containment methods. These practices not only increase the risk of on-site microbial proliferation but also contribute to broader environmental contamination. Global guidelines, including those from UNEP and UNICEF, advocate for comprehensive waste management and water safety planning, especially in resource-limited settings where children and vulnerable populations face disproportionate risks (21,22). The limited adoption of sustainable waste handling protocols in this study underscores an area requiring urgent policy intervention.

This study has several strengths. It utilized a rigorous microbiological method (Multiple Tube Fermentation) for *E. coli* detection and employed a city-wide sampling strategy to ensure representativeness. The incorporation of operational, environmental, and community variables provides a holistic perspective on the determinants of water contamination. However, the study is not without limitations. The cross-sectional design restricts causal inference, and seasonal variability was not accounted for, which could influence microbial load. Additionally, reliance on self-reported data for past contamination and preventive measures may introduce recall bias or over-reporting. The absence of quantification for microbial load beyond *E. coli*, and lack of chemical contaminant analysis, also limits the broader applicability of findings. Future research should include longitudinal designs to assess contamination trends over time and incorporate a broader spectrum of microbial and chemical parameters. There is also a need to evaluate the impact of specific policy interventions, such as the implementation of Water Safety Plans and decentralized monitoring technologies, on reducing contamination risks. Involving communities in routine surveillance and promoting data-driven decision-making at the municipal level could further enhance the safety and sustainability of urban water systems. Overall, the study provides valuable insights into the multifactorial nature of water contamination and underscores the urgent need for integrated strategies that combine infrastructure upgrades, preventive practices, community engagement, and regulatory enforcement to ensure safe drinking water for urban populations.

CONCLUSION

This study concluded that E. coli contamination remains a critical concern in public water filtration plants across Lahore, primarily influenced by their proximity to sewerage infrastructure and lapses in maintenance. While the implementation of certain preventive measures showed promise, the overall inconsistency in monitoring and inadequate infrastructure limited their effectiveness. The findings underscore the urgent need for systemic improvements, including reliable testing protocols, targeted infrastructure upgrades, and active community engagement. Strengthening these areas is essential not only to safeguard public health but also to build long-term trust in the safety of urban drinking water systems.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Mohsin Khan	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Maryam Rao	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Uzair Mukhtar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Usman Haider Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ayesha Rasheed Mughal	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Amina Riaz*	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Muniba Riaz	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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