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A STUDY ON SEASONAL BACTERIOLOGICAL WATER QUALITY AND SURFACE WATER BODIES IN DELHI/NCR

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ABSTRACT

Rivers, streams, and lakes are examples of natural surface water bodies. Around 4,000 trillion litters of fresh water are supplied to India each year by rainfall and snowfall. Only a very small portion of freshwater is kept in inland and artificial bodies of water; the majority is transported to seas and oceans by major rivers, tributaries, and streams that span the nation. The majority of human activities involve the utilisation of river water, including agriculture, recreation, activities related to pilgrimage, and use as a coolant in industrial settings. Moreover, it is utilized for drinking in rural regions with or without basic water treatment. By increasing the prevalence of water-borne diseases, polluted rivers can endanger public health. Diarrhoeal illnesses and enteric fevers are brought on by drinking water polluted with faecal organisms. Floods encourage the growth of vector habitats and raise the incidence of diseases carried by vectors. Heavy rains or river overflows provide stagnant water, which can serve as mosquito breeding grounds and so hasten the possibility of dengue, malaria, and West Nile fever illnesses.

KEY WORDS: Seasonal, Bacteriological Water Quality, Drinking Water Polluted.

1. INTRODUCTION

Himalayan rivers and peninsular rivers are the two categories into which Indian rivers fall based on their origins. Jhelum, Chenab, Ravi, Beas, Sutlej, Ganga, and Yamuna are Himalayan rivers, whereas Narmada, Tapi, Godavari, Krishna, Cauvery, and Mahanadi are Peninsular rivers. There are several tributaries to these major rivers. These tributaries pollute the major rivers by bringing pollutants there. In India, the amount of fresh, potable water available has significantly decreased. According to a report by the Central Pollution Control Board, out of the 475 rivers evaluated, 121 were polluted in 2009; by 2015, this number has increased to 275. Yamuna, Ganga, Sabarmati, Oshiwara, and Damodar rivers are the most polluted in India. The Ganga and Yamuna rivers are among the ten dirtiest rivers in the world. The Yamuna River receives the largest garbage from metropolitan city Delhi (58%). India's longest river is the Ganga. In its basin and along its banks, 32 sizable drains discharge their contents into the Ganga. The pollution levels in the Ganga are currently greater than the WHO allowed limits despite numerous efforts to clean it up. After the Yamuna and Ganga, the Sabarmati River in Ahmedabad, Gujarat, is the third most polluted river in India. Oshiwara, a river that runs through Mumbai, Delhi/NCR, is the fourth-most polluted river. Due to the ongoing release of domestic, industrial, and agricultural pollutants into river water that is either untreated or just partially treated, these rivers are severely polluted.

Before using river water for drinking or recreational purposes, it must undergo a microbiological test for faecal indicator bacteria. The "designated best use" idea has been introduced in India by the Central Pollution Control Board (CPCB). A given water body's "designated best use" is the one that requires the highest quality of water out of all the purposes to which it is put. Five of these "approved best applications" have been determined by the CPCB. In addition, the CPCB has created primary water quality criteria, or requirements for the chemical and biological features of water. The following table lists the "designated best uses" and the associated water quality standards.

1.1 ANTIBIOTIC RESIDUES AND ANTIBIOTIC RESISTANT BACTERIA IN WATER BODIES

After animal and human excretion, there were only trace amounts of antibiotic residues found in the water bodies. Similar to this, the levels found following the wasteful disposal of unneeded antibiotics were low. Nonetheless, large quantities were discovered to have been observed following the release of untreated effluents from pharmaceutical businesses. The problem of declining river water quality has been made worse by the rising levels of antibiotic residue in rivers. Antibiotics are classified as environmental pollutants. Direct antibiotic discharges from antibiotic manufacturing facilities into rivers or oceans, whether during the formulation process or during the actual production of the active ingredient, contaminate aquatic environments and change the distribution of bacterial communities in the water bodies. The presence of antibiotic residues and their destiny in aquatic systems are influenced by physical-chemical features, antibiotic partition characteristics, and hydrological dynamics. In contrast to fluoroquinolones and tetracyclines, which remain for a very long period, other antibiotics, like as penicillins, can breakdown quickly in the aquatic environment. Several rivers across the world have high levels of antibiotic residues. In the Seine River in France, sulfamethoxazole, diaminopyrimidines, and quinolones were found up to 544 ng/L throughout the year.

1.2 ANTIBIOTIC RESISTANT BACTERIA IN DELHI/NCR

The excessive discharge of partially treated/untreated municipal garbage into the river Yamuna River was brought to light in research. The increasing abundance of ARGs in the sediments of the Yamuna River River at sites adjacent to the city of Delhi was caused by the dumping of rubbish into the river. Both in rural and urban Delhi, self-medication with antibiotics has been documented. The use of antibiotics in poultry is common, which causes the development of ARBs in chicken and subsequent environmental contamination. From poultry in Delhi, antibiotic-resistant Campylobacter jejuni was discovered. In Delhi-based hospitals, the "Super bug" harbouring NDM-1 was also found. A survey was conducted in Delhi, India, to examine the general practitioners' prescribing procedures. The survey results showed that allopathic and ayurveda practitioners prescribed 2.5 and 4.5 medications on average every contact, respectively. These values above the range (1.8–2.2) allowed by the WHO for prescription indicators. Prior to urinary tract infections, gastroenteritis, and skin and soft tissue infections (SSTI), the ayurvedic doctors often employed antibiotics to treat viral fevers and respiratory tract infections. Yet, more than 85% of patients with viral fever were managed by allopathic doctors without the need for antibiotic prescriptions. Whereas allopathic doctors employ penicillin and lactams, ayurveda doctors typically use cephalosporins. In general, ayurvedic and allopathic physicians frequently employed antibiotics from the -lactam antibiotics, quinolones, and macrolides families to treat viral fever in Delhi city.

2. MATERIAL METHODS

2.1 SELECTION OF THE STUDY AREA

A significant river called Yamuna River flows through the heart of Delhi city and is located in the Delhi district. The Mula and Yamuna River rivers come together at this point. While the Yamuna River originates close to Tamgher Dam, the Mula originates at Narela Dam. At Sangamwadi village (in the city of Delhi), these two rivers merge. The river then travels through Delhi and Khadki before meeting the river, Yamuna. The river is based on the monsoon and typically floods during the monsoon and dries up in the summer. It receives agricultural run-off, sewage waste, emissions from the burning of fossil fuels, and the discharge of domestic, hospital, and industrial effluents from small- and large-scale companies located along the river's banks. Eight sampling locations along the Yamuna River banks were chosen for the current study. With regard to Delhi city, these sites spanned the whole river, including the upstream, confluence, and downstream. Six of the eight sampling locations in the Delhi district were in the rural areas, and two were in the urban areas. Out of the six villages, two were located downstream and four were located upstream of Delhi.

2.2 A SEMI-STRUCTURED QUESTIONNAIRE USED FOR A VILLAGE SURVEY

Prior to collecting water samples, a survey of the chosen villages' residents, sanitary infrastructure, and presence of livestock and poultry was conducted. In the five villages that were chosen, a semi-structured questionnaire was utilised to gather data on the prescription practises of private practitioners, Primary Health Centers (PHCs), private pharmacies, pharmacies at PHCs, veterinary doctors, and Auxiliary Nurse Midwives (ANMs). Ceftazidime (3rd generation cephalosporin) and ciprofloxacin (2nd generation fluoroquinolone) were used to count single and dual antibiotic resistance TFC from the river water samples based on the survey and available literature on the use of antibiotics in urban and rural Delhi.

2.3 COLLECTING WATER SAMPLES AND ANALYSING THEM FOR GERMS

Using sterile polystyrene bottles, a 1000 mL sample of river water was taken from around 60 cm below the surface. In contrast to HH water samples, which were only taken during post-monsoon, the samples were taken three times over the course of a year, during post-monsoon, pre-monsoon, and monsoon.

The Bureau of Indian Standards (BIS) criteria were followed when analysing water samples for bacteriology. After membrane filtering with cellulose acetate 0.22 filters, thermotolerant faecal Coliforms (TFC) were counted on m-FC agar (Millipore, Massachusetts, United States). Results were represented as Colony Forming Units (CFU) per 100 ml after a 24-hour incubation period at 44.5°C. Filter sterilised ceftazidime (16 g/ml; Sigma-Aldrich, Missouri, United States) and ciprofloxacin (4 g/mL; Sigma-Aldrich, Missouri, United States) antibiotics were included individually and both together in the m- FC agar to isolate and count antibiotic resistant TFC. These antibiotic doses were chosen in accordance with the recommendations of the Centre for Clinical and Laboratory Standards Institute.

Clean, sterile plastic bottles were used to collect all the samples for examination. Before sterilisation, 300 l of 3% sodium thiosulphate was applied to the bottles in order to collect water from previously chlorinated sources. While the water is being transported, sodium thiosulphate neutralises the chlorine and stops additional bactericidal effects on the bacteria. If BIS requirements were not available, WHO guidelines were applied. Standard methods for drinking water analysis were carried out in accordance with the specifications set out by the Bureau of Indian Standards and the American Public Health Association.

2.4 WATER PHYSICOCHEMICAL ANALYSIS

On the field, a simple physico-chemical analysis was done. Temperature, pH, conductivity, total dissolved solids (TDS), and salinity were the variables that were measured. Prior to this, manufacturers' recommendations were followed when using calibrated soil and water analysis probes (kit from Chandigarh, India-based Zennith Engineers). Chlorine detection strips (HiMedia, Mumbai, India) were used to check for residual chlorine. The Nephelometric method was used to calculate turbidity. Dissolved Oxygen (DO) was fixed on sites using Winkler reagents, and the values were then titrated the same day. Also, the samples were examined using the APHA 5220 B technique for Chemical Oxygen Demand (COD). Transported to Mumbai for testing were the water samples for the remaining criteria. Filtration was used to measure Total Suspended Solids (TSS), which were then quantified as mg/L. Ammonia was estimated using the phenol-hypochlorite method.

2.5 ANALYSIS OF BACTERIAL DATA

For the portrayal of seasonal TFC, ciprofloxacin-resistant TFC, ceftazidime-resistant TFC, and ciprofloxacin and ceftazidime-resistant TFC counts for rivers and important drinking water sources, a tabular format was utilised. According to WHO drinking water guidelines, TFC counts of 0–1, 10–100, 100–1000, and >1000 per 100 mL were connected with varying levels of danger (no risk, moderate risk, intermediate risk, high risk, and extremely high risk).

2.6 STATISTICAL INVESTIGATION

To reduce data entry errors, manual data entry was performed using Microsoft Excel 2010 and external quality checks. With SPSS, a statistical analysis was carried out (version 0.8.5). Calculations of the mean, standard deviation, and range were made for the examination of demographic and physico-chemical data.

3. RESULT AND DISCUSSION

Table lists potential Yamuna River pollution sources. In the chosen settlements, open conduits for household waste, agricultural runoff, and animal excrement were discovered to be causes of river contamination. Gorekhurd has the least open defecation of the four upstream communities. Yet, Gorekhurd's usage of poultry waste as manure may be a source of antibiotic-resistant bacteria in the river. At Sangam Bridge and Manjari, multiple point and non-point sources of contamination were found in the Yamuna River.

3.1 ANTIBIOTIC USE IN DELHI'S RURAL AREAS

Villagers from Palase, Harewali, and other nearby areas sought Male and Paud PHC, respectively, to obtain medical facilities. Ambegaon and Gorekhurd villagers respectively visited Panshet PHC and Delhi city. According to Kusumpur and Panshet PHCs, fluoroquinolones and/or cephalosporins were frequently used to treat common illnesses and ailments. Tetracycline, the combination of amoxicillin and docoxacillin, and septran/co-trimoxazole were among the antibiotics that were frequently sold according to chemists' and doctors' prescription procedures.

TABLE-1: PHYSICO-CHEMICAL PROPERTIES OF WATER

VILLAGE	**Sample Code**	**Temperature(°C)**			**pH** (permissible limit:6.5-8.5)			**Conductivity (mS)** (permissible limit not available)			**Salinity (ppt)** (permissible limit not available)			**Total Dissolved Solids (ppt)** (permissinle limits:0.6ppt)			**Turbidity (NTU)**(permissinle limit: 10NTU)		
		A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Palse	P21/B	20	26	24	7	7.42	7.31	0.075	0.093	0.076	0.056	0.072	0.057	0.037	0.041	0.038	0.3	1.3	2.8
Harewali	P8	23	25	22	7	8	7.1	0.084	0.103	0.079	0.063	0.077	0.060	0.042	0.051	0.040	0.3	0	0.4
Narela	P8/B	23	28	22	7	8.1	7.21	0.092	0.009	0.106	0.0013	0.069	0.079	0.046	0.046	0.053	2.3	0.2	4
Ambegaon	P22/B	20	X	24	7	X	6.79	0.224	X	0.177	0.169	X	0.133	0.112	X	0.088	0.3	X	0.4
	P22/C	20	X	25	7.5	X	6.8	0.237	X	0.214	0.179	X	0.161	0.116	X	0.107	4.3	X	0.9
Gorekhurd	P23/B	20	27	25	7	6.7	7.1	0.098	0.114	0.277	0.078	0.086	0.201	0.049	0.057	0.137	3.2	0.2	5.5

Kusumpur	P24/D	21	26	26	7	6.92	6.92	0.085	0.068	0.086	0.067	0.050	0.68	0.044	0.032	0.045	0.5	0.5	1.5
Walki	P26/B	27	26	25	7	8.12	6.64	0.165	0.232	0.189	0.124	0.14	0.114	0.082	0.102	0.095	0.4	0.6	1

Key: A: Post-monsoon, B: Pre-monsoon, C: monsoon, X: since sources were dried samples were not collected.

VILLAGE	**SampleCode**	**Dissolved oxygen (ppm)** (permissinle limit:6ppm)			**Total SuspendedSolids**			**Nutrient**											
								Ammonia (mg/L) (permissible limit not available)			**Nitrate (mg/L)** (permissinle limit 45mg/L)			**Phosphorus mg/L** (Permissible limit not available)			**Calcium mg/L** (Permissinle limit: 75mg/L)		
		A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Palse	P21/B	7.84	6.4	8.2	0.4	2.8	1.9	< 0.1	3.14	<0.1	< 0.1	<5	<5	< 0.1	0.01	0.36	9.2	10	<10
Harewali	P8	4.9	6.9	9.4	3.4	0.4	0.3	< 0.1	<0.1	20	< 0.1	<5	<5	< 0.05	0.01	0.1	7.2	<10	20
Narela	P8/B	2.8	5.3	13.6	0	0.1	3.1	ND	<0.1	0.21	ND	<5	<5	ND	0.01	0.14	ND	<10	10
Ambegaon	P22/B	2.68	X	8.0	3.5	X	0.6	< 0.1	X	0.41	< 0.1	X	6.3	0.4	X	0.28	X	X	16
	P22/C	1.12	X	5.6	4.4	X	1.4	< 0.1	X	0.42	0.1	X	<5	< 0.05	X	0.42	X	X	18
Gorekhurd	P23/B	2.9	6.72	5.1	0.2	0.4	5.5	< 0.1	0.13	3.65	0.1	<5	8	< 0.05	0.01	8.1	28.3	10	18
Kusumpur	P24/D	5.72	10	7.1	0	0.9	0.1	< 0.1	<0.1	<0.1	1.9	12.7	12.7	< 0.05	<0.1	<.01	1.3	<10	<10
Walki	P26/B	5.7	2.7	6.9	0.2	1.	0	<	0.2	<0.	2.8	54.	23.	<0.0	<0.	<.0	4.8	<1	<1

		2				6		0.1	5	1		5	8	5	1	1		0	0

Note: X: source was dried hence samples were not collected, ND: not done

Key: A: Post-monsoon, B: Pre-monsoon, C: monsoon

TABLE-2: SEASONAL BACTERIOLOGICAL WATER QUALITY OF MAJOR DRINKING WATER SOURCES(MDWS)

Rainfall zone	**VILLAGE**	**SAMPLING POINT**	**Sample Code**	**TFC (CFU/100mL)**		
				monsoon	**Post-monsoon**	**Pre-monsoon**
High	Palase	Storage tank	P21/B	32	5	2
	Harewali	Storage tank	P8/A	6	44	0
	Narela	Storage tank	P8/B	1	0	0
	Ambegaon	Natural spring	P22/B	8	300	X
	Ambegaon	Open well	P22/C	28	4	X
	Gorekhurd	storage tank	P23/B	87	35	1
	Kusumpur	Filtration plant	P24/D	8	0	1
	Walki	Filtration plant	P26/B	2	0	6

Note: X - source was dried; cipro resistant TFC and cefta resistant TFC were not detected in MDWS

TABLE 3: LOAD OF TFC IN HH WATER IN POST-MONSOON

	Delhi district
	HHs dependent on **MDWS** in respective **villages**

Village	Palase	Harewali	Ambegaon	Gorekhurd	Kusumpur	Walki
No of HHs	N=13	N=12	N=12	N=12	N=12	N=12
Mean ± SD (TFC in CFU/100mL)	47.9 ± 114	505 ± 693	82.8 ± 98.5	145 ± 446	12.7 ± 37.2	248 ± 430
Range (TFC in CFU/100mL)	0 - 420	0 - 2000	0 - 240	0 -1560	0 -130	0 -1280

3.2 RIVER PHYSICO-CHEMICAL ANALYSIS

Pollutants are transported to large rivers through tributaries. The impact of atmospheric, geological, and agricultural activities on riverine water quality is reflected in the analysis of physico-chemical parameters. For temperature and salinity, BIS/WHO has no acceptable thresholds. Yet, the current study's salinity fluctuated from 0.05 to 0.113 ppt year-round while temperature ranged from 20 to 28 oC. The pH, conductivity, and TDS values were within acceptable ranges. However, during the monsoon, increased turbidity and TSS levels were observed, likely as a result of the mixing of surface runoff with river water. The dissolved oxygen (DO) is essential for the survival of aerobic aquatic microorganisms, plants, and animals. Water quality can be impacted by very high or low DO values. The distribution of DO is significantly influenced by river stratification. The bacterial burden and DO are reported to have an inverse relationship in various research. Lower salinity and warmth, which can saturate rivers with oxygen, are physico-chemical factors that can also affect DO.

In this study, year-round DO concentrations varied from 0.6 to 13.4 ppm. With the exception of the monsoon, the river Yamuna consistently had a DO value below 1 ppm at the Sangam bridge (P27) and Manjari (P25). Heavy bacterial pollution at locations nearby Delhi city throughout the year is the most likely cause of this. Furthermore, the pre-monsoon river drying up may have concentrated pollutants and bacterial load in river waters, causing the low DO value. Furthermore, field observations indicated that P27 and P25 had several point and non-point sources of organic pollution. The DO levels at P27 and P25 were decreased by these organic pollutants. Unexpectedly, high values at P27 (4.25ppm) and P25 were found during the monsoon (4.70ppm). The river flow regime significantly widens during the monsoon season. The fact that the river has more water than it needs and the air is cooler may have negated the impact of the high bacterial load and increased the DO level in P27 and P25.

Rivers passing through the communities of Palase (P21/A), Ambegaon (P22/A), and Harewali (P8) all year long recorded DO readings exceeding 5 ppm. These communities were geographically located at a high altitude, about 800 metres above sea level. Because of the low atmospheric pressure and temperature at high altitudes, rivers may hold more water. Moreover, a river basin is widened by a lot of rain. The DO levels of the river in the aforementioned upstream communities were increased by the combined effects of meteorological factors, rainfall, and physical terrain.

Harewali's P8 recorded an unusually high DO value of 13.4 ppm during the monsoon. As was previously mentioned, geographical and atmospheric factors affected the DO at P8, Harewali. Also, during the monsoon, a torrential river flow was seen at Harewali due to the release of extra water from Narela dam into Yamuna River, which improved the mixing of river water with atmospheric oxygen even more.

Ammonia, calcium, and nitrate levels were checked to determine the effects of industrial and agricultural activities on waterways. Except at P27 and P25, values for nitrate (45 ppm), calcium (75 ppm), and ammonia (1 ppm) were always within allowable ranges. High nitrate levels (>47ppm) were also found in the river Yamuna (P26/A) near Walki. Given the widespread cultivation of sugarcane that has been noticed in Walki, the likely cause of the high nitrate concentration in the area could be the excessive use of chemical fertilisers (urea, diammonium phosphate, and superphosphate) in agricultural operations. Total phosphorus (TP) is the sum of organic and inorganic phosphorus. Water phosphorus contamination is a result of industrial and home waste containing detergents as well as runoff from agriculture. Toxic algae blooms are caused by a high concentration of total phosphorus in surface water. Total phosphorus does not meet BIS, WHO, or EU criteria for permitted levels. In the current investigation, all sample locations, with the exception of P27 and P25, had TP values for the majority of the sources below the detection limit (0.05 mg/L).

At Sangam Bridge (P27) and Manjari (P25), it was discovered that the river Yamuna was consistently contaminated. At P27 and P25 in all seasons, high levels of nitrate, ammonia, total phosphorus, and calcium were found. The pollution of the river at P27 and P25 may be caused by the disposal of rubbish from Delhi into the River Yamuna. Chemical Oxygen Demand was also tested on samples of river water (COD). The COD test measures the quantity of oxidizable contaminants present in surface water or waste-water, which reveals levels of water pollution. It also measures the number of organics in water. In the case of rivers, there are no available standards for COD. In the current investigation, COD measurements at P27 and P25, respectively, showed very high loads of organic wastes in the river Yamuna at locations close to the city of Delhi. The COD values were 280 ppm and 180 ppm.

3.3 MAJOR DRINKING WATER SOURCES' WATER QUALITY (MDWS)

The majority of the communities' MDWS were closed sources (storage tanks, filtration plants). River water was raised and pumped into the corresponding storage tanks in the cases of Palase and Gorekhurd. Narela filtration plant supplied treated water to Harewali storage tank. MDWS of Ambegaon was surrounded by a river, an open well, and a natural spring. Villagers in Kusumpur and Walki could access drinking water thanks to filtration facilities.

3.4 MDWS PHYSICHO-CHEMICAL ANALYSIS

Since the obtained values for the majority of the indicators were within allowable levels, the physicho-chemical quality of the main drinking water sources was determined to be good. The TDS ranged from 0.03-1.37ppt, turbidity ranged from 0-5.5NTU, and TSS ranged from 0-5.5 ppm. The pH ranged from 6.9 to 8.1. Levels for total phosphorus, calcium, ammonia, and nitrate were likewise low and below acceptable ranges. Temperature in the current study ranged from 20 to 26 °C, conductivity from 0.009 to 0.277 mS, and salinity from 0.03 to 0.68 ppt. For drinking water, there were no acceptable thresholds for conductivity, salinity, or temperature.

3.5 MDWS WATER QUALITY BACTERIA

TFC load in the main drinking water sources fluctuated between 0-300CFU/100mL during the course of the year. Due to the building of filtering facilities, the MDWS from the villages of Kusumpur and Walki carried the least amount of TFC (0-8 CFU/100mL). In the villages Gorekhurd, Palase, Harewali, and Ambegaon, which lack filtering units, faeces were found in the MDWS. Water from the Yamuna River was directly pumped into Gorekhurd's storage tank. The water was directly removed from the Yamuna River.

4. CONCLUSION

Prior to collecting water samples, a survey was conducted in the chosen hamlet to identify the many factors that contribute to HH water pollution. Socioeconomic factors, family size, number of children in the family, and methods used to store and handle water are all on the list of parameters. For HH potability, 73 HHs based on the aforementioned MDWS were chosen. Following the monsoon, water samples from these HHs were taken and examined to determine the load of TFC and ARTFC. In HHs samples, the TFC load ranged from 0-2000CFU/100mL. The WHO classed 53% of HHs as having no danger to low risk water quality, while 47% were classified as having intermediate risk, high risk, or very high risk (Table 4.5.7B). No water samples were found to have ARTFC in them. The HH sample size was limited, therefore it was not possible to analyse the bacteriology in relation to socioeconomic position, family size, the number of children in the family, or water handling procedures.

Chemical pollutants, TFC, and AR TFC were concentrated in urban river segments as a result of the unchecked inflow of sewage, medical, and industrial waste from Delhi city. The river was overflowed with various types of wastes at the confluence (Sangam bridge) in Delhi city as a result of the sewage treatment system being utterly insufficient in Delhi city. A dilution effect, primarily in urban areas, and b external contamination by mixing of surface run off, primarily in rural regions, both dynamically altered the bacterial contamination in the Yamuna River water during monsoon.

The findings of the current study highlight the need for immediate and corrective village-level initiatives to improve sanitation and safeguard rivers and the main sources of drinking water from sewage and other dangerous wastes produced in the neighbourhood. Regular household chlorination is necessary. Above all, local Gram Panchayats or other authorities must start teaching communities on hygiene and sanitation practises.

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