Bulletin of Nexus
Multidisciplinary International Research Journal, Double-Blind Peer Reviewed, Open Access Journal
ISSN : 3065-7865 / Volume-3, Issue-2 , February 2026

Original Article

Seasonal assessment of Pathogenic Bacteria from Waters of Upper Lake Bhopal

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Manuscript ID:
BN-2026-030230

ISSN: 3065-7865

Volume 3

Issue 2

February 2026

Pp. 162-167

Submitted: 15 Jan 2026

Revised: 27 Jan 2026

Accepted: 15 Feb 2026

Published: 28 Feb 2026

DOI:
10.5281/zenodo.20656706

DOI link:
https://doi.org/10.5281/zenodo.20656706

Abstract

The present study evaluates the seasonal distribution and percentage occurrence of harmful bacteria isolated from ten water sampling stations of Upper Lake (Bhojtal), Bhopal, Madhya Pradesh, India. The present study show the seasonal bacterial variation in Upper Lake using bacterial load data collected during summer, monsoon, post-monsoon, and winter seasons. The study primarily focuses on major fecal contaminants including Escherichia coli, fecal coliforms, fecal streptococci, Staphylococcus spp., Salmonella spp., and Shigella spp. Seasonal fluctuations revealed that bacterial contamination was highest during summer and lowest during monsoon. The total mean bacterial load recorded during summer was 315.153 x 10^{04} CFU/100 mL, whereas monsoon showed a comparatively lower load of 13.0075 x 10^{04} CFU/100 mL. The findings indicate that climatic conditions, runoff dynamics, temperature variation and human activities directly influence bacterial abundance and prevalence in the lake ecosystem. The study emphasizes the urgent need for sustainable lake management, sewage control and regular monitoring of microbial flora to maintain the ecological and public health significance of Upper Lake Bhopal.

Keywords: *Upper Lake Bhopal, Seasonal Bacterial Distribution, Pathogenic Bacteria, Water Quality Assessment, Fecal Contamination, Escherichia coli, Fecal Coliforms, Freshwater Ecosystem*

Introduction

Freshwater lakes are ecologically sensitive systems that support biodiversity, fisheries, groundwater recharge, recreation and drinking water supply. Upper Lake of Bhopal, popularly known as Bhojtal, is one of the oldest man-made lakes in India and contributes significantly to the domestic water requirements of the city. Despite its ecological and cultural importance, the lake has been increasingly subjected to pollution due to urbanization, domestic wastewater discharge, religious activities, tourism pressure and catchment degradation.

Among various forms of pollution, microbial contamination poses a serious threat because pathogenic bacteria can directly affect human health. Bacterial indicators such as fecal coliforms and *Escherichia coli* are commonly used to evaluate fecal contamination and sanitary conditions of freshwater bodies. Seasonal changes strongly influence bacterial growth and distribution in lake ecosystems. Temperature, nutrient enrichment, rainfall runoff and dissolved oxygen collectively affect microbial dynamics in water bodies.

Previous studies on Upper Lake have mainly focused on physicochemical parameters and water quality index assessment, while fewer investigations have emphasized seasonal bacterial variation. Therefore, the present study was conducted to analyze the seasonal fluctuation of major bacterial contaminants in Upper Lake Bhopal and understand their ecological implications.

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How to cite this article:
Pauranik, A., & Kushwah, S. (2026). Seasonal assessment of Pathogenic Bacteria from Waters of Upper Lake Bhopal. Bulletin of Nexus Journal, 3(2), 162–167. https://doi.org/10.5281/zenodo.20656706

Quick Response Code:

Website: https://bnir.us

It also determines the percentage distribution of harmful bacteria obtained from twenty water sampling sites of Upper Lake Bhopal during different seasons.

Study Area

Upper Lake is located in Bhopal, Madhya Pradesh, India, between latitude 23°12′N and longitude 77°18′E. It was constructed during the 11th century by Raja Bhoj, the lake covers approximately 31 km² and forms a crucial freshwater ecosystem for central India. The lake supports drinking water supply, fisheries, recreation, irrigation and biodiversity conservation.

Twenty sampling sites were selected for the study. These locations represent different ecological and anthropogenic zones of the lake including recreational areas, domestic influence zones, and comparatively less disturbed regions. The sampling stations are selected in such the way that the whole lake may be covered for proper sampling and better data analysis.

A total of 20 sites have been selected for the study

The observations were categorized into four seasons:

- Summer
- Monsoon
- Post-monsoon
- Winter

Sampling Sites details				
S.No.	Name of Sampling Sites	Sample Sites Code	Location	
			Latitude	Longitude
1	Sair Sapata, Upper Lake, Bhopal	BUL1	23°21'62.5"N	77°37'54.5"E
2	Van vihar National Park, Upper Lake, Bhopal	BUL2	23°14'18.6"N	77°21'26.8"E
3	Beside Shamala Hills, Upper Lake, Bhopal	BUL3	23°14'30.6"N	77°22'38.2"E
4	Krishna Nagar, Upper Lake, Bhopal	BUL4	23°14'52.2"N	77°23'31.1"E
5	Ginnori Road, Upper Lake, Bhopal	BUL5	23°15'02.0"N	77°23'56.4"E
6	VIP Road, Street View, Upper Lake, Bhopal	BUL6	23°15'18.0"N	77°23'49.3"E
7	VIP Road, Nakkar Khana, Upper Lake, Bhopal	BUL7	23°15'35.2"N	77°23'10.0"E
8	IPC College Road, Upper Lake, Bhopal	BUL8	23°15'25.0"N	77°21'41.2"E
9	Near Panchmukhai Hanumam	BUL9	23°16'05.3"N	77°21'31.1"E

	Temple, Upper Lake, Bhopal			
10	Boor Van, Upper Lake, Bhopal	BUL10	23°15'29.7"N	77°20'54.6"E
11	Sant Hirdaramdas Nagar, Upper Lake, Bhopal	BUL11	23°16'01.5"N	77°19'46.0"E
12	Chirayu Madical College, Upper Lake, Bhopal	BUL12	23°15'39.6"N	77°18'53.4"E
13	Near Playotel Resort, Upper Lake, Bhopal	BUL13	23°15'33.8"N	77°18'12.4"E
14	Jamoniyachhir, Upper Lake, Bhopal	BUL14	23°15'03.6"N	77°17'14.6"E
15	Khetlakhedi, Upper Lake, Bhopal	BUL15	23°14'34.9"N	77°15'56.5"E
16	Inhkhedichhap, Upper Lake, Bhopal	BUL16	23°13'58.4"N	77°15'48.5"E
17	Huzur, Upper Lake, Bhopal	BUL17	23°14'11.9"N	77°16'48.5"E
18	Mugaliya Chhap, Upper Lake, Bhopal	BUL18	23°14'42.4"N	77°17'50.2"E
19	Bhoj wetland, Upper Lake, Bhopal	BUL19	23°13'57.1"N	77°19'59.2"E
20	Bisankhedi, Upper Lake, Bhopal	BUL20	23°14'34.5"N	77°20'47.2"E
	Note : BUL01- BUL20 corresponds to Bhopal Upper lake sample stations 01-20			

Materials and Methods

Data Collection

The present assessment is based on recent local studies conducted for seasonal physicochemical analyses of water reported for Upper Lake, Bhopal. Early morning samples were collected from all 20 the sampling sites during all four seasons i.e. Summer, Monsoon, Post Monsoon and Winter.

Bacteriological analysis was performed using standard culture techniques, selective media, serial dilution, and membrane filtration methods according to APHA guidelines. Identification was done by isolating bacteria in pure culture and identifying organism based on their colonial morphology, gram's staining and biochemical tests. Bacterial counts were expressed as CFU/100 mL and converted into percentage composition for seasonal comparison.

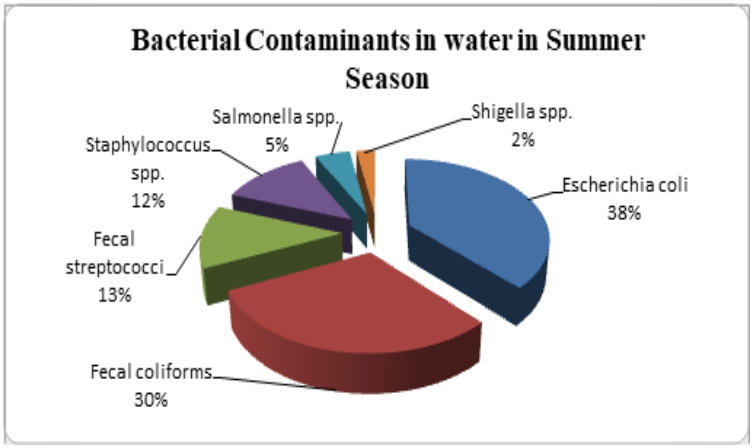
Results and Observations

Seasonal Distribution of Harmful Bacteria

Fecal contaminant / bacteria	**Summer (CFU/100 mL)**	**Summer %**	**Monsoon (CFU/100 mL)**	**Monsoon %**	**Post-monsoon (CFU/100 mL)**	**Post-monsoon %**	**Winter (CFU/100 mL)**	**Winter %**
Escherichia coli	1,198,350	38.00%	34765	26.70%	377450	34.90%	274,140	31.70%
Fecal coliforms	947,800	30.10%	29945	23.00%	299,150	27.70%	248,000	28.70%
Fecal streptococci	397,200	12.60%	19675	15.10%	139,100	12.90%	109,250	12.60%
Staphylococcus spp.	378,850	12.00%	24275	18.70%	134,850	12.50%	129,460	15.00%
Salmonella spp.	149,695	4.70%	12535	9.60%	79840	7.40%	64430	7.40%
Shigella spp.	79635	2.50%	8880	6.80%	49755	4.60%	40080	4.60%
Total Mean Bacterial Load	**3,151,530**	**100%**	**130075**	**100%**	**1080145**	**100%**	**865,360**	**100%**

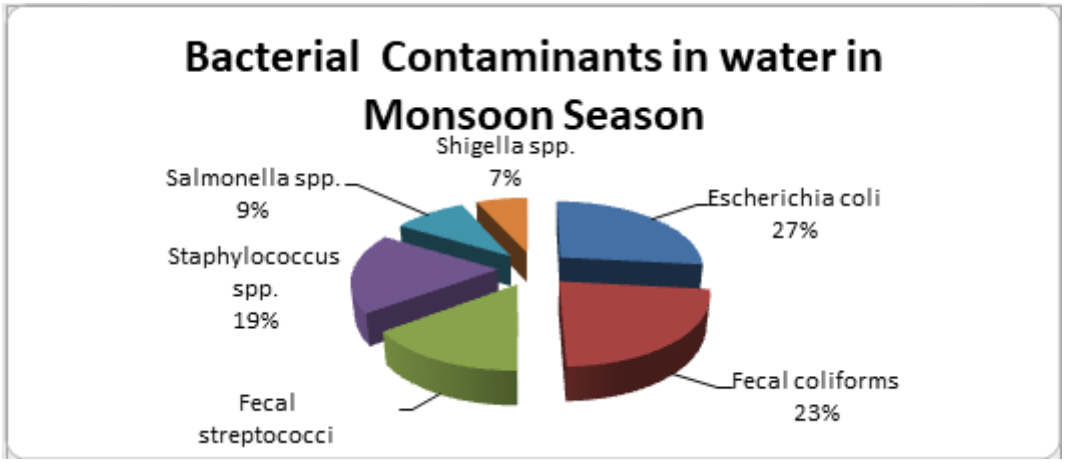
Pie Chart Interpretation of Seasonal Bacterial Distribution

Summer Season



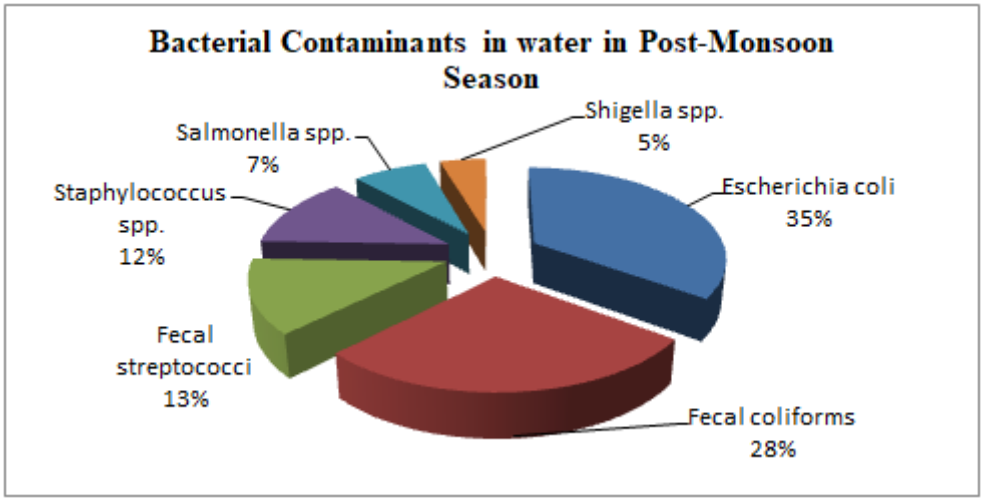
- *E. coli* — 38%
- Total fecal coliforms — 30%
- Fecal streptococci — 13%
- *Staphylococcus* spp. — 12%
- *Salmonella* spp. — 5%
- *Shigella* spp. — 3%

Monsoon Season



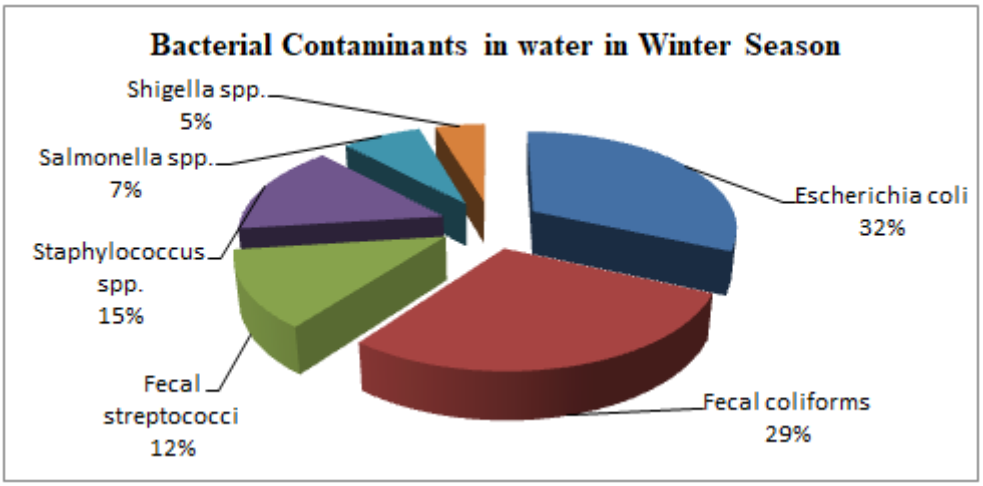
- *E. coli* — 27%
- Total fecal coliforms — 23%
- Fecal streptococci — 15%
- *Staphylococcus* spp. — 19%
- *Salmonella* spp. — 10%
- *Shigella* spp. — 7%

Post-monsoon Season



- *E. coli* — 32%
- Total fecal coliforms — 25%
- Fecal streptococci — 13%
- *Staphylococcus* spp. — 12%
- *Salmonella* spp. — 7%
- *Shigella* spp. — 4%

Winter Season



- *E. coli* — 29%
- Total fecal coliforms — 25%
- Fecal streptococci — 12%
- *Staphylococcus* spp. — 13%
- *Salmonella* spp. — 7%
- *Shigella* spp. — 4%

Discussion

The present investigation revealed that *Escherichia coli* was the dominant bacterial contaminant during all seasons, particularly during summer, where it constituted 37% of the total bacterial load. High summer temperature, reduced water volume, nutrient enrichment, and sewage accumulation favored rapid bacterial multiplication.

Total fecal coliforms represented the second major group of contaminants, confirming extensive fecal pollution in the lake ecosystem. Monsoon season showed comparatively lower bacterial abundance because rainfall diluted the microbial load.

The occurrence of pathogenic bacteria such as *Salmonella* spp. and *Shigella* spp. indicates substantial anthropogenic pressure and sewage contamination in Upper Lake. Persistent occurrence of fecal streptococci and *Staphylococcus* spp. further confirms poor microbiological quality and potential public-health risks associated with lake water.

Conclusion

The study confirms significant seasonal variation in harmful bacterial population in Upper Lake, Bhopal. Summer season exhibited the highest bacterial contamination, whereas monsoon showed comparatively lower bacterial load due to dilution effects. The continuous presence of fecal indicator and pathogenic bacteria highlights severe sewage pollution and ecological stress in the lake ecosystem. Proper sewage management, regular microbiological monitoring, and effective conservation measures are urgently required for restoration of Upper Lake water quality.

Acknowledgment

The author expresses sincere gratitude to the faculty and research supervisors of Mansarovar Global University, Bhopal, for their valuable guidance, encouragement, and continuous support throughout the course of this study. Special thanks are extended to all individuals who assisted in field sampling, laboratory analysis, and data collection.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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