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Bacteriological water quality status of River Yamuna in Delhi

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Abstract: *Bacteriological water quality status in terms of total coliform and faecal coliform count was studied on both - east and west banks of river Yamuna in Delhi. Membrane filtration technique was adopted for enumeration of total coliform and faecal coliform count in the river water sample collected on monthly basis for 2 years – 2002 and 2003. The study reveals the impact of diverse anthropogenic activities as well as the monsoon effect on the bacterial population of river Yamuna in Delhi stretch. Microbial population contributed mainly through human activities prevailed in the entire stretch of Yamuna river with reduction in bacterial counts during monsoon period due to flushing effect. Bacteriological assessment does not provide an integrated effect of pollution but only indicate the water quality at the time of sampling. Hence, this parameter is time and space specific.*

Key words: *Bacteriological water quality, Total coliform, Faecal coliform, Membrane filtration technique.*

Introduction

River Yamuna – a perennial river is the lifeline of Delhi forming the eastern boundary of the city. River water is being extensively harnessed from both of its banks for domestic, industrial and irrigation purpose. To meet the ever-growing water demand of the city, the river is trapped at three points – Wazirabad, ITO and Okhla by construction of Barrages. About 510 million m^3 of water is abstracted from Wazirabad-Okhla stretch of Yamuna river. Both the east and west banks of the river stretch in Delhi are subjected to diverse anthropogenic activities. Biological life has been observed to be more affected on eastern bank of the river than on the western bank (Anand *et al*., 2002). (In this 2002 study, the authors had considered East bank, as the side from where most of the drains fall into R. Yamuna which in the present study has been ascertained as West Bank on the basis of North-South direction). Delhi generates about 3600 MLD (million liters per day) of wastewater. 3296 MLD of sewage is contributed by virtue of 19 drains outfalling in Yamuna (Table 1).

Rapid urbanization in Delhi has further compounded the pressure on the sewerage system. Various pollution abatement measures such as under Yamuna Action Plan are being taken to restore river water quality. Number of STPs has been constructed and more under construction making total treatment capacity of 2191 MLD but still about 1341 MLD of waste water remains untreated in Delhi area. About 700 MLD treated waste water in Delhi is directly discharged into the Yamuna (CPCB, 2004-05). Apart from point sources of pollution, diffused sources of pollution such as agricultural pollution and various instream uses of water such as cattle wading, bathing, open defaecation and cloth washing add to the deterioration of river water quality. Domestic sewage in the river aid in the survival of pathogens (CPCB, 2002-2003).

The natural bacterial communities of freshwaters are largely responsible for the self purification processes which biodegrade organic matter. They are particularly important with respect to the decomposition of sewage effluents. However, domestic sewage effluents also add to water bodies large numbers of certain bacterial species which arise from intestine. Presence of these bacteria presents significant health risks. Coliform bacteria have been used for microbial analysis of drinking water, groundwater, food, pharmaceuticals, freshwater, marine water and other environmental samples. The coliform group refers to Gram –ve, non-spore forming oxidase, rod-shaped bacteria capable of growth in the presence of bile salts or other surface-active agents. This group is able to ferment lactose at 35 $\pm$ 0.5ºC with the production of acid, gas and aldehyde within 24-48 hrs. Faecal coliforms are among the coliform group of bacteria present in the alimentary canal and faeces of warm blooded animals capable of producing gas from lactose in a suitable culture medium at 44.5 $\pm$ 0.2ºC for 24 hrs.

CPCB has been monitoring the river water quality in the entire stretch since 1974. A study conducted in 1988-89 of Delhi segment (22 km) reported an average of 9×10^6 (5.4×10^6 – 54×10^6) MPN/100 ml of Total coliforms and 77×10^5 (1×10^5 – 35×10^5) MPN/100 ml of faecal coliforms (CPCB, 1989-90).

A similar study (conducted during 1995-1998) revealed that the water quality of river with respect to total and faecal coliform remained in deteriorated condition in Delhi segment (Table 2) and downstream upto Etawah with coliform count between 10^4-10^5 Nos./100ml (CPCB, 1999-2000).

CPCB has laid down a primary water quality criteria (presently under revision) limits of total coliform organisms in various water quality classes defined on basis of their designated best use (Table 3). In the present study, bacteriological water quality status of River Yamuna on both of its banks subjected to diverse anthropogenic activities has been discussed including the monsoon effect on the total bacterial count.

Materials and Methods

About 35 km stretch of river Yamuna from Palla (reference point) till Okhla Barrage downstream was selected for the study during the period January 2002 – December 2003.

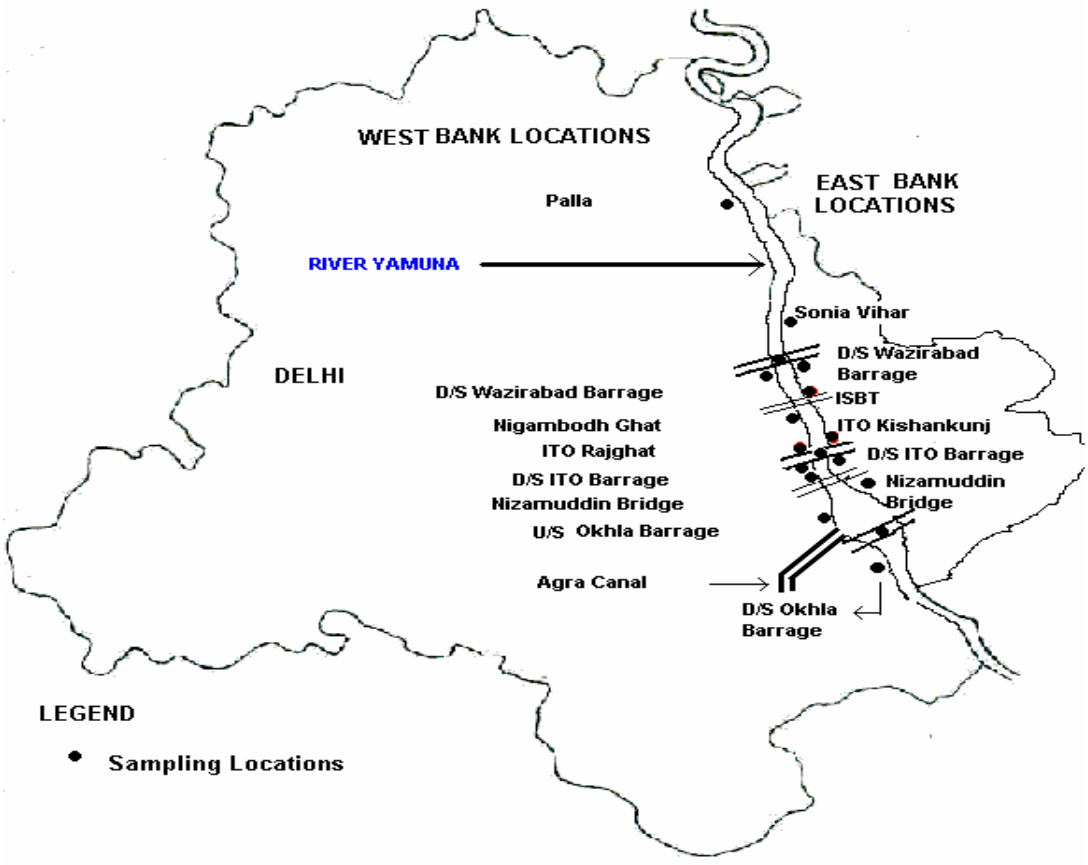

Fig. 1: Diagram depicting sampling locations.

Table – 1: Drains outfalling into river Yamuna (Yamuna action plan).

S.No.	Name of drains	Average discharge to Yamuna (MLD)
1.	Supplementary drain	
2.	Najafgarh drain	1993
3.	Magazine road nalla	5
4.	Sweeper colony nalla	7
5.	Khyber pass nalla	8
6.	Metycalf house drain	6
7.	Qudasia bagh drain	54
	Mori gate drain	
8.	Moat nalla	Negligible
9.	Kalkaji nalla	
10.	Civil mill drain	22
11.	Rajghat / Delhi gate drain	125
12.	Sen nursing home drain	113
13.	Nala No. 12A	17
14.	Nala No. 14	113
15.	Barapulla nalla	156
16.	Maharani bagh nalla	17
17.	Tehkhand drain	52
18.	Tughlakabad drain	2
19.	Trans Yamuna drain	606
	Total	**3296**

Monthly bacteriological samples were collected from both the east and west banks of the river including midstream (M/S) and downstream (D/S) of the three Barrages at Wazirabad, ITO and Okhla accounting to total of 17 locations. Parameters studied were total coliform and faecal coliform.

Membrane filtration technique as per standard methods (APHA, 1998) and WHO guidelines (WHO, 1985) was adopted. Membrane filter of pore size 0.45µ and 47 mm diameter were used. Media used were - HiMedia M-Endo broth for total coliforms and M-FC broth for faecal coliforms. The filter, through which required concentration of sample to be analysed has been passed, is placed on the absorbent pad with selected media and the petridish containing the above filter is then incubated. Incubation temperature and time taken for total coliform was 35 ± 0.5ºC for 24 hrs and 44.5 ± 0.2 ºC for 24 hrs for faecal coliform. Autoclave sterilized dilution water prepared from potassium dihydrogen phosphate (34 gms in 1ltr) is used for making required concentrations of the sample.

After incubation, red (magenta) coloured colonies with metallic (green gold) surface sheen developed for total coliform and blue coloured colonies developed for faecal coliform.

Total and faecal coliform count was computed as coliform colonies counted/ml sample filtered X 100 and expressed as total or faecal coliforms nos per 100ml.

Table – 2: Trend of water quality of river Yamuna at few locations

Location	Parameter	Year			
		1995	1996	1997	1998
Palla	Total coliform/faecal colofirm (nos./100ml)	5,483 / 3,944	3,645 / 2,901	5,892 / 549	8,288/230
Nizamuddin Bridge	Total coliform/faecal colofirm (nos./100ml)	3,86,092 / 1,41,457	1,47,818 / 1,42,682	4,44,918 / 4,25,422	98,633/25,807
Agra canal at Okhla Barrage	Total coliform/faecal colofirm (bos./100ml)	3,33,437 / 1,84,967	91,955 / 76,136	2,47,525 / 1,54,481	93,818/35,856

Table – 3: Primary water quality criteria limits of total coliform.

	Water quality class based on designated best use				
	A (Drinking water source without conventional treatment but after disinfection)	**B** (Outdoor bathing)	**C** (Drinking water source with conventional treatment & disinfection)	**D** (Propagation of wildlife)	**E** (Irrigation, industrial cooling, controlled waste disposal)
Total coliform organisms MPN/100 ml, Max.	50	500	5000	---	---

Source : CPCB, 2001-2002

Table – 4: Average, maximum and minimum bacteriological count of the water quality of river Yamuna in Delhi (2002).

Location		West bank		Location		East bank	
		Total coliform nos/100 ml	Faecal coliform nos/100 ml			Total coliform nos/100 ml	Faecal coliform nos/100 ml
Palla	Avg	32,683	1,642	Sonia Vihar	Avg	6,43,750	5,055
	Max	1,02,000 (March)	8,000 (April)		Max	40,00,000 (May)	40,000 (April)
	Min	3,000 (July,Oct)	60 (June, Nov)		Min	6,000 (Oct,Feb)	60 (Dec)
D/S	Avg	21,91,000	10,183	D/S Wazirabad	Avg	9,85,250	14,900
Wazirabad	Max	80,60,000 (May)	35,000 (Aug)	Barrage	Max	40,00,000 (Dec)	10,200 (Feb)
Barrage	Min	50,000 (Sep)	1,900 (Feb)		Min	3,000 (Oct)	100 (Oct)
Nigambodh	Avg	3,07,91,666	21,375	ISBT	Avg	1,77,64,166	49,100
Ghat	Max	3,32,00,000 (Dec)	1,10,000 (Mar)		Max	4,95,00,000 (Apr)	4,00,000 (Apr)
	Min	3,00,000 (Oct)	1,000 (June)		Min	70,000 (Oct)	400 (July)
ITO Rajghat	Avg	6,27,41,666	3,83,025	ITO Kishan	Avg	2,59,43,333	2,28,191
	Max	14,70,00,000 (July)	20,20,000 (Feb)	Kunj	Max	10,10,00,000 (Feb)	18,20,000 (Feb)
	Min	7,00,000 (Oct)	6,300 (Oct)		Min	1,00,000 (Sept)	2,000 (June,July)
D/S ITO	Avg	2,41,54,166	69,783	D/S ITO	Avg	1,07,25,833	17,000
Barrage	Max	11,10,00,000 (June)	3,60,000 (Feb)	Barrage	Max	4,30,00,000 (Apr)	1,00,000 (Feb)
	Min	3,00,000 (Oct)	5,900 (Oct)		Min	5,10,000 (Sep)	900 (Oct)
Nizamuddin	Avg	1,56,92,500	4,17,808	Nizamuddin	Avg	87,08,166	25,991
Bridge	Max	5,20,00,000 (Dec)	43,00,000 (Jan)	Bridge	Max	2,83,00,000 (Feb)	86,000 (Feb)
	Min	10,00,000 (Sept)	8,700 (Oct)		Min	98,000 (Oct)	500 (July)
U/S Okhla	Avg	38,57,500	36,366				
Barrage	Max	1,13,00,000 (Jan)	3,20,000 (Jan)				
	Min	50,000 (Oct)	1,000 (Oct,July)				
D/S Okhla	Avg	2,10,59,166	96,721				
Barrage	Max	22,40,00,000 (May)	7,20,000 (May)				
	Min	1,00,000 (Oct)	400 (Oct)				

Location		Mid stream of Barrages	
		Total coliform, nos/100ml	Faecal coliform, nos/100 ml
M/S Wazirabad Barrage	Avg	10,85,333	1,264
	Max	55,00,000 (Dec)	4,900 (Dec, Sept)
	Min	1,000 (Oct)	80 (June)
M/S ITO Barrage	Avg	1,07,10,833	57,950
	Max	4,00,00,000 (Feb)	70,000 (Feb)
	Min	2,10,000 (Oct)	1,900 (Dec)
M/S Okhla Barrage	Avg	4,51,333	5,097
	Max	16,70,000 (Dec)	11,250 (Jan)
	Min	30,000 (Oct)	300 (Oct)

Table – 5: Average, maximum and minimum bacteriological count of the water quality of river Yamuna in Delhi (2003).

Location		West bank		Location		East bank	
		Total coliform nos/100 ml	Faecal coliform nos/100 ml			Total coliform nos/100 ml	Faecal coliform nos/100 ml
Palla	Avg	47,941	2,795	Sonia Vihar	Avg	1,20,850	6,400
	Max	1,20,000 (Apr)	8,000 (July)		Max	3,50,000 (June)	19,000 (June)
	Min	9,000 (Sept)	900 (Sept)		Min	10,000 (Sept)	900 (Dec)
D/S	Avg	1,32,15,583	17,74,425	D/S Wazirabad	Avg	1,26,22,500	18,50,750
Wazirabad	Max	5,50,00,000 (June)	90,00,000 (June)	Barrage	Max	5,00,00,000 (June)	78,00,000 (June)
Barrage	Min	37,000 (Sept)	900 (Sept)		Min	1,20,000 (Sept)	20,000 (Sept)
Nigambodh	Avg	7,91,07,500	31,52,000	ISBT	Avg	2,31,90,500	9,93,166
Ghat	Max	58,00,00,000 (Feb)	76,00,000 (Feb)		Max	6,90,00,000 (Mar)	60,00,000 (June)
	Min	90,000 (Sept)	34,000 (Sept)		Min	1,00,000 (Sept)	38,000 (Sept)
ITO Rajghat	Avg	7,46,08,333	32,58,333	ITO Kishan	Avg	7,44,08,333	14,81,666
	Max	27,40,00,000 (March)	1,20,00,000 (June)	Kunj	Max	55,00,00,000 (Feb)	45,00,000 (March)
	Min	6,00,000 (Sept)	90,000 (Sept)		Min	4,00,000 (Sept)	90,000 (Sept)
D/S ITO	Avg	4,97,83,333	38,47,500	D/S ITO	Avg	2,02,25,000	10,87,500
Barrage	Max	22,40,00,000 (Jan)	1,15,00,000 (June)	Barrage	Max	9,20,00,000 (Mar)	31,00,000 (June)
	Min	35,00,000 (Sept)	60,000 (Jan)		Min	9,00,000 (Sept)	1,20,000 (Sept)
Nizamuddin	Avg	3,42,92,500	20,65,000	Nizamuddin	Avg	95,23,333	11,50,583
Bridge	Max	15,00,00,000 (Mar)	75,00,000 (June)	Bridge	Max	1,87,00,000 (Feb)	70,00,000 (June)
	Min	16,00,000 (Sept)	10,000 (Jan)		Min	6,80,000 (Sept)	10,000 (Jan)
U/S Okhla	Avg	64,50,000	3,12,500				
Barrage	Max	2,25,00,000 (March)	8,90,000 (March)				
	Min	4,00,000 (Sept)	20,000 (Jan)				
D/S Okhla	Avg	1,18,82,500	3,63,333				
Barrage	Max	11,00,00,000 (Apr)	11,00,000 (Oct)				
	Min	2,00,000 (Sept)	40,000 (Feb)				

		Mid stream of Barrages	
Location		Total coliform, nos/100ml	Faecal coliform, nos/100 ml
M/S Wazirabad Barrage	Avg	98,19,166	6,96,575
	Max	1,70,00,000 (May)	35,00,000 (May)
	Min	10,000 (Sept))	900 (Sept)
M/S Okhla Barrage	Avg	18,95,833	1,00,250
	Max	59,00,000 (March)	2,40,000 (July)
	Min	90,000 (Sept)	10,000 (Jan)

Results and Discussion

Tables 4 and 5 give the average, maximum and minimum values of total and faecal count on the selected study location for the year 2002 and 2003 respectively. Midstream ITO Barrage sampling location was discontinued from 2003 due to installation of iron mesh on ITO Bridge.

The results indicated increase in bacterial total count from upstream to downstream stretch of river Yamuna. However the bacterial count at any location depends on hydrological condition, anthropogenic activities prevalent on that location at the time of sampling as well as on the discharges. Bacteriological assessment for any location cannot be compared as the bacteriological water quality is subjected to frequent changes. Summer months (March, April, May and June) with reduced water content and flow in the river supported the bacterial survival. Contribution of high bacterial counts in the river was beyond to the limits specified in the primary water quality criteria of CPCB. (Table 3).

Total and faecal coliform count at upstream reference location at Palla was observed to be less than the downstream locations indicating less anthropogenic influence. Slight increase was observed at Sonia Vihar on east bank of the river.

Increase in total and faecal coliform count was observed downstream Wazirabad Barrage on west bank compared to the upstream stretch indicating the effect of religious activities, the backflow of Najafgarh drain carrying industrial and domestic waste and the confluence of stream carrying wash water from Wazirabad water works. Total coliform count on downstream Wazirabad Barrage at eastern bank, occasionally used as a cremation ground was comparatively lesser than that of downstream Wazirabad Barrage on western side. Faecal coliform count was slightly higher in the east bank (14,900 and 18,50,750 faecal coliforms No./100 ml in 2002 & 2003 respectively).

Further downstream of river, gradual increase in total as well as faecal coliform count was observed with slight difference in bacterial count on both the banks. Total and faecal coliform counts were on higher side throughout the years at Nigambodh Ghat, a cremation ground and recipient of Najafgarh and other drain discharges while further downstream at ISBT

location on opposite bank the bacterial counts reduced where bank is mainly under agricultural practices.

Average total coliform and faecal coliform counts at Nigambodh Ghat were 3,07,91,666 nos./100 ml and 21,375 nos./100 ml in 2002 and 7,91,07,500 nos./100 ml and 31,52,000 nos./100 ml in 2003 respectively, while at ISBT location on opposite bank it was 1,77,64,166 (total coliform nos./100 ml) and 49,100 (faecal coliform nos./100 ml) in 2002 and 2,31,90,500 (total coliform nos./100 ml) and 9,93,166 (faecal coliform nos./100 ml) in 2003 respectively.

Similar trend of difference in bacterial counts on both the banks was observed in D/S locations i.e. at ITO and Nizamuddin Bridge. Total coliform count at ITO Rajghat (6,27,41,666 no./100 ml) was thrice that of opposite bank at ITO Kishan Kunj (2,59,43,333 no./100 ml) in 2002. However, almost similar count of total coliform was observed in 2003. On the contrary faecal coliform count was more on ITO Rajghat than on ITO Kishan Kunj. Marked difference in total and faecal coliform count was observed at east and west banks of the river at Nizamuddin Bridge. Coliform counts (nos.) were high on west bank at Nizamuddin Bridge receiving industrial and domestic waste discharges. As observed at D/S Wazirabad Barrage, water D/S of the ITO Barrage on both banks also showed marked difference in faecal coliform count.

Difference in terms of reduction in bacterial count was observed as the river water reaches upstream Okhla Barrage probably due to more water retention time and in a catchment area of about 17,930 Km^2 and dilution due to confluence of Hindon Canal water. Average total coliform nos./100ml was reported as 38,57,500 and faecal coliform nos./100ml as 36,366 in 2002, whereas during 2003 total coliform counts were 64,50,000 nos./100ml and faecal coliform counts were 3,12,500 nos./100ml were at U/S Okhla Barrage. The bacterial count again increases at D/S Okhla Barrage.

Midstream of all the 3 Barrages – Wazirabad, ITO & Okhla Barrage – being less exposed to human influence showed less bacterial counts, specifically the faecal count, than reported at east and west upstream and downstream of the Barrage locations. Total coliform count at M/S Wazirabad Barrage was influenced by the backflow of Najafgarh drain.

Pre-monsoon, monsoon and Post-monsoon effect in bacterial water quality was also observed in the study. The bacterial count at all the locations was reduced tremendously in the monsoon months due to flushing effect, while count was high in the Pre-monsoon month due to receiving of surface runoffs. The bacterial count again increases in the post monsoon period with reduced water flow. Minimum bacterial counts were observed in the monsoon months of October and September in 2002 and September in 2003.

The study infers that the bacterial water quality assessment depends totally on hydrological conditions along with the natural or man-made activities influencing the water body at the time of sampling and does not provide an integrated effect of pollution prevalent in the water body. Bacteriological assessment is time and space specific. Sampling point may not be the actual origin of the bacterial population and hence cannot serve as pollution indicator of water quality at particular location.

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