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## ASSESSMENT OF DRINKING WATER QUALITY AND ASSOCIATED HEALTH RISKS AMONG RESIDENTS IN A COSMOPOLITAN CITY OF PAKISTAN.

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### ABSTRACT

**BACKGROUND:** Lahore is a congested metropolitan area in the Punjab province, and large segments of its population obtain drinking water from various sources. The drinking water quality is not addressed according to the Environmental Protection Agency (EPA) standards. Thus, it becomes imperative to analyze this city's drinking water quality. Bacterial contamination of drinking water, notably from enteric microorganisms, has shown alarming health effects such as bacillary dysentery, Typhoid, Hepatitis A & E, Poliomyelitis, gastroenteritis (commonly termed food poisoning), etc. The primary purpose of this study is to analyze and detect the presence of fecal coliform bacteria in drinking water samples obtained from different areas. **METHOD:** The sampling locations were conveniently selected from 20 regions of Lahore. The samples were transported to the lab in specific ice boxes within 4-6 hours of the collection. Testing for fecal coliforms employed inoculation of EMB agar (Eosin Methylene Blue Agar), followed by incubation at 44.5 °C for 24 hours. Samples free from fecal coliforms were labeled as **FFC** (fit for consumption), whereas the samples detected for the presence of coliforms were labeled as **NFFC** (not fit for consumption). **RESULTS:** A total of 457 samples were collected and analyzed for the presence of fecal coliforms from December 2022 till August 2023. Among these, 53.5% water samples were found to be fit for human consumption (FFC), whereas, 46.5% were not suitable for consumption (NFFC). **CONCLUSION:** The current study identified that half of the population consume unsafe water, hence vulnerable to waterborne diseases. A higher percentage of contamination was reported in densely populated and less privileged city areas.

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### INTRODUCTION

Clean and safe drinking water is indeed the most vital necessity in the everyday life of all living beings. World Health Organization (WHO) has notably declared that access to clean drinking water is among the most critical determinants of health<sup>1</sup>. Lahore is the 2<sup>nd</sup> largest densely populated cosmopolitan city, estimated

to be 13.5 million, according to the census conducted in year 2022-23<sup>2</sup>.

A large segment of this population obtains drinking water derived from different sources. The quality of drinking water is, however, not addressed according to the standards of public health regulations. Thus it becomes imperative

to analyze drinking water quality, acceptable for general human consumption.

Bacterial contamination of drinking water, notably from the enteric microorganisms, which infect the human intestinal tract, can precipitate various water-borne illnesses. These organisms are released from the feces/stools of infected humans and consequently contaminate the drinking water systems<sup>3</sup>. Fecal coliform bacteria are generally used as primary indicators of fecal pollution in water resources. Contamination of drinking water by these pathogenic bacteria can potentially lead to bacillary dysentery, gastroenteritis (commonly termed as food poisoning) and infective diarrhea<sup>4</sup>. Coliform bacteria are gram negative, rod-shaped, facultative anaerobes, and are non-sporulating bacteria, mostly employed to measure the sanitary quality of water<sup>5</sup>. Regarding their microbial properties, these coliforms are lactose fermenters, produce gas and acid, when incubated at temperature 35°C to 37°C<sup>6</sup>. Primary factors implicated in the contamination of water by coliforms are; defective sewerage systems, unhygienic life styles, damaged water supply pipelines and improper storage of water<sup>7</sup>.

In Pakistan, the primary factors implicated in water contamination by coliforms are; defective sewerage systems, unhygienic life styles, damaged water supply pipelines and improper water storage.

In fact, the use of fecal coliforms as biological indicators for water quality dates back to the early 20<sup>th</sup> century, when scientist MacConkey detected the presence of lactose-fermenting organisms in numerous fecal samples<sup>8</sup>. Coliforms are usually not pathogenic, but their detection in drinking water indicates fecal contamination, which may lead to outbreaks of various water-borne infectious diseases<sup>9</sup>.

This research study aims to analyze and detect the presence of fecal coliform bacteria in drinking water samples obtained from different regions of the cosmopolitan city.

#### **MATERIAL AND METHODS:**

**Collection of samples;** The city-based research was conducted from January to August 2023, with the primary purpose to explore the sanitary quality of drinking water samples obtained from different city regions. Samples were collected aseptically, in sterile plastic containers with 500 ml capacity, transported in specific ice-boxes within 4-6 hours of the collection. Testing for fecal coliforms

employed inoculation of EMB agar (Eosin Methylene Blue Agar), followed by incubation at 44.5 °C for 24 hours. Coliform growth was accompanied by gas production and the appearance of red colonies. EMB agar is generally preferred over MacConkey agar because EMB clearly differentiates between lactose fermenting colonies and the non-lactose fermenting microbes on culture plates. In addition, EMB is more stable and sensitive in detecting fecal coliforms at incubating temperatures. EMB agar is, therefore, a valuable tool for the isolation and detection of fecal coliforms<sup>10</sup>; lactose fermenters produce colored colonies, whereas non-lactose fermenters produce colorless colonies. Lactose-fermenting coliforms acidify the nutrient medium. In an acidic environment, the added dyes have a dark purple color, which may be associated with a dull green metallic sheen, indicating lactose fermentation by the fecal coliforms. Samples considered fit for human consumption were labeled as FFC (fit for consumption), while the samples not fit for consumption were labeled as NFFC (not fit for consumption)

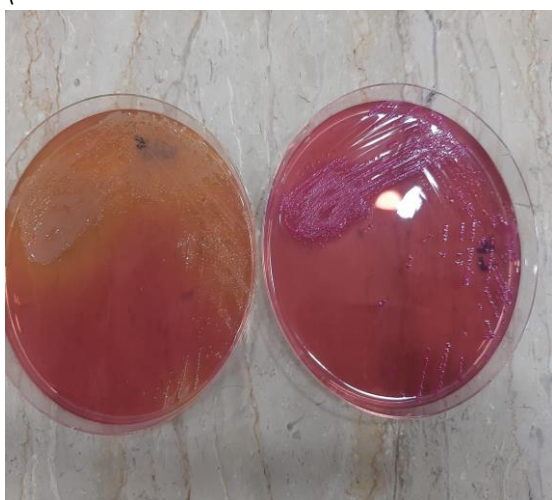
**Preparation of EMB agar;** 10 g of peptone, 5 g of lactose, 5 g of sucrose, 2 g of dipotassium phosphate, 13.5 g of agar, 0.4 g of eosin Y, 0.065 g of methylene blue. Distilled water was added to bring the final volume to 1 liter. pH is now adjusted at 7.2, and the mixture is boiled to dissolve the agar completely. After boiling, the mixture is sterilized in an autoclave for about 15 minutes at 121°C and then cooled to 60°C. Some precipitate appeared in the medium during the process; therefore, the mixture was gently swirled and then gradually poured into sterile double-chambered, properly labeled petri dishes. EMB agar plates were obtained and streaked with sample, utilizing quadrant streak plate method, which inhibited gram-positive bacterial growth in the labeled plates.

#### **RESULTS**

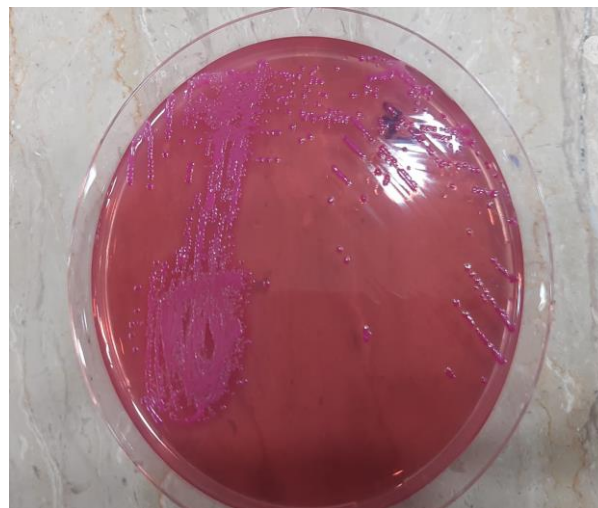
A total of 457 samples were collected and analyzed for the presence of fecal coliforms from January 2023 to August 2023 in 20 different regions of the cosmopolitan. Among these, 53.5% water samples were fit for human consumption (FFC), whereas, 46.5% were not fit for consumption (NFFC; Table-1).

**Table 1: List of FFC or NFFC samples in different regions of the Lahore**

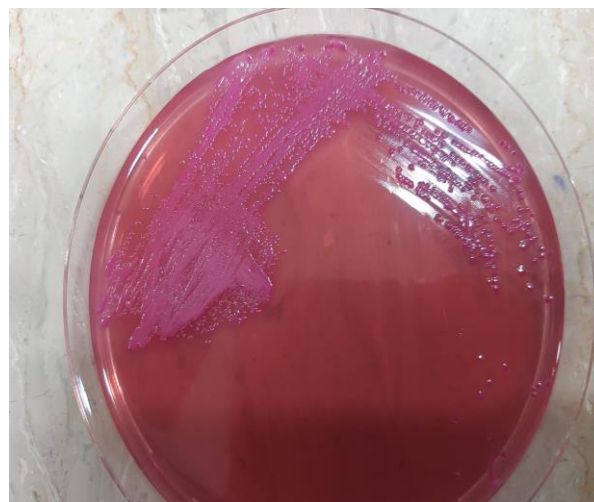
#	Region	No of samples collected	% age of FFC samples	% age of NFFC samples
1	Model town	22	93	7
2	Johar town	19	89	11
3	Wapda town	34	95	5
4	Valencia town	15	90	10
5	Baghbanpura	26	88	12
6	Garhi Shahu	30	90	10
7	Kahna Nau	28	89	11
8	Gulberg II	33	90	10
9	Defense phase VI	15	94	6
10	Bahria Town	18	95	5
11	Cavalry ground	16	88	12
12	Saddar cantt	17	87	13
13	Chauburji	24	90	10
14	Allama Iqbal	31	92	8
15	Samanabad	28	91	9
16	Taj Bagh	20	89	11
17	Harbanspura	31	87	13
18	Green Town	28	90	10
19	Township	19	93	7
20	Kot Lakhpath	11	89	11



**Figure-1** Lactose fermenting and non-lactose fermenting colonies, in samples obtained from Allama Iqbal Town



**Figure-2** Lactose fermenting colonies, in samples obtained from Cavalry Grounds

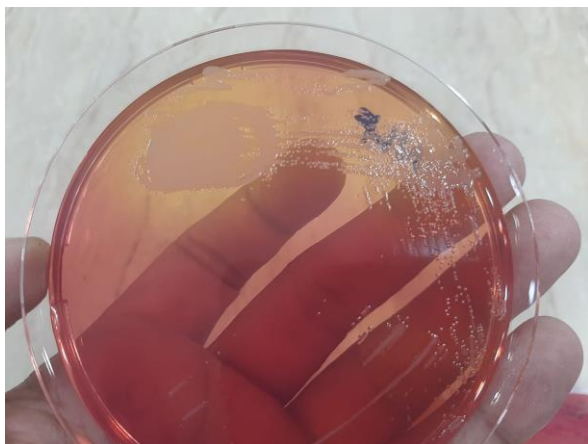


**Figure-3** Lactose fermenting colonies, in samples obtained from Kahna Nau

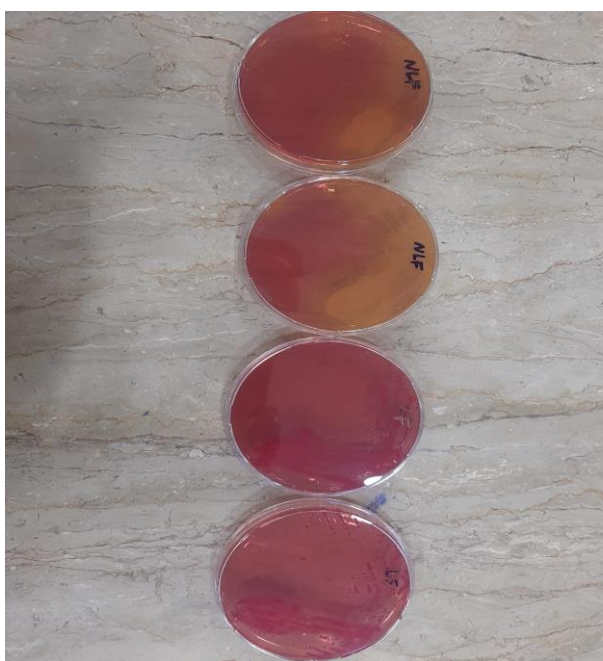


**Figure-4** Non-lactose fermenting colonies, in samples obtained from Cavalry Grounds





**Figure-5 Non-lactose fermenting colonies, in samples obtained from Chauburji**



**Figure-6 Lactose fermenting and non-lactose fermenting colonies, in samples from Gulberg**

## DISCUSSION

The obtained results show alarming number of water samples with high bacterial load, mainly the samples collected from densely populated regions in the cosmopolitan. The overall percentage of NFFC samples was less compared with the FFC samples. National Standards for Drinking Water Quality (NSDWQ) and World Health Organization (WHO) have recently stated that fecal coliforms should not be detectable in water supply systems<sup>11,12</sup>.

The study shows overall 9.45% of drinking water samples contaminated with fecal

coliforms. Strikingly, higher percentage of contamination was observed in the heavy populated regions of the city, comprising mostly low-income groups, compared with regions with better housing facilities and drainage systems and comprising higher income population. Highest contamination was detected in four heavily populated regions of the city; Johar town, Jahna Nau, Cavalry ground and Kot Lakhpat respectively.

These findings emphasize the implementation of rigorous water screening strategies and purification methods to provide safe and clean drinking water to the general public. It is also high time to employ water treatment units across the city. In the same line, assessment and treatment of the sources of water contamination within the sewage system must be initiated on large scale basis.

## Conclusion

The current study clearly shows a high number of contaminated water supplied for drinking purposes to almost regions of the cosmopolitan. The results highlight relatively higher percentage of contamination in densely populated and less developed regions accommodating lower middle class and poor sections of the population.

## Recommendations

Adequate water purification methods must be launched to improve the quality of drinking water. Enforcement of extensive and effective water quality testing and treatment strategies must be implemented by the municipal committees in the city. Similar studies are required in other cosmopolitan cities, to analyze the percentage of contamination of drinking water by fecal coliforms.

**ETHICS APPROVAL:** The ERC gave ethical review approval.

**CONSENT TO PARTICIPATE:** written and verbal consent was taken from subjects and next of kin.

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take public responsibility of this manuscript. All authors read and approved the final manuscript.

**CONFLICT OF INTEREST:** No competing interest declared.

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