Seasonal Variation of physico-chemical and microbiological properties in different banks of Ganga (Hooghly) River in West Bengal

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Abstract

Pre-monsoon (April -June), monsoon (July – September) and post-monsoon (October- December) seasonal variations of coliform bacteria, along with some physico-chemical properties like pH, temperature, DO and BOD of different banks of Hooghly River (Ganga) in the district North 24 Parganas, West Bengal were studied for three years (2022-2024). Data analysis showed that different banks of the river were mostly affected by fecal coliforms in 10^5 – 10^6 range. Dakhineswar bank of the Ganga River was found to be most contaminated with fecal coliforms, followed by Baro mandir river bank of Sodepur and Nababgunj river bank of North Barackpore in monsoon season. The plate count exhibited average 10^2 fold higher coliform in every monsoon in comparison to other seasons. The average DO and BOD levels in all the river banks exceeded the BIS standard of 5 mg/L and 3 mg/L respectively. Highest concentration of multiple heavy metal resistant coliform was found in the Dakhineswar river bank (MIC 750 µg/mL for Pb, 250 µg/mL for Zn, 100 µg/mL for Cd and 500 µg/mL for Cr respectively), followed by Sodepur baro mandir river bank (MIC 250 µg/mL for Pb, 100 µg/mL for Zn, 100 µg/mL for Cd and 500 µg/mL for Cr respectively).

Keywords

Seasonal variation, Ganga river, coliform, BOD, heavy metal.

INTRODUCTION

Ganga is the main river source in Northern and Eastern Indian states, including West Bengal. Originating at Gomukh of Gangotri, the river travels a distance of 2,525 km before reaching to the Bay of Bengal [1]. River Ganga is popular as ‘Hooghly river’ or ‘Bhagirathi river’ in West Bengal [2]. Since ancient age, the river plays a crucial role in human civilization in the Gangetic plain. With the increasing human population in last five decades, we have witnessed the increasing trends of Ganga river pollution. The chief cause behind it is the agricultural and industrial revolution that causes limitless disposal of agricultural and industrial sewage in the river [3]. In addition to that, cremation, immersion of idols, regular household activities of human, bathing of animals added the pollution load

in the river [4]. These malpractice increases Biochemical Oxygen Demand (BOD) or Chemical Oxygen Demand (COD) of water, which in turn increases the microbial load of the water [5]. Coliforms are the major group of contaminating bacteria found in polluted water. Greater number of coliforms in water indicates greater water pollution [6]. Polluted water not only posses a large number of coliform, but it also indicate the probability of presence of pathogenic, antibiotic resistant and heavy metal resistant bacteria in water. The existence of chemical pollutants, as well as microbial pollutants makes Ganga water unsafe for human consumption [7].

Protection of Ganga river from such pollution requires effective monitoring at continuous level in both physicochemical properties like BOD, COD, Dissolved Oxygen (DO), Total Dissolved Solids (TDS) and microbiological properties like estimation of coliforms, detection of pathogenic contamination in water etc [8, 9]. Present study attempts to exploit both physicochemical parameters like pH, temperature, dissolved oxygen (DO) and BOD, as well as microbiological properties like total microbial load, total coliform count, fecal coliform count and heavy metal resistant bacterial population in Ganga water in different seasons.

OBJECTIVE OF THE STUDY

The study aims to:

1. Test the physico-chemical properties of different river banks of Ganga water
2. Seasonal variation of colifrom count in Ganga water
3. Test the microbiological quality of different river banks of Ganga
4. Isolation of different heavy metal resistant bacteria from Ganga water

MATERIALS AND METHODS

Sampling area: A total distance of 29 km from Shyamnagar Kalibari Ganga river bank (22^0 49’ 48” N, 88^0 22’ 44” E) to Dakineswar Ganga river bank (22^0 65’ 48” N, 88^0 35’ 72” E) of North 24 Parganas district of West Bengal was chosen as the sampling area. Water samples were collected from most crowded five river banks viz. Shyamnagar kalibari, Nababgunj ghat (North Barrackpore), Barrackpore Annapurna temple ghat, Sodepur baro mandir ghat and Dakhineswar ghat in pre-monsoon (April - June), monsoon (July – September) and post-monsoon (October- December) season for the three consecutive years (2022 – 2024) (Figure 1).

Physico-chemical properties of water: Water samples were collected in sterilized glass bottle and analyzed within 6 hours of sample collection. pH and temperature of the water sample were measured immediately at the sampling site with the help of portable pH meter and thermometer. Dissolved Oxygen (DO) concentration (mg/L) and Biochemical Oxygen Demand (BOD) were analyzed by Winkler’s method and 5-day BOD test respectively by following the protocols mentioned in American Public Health Association [10].

Isolation of microbes: Water samples were collected in sterile glass bottles and transported in cold packs to the laboratory. Water samples were serially diluted in 0.1 M phosphate buffer (pH 7.0) and plated in EMB agar, MacConkey agar and Mannitol agar medium. Quantitative analysis of coliform

was tested in EMB agar medium, where as MPN index of coliform was measured by tube fermentation technique [11]. Confirmation for the presence of coliform was detected by IMViC test. Total count of culturable water-borne bacteria was carried out in Nutrient agar plates.

Heavy metal sensitivity assay:

Isolates grown in MacConkey agar plates were exposed to chloride salts of Pb, Zn, Cd and Cr. A concentration range of 0– 1000 μg/ml of all the heavy metal salts was prepared and a Minimum Inhibitory Concentration (MIC) of all the isolates was tested.

RESULTS AND DISCUSSION

Physico-chemical analysis of water: The physico-chemical analysis of Ganga water from different river banks during pre-monsoon, monsoon and post monsoon seasons for the consecutive three years (2022-2024) are summarized in Table 1. The analysis revealed that average pH of the water in all river banks are alkaline and lies in range of 7.8 – 8.9. The findings are quite consistent with previous reports in this area [12, 13]. However, the alkalinity decreases in monsoon season due to deposition of slightly acidic rain water in the Ganga river. The acid reacts with dissolved solids in the water to generate acidic salts, which in turn decreases the pH of the water [4].

The average temperature of Ganga water in different river banks varied from 30^0C – 35^0C in summer (pre-monsoon), 28^0C – 33^0C in monsoon and 23^0C – 27^0C in post-monsoon season. Statistical analysis by ANOVA of temperatures of different river banks in different seasons did not posses any significant difference ($p<0.05$). Temperature of water plays a crucial role in the growth of the coliforms, and the temperature range in the pre-monsoon and monsoon accelerates the growth of colifoms in comparison to winter season [14, 15].

Dissolved Oxygen (DO) concentration also depends on temperature and the degradation of organic matter suspended in water by the water-borne microorganisms [16]. The DO content in different river banks varied from 5.9 – 7.1 mg/L in pre-monsoon, 4.75 – 5.6 mg/L in monsoon and 6.8 – 7.5 mg/L in post monsoon. Although the average DO content is significantly higher (statistically analyzed by one-way ANOVA at $p<0.05$) in monsoon than that of other two seasons, but the average value in all the seasons are greater than the BIS standard of 5 mg/L [15]. Highest DO was found in Dakhineswar Kali temple river bank, followed by Sodepur Baro mandir river bank. The former bank is one of the most crowded river banks due to gatherings of pilgrims throughout the year. The later river bank exposed to industrial waste discharge from nearby factories, immersion of idols etc. Similar pattern findings were reported by Verma, (2013) [16], Chatterjee et al., (2025) [4] and Vidyarthi et al., (2020) [15] in various river banks of Northern India and Eastern Indian states, where the Ganga water is contaminated with industrial waste.

BOD analysis of Ganga water from different river banks exhibited to exceed the BIS standard of 3 mg/L in all the river banks, which is an indicator of highly polluted water [17, 18]. BOD of different river banks showed 2.6 – 3.3 mg/L in pre-monsoon, 2.2 – 3.1 mg/L in monsoon and 2.6 – 3.5 mg/L in post monsoon season. Dakhineswar Kali temple bank exhibited the most polluted river bank in terms of BOD data. Beg et al. (2008), Hasan (2015) and Singh et al. (2012) reported increased level of BOD in different river banks of Ganga in Uttar Pradesh, India. They found that deposition of toxic chemicals

contaminants increased BOD level of Ganga water in Kanpur and surrounding area of North India [19, 20, 21].

Microbiological analysis of Ganga water:

Microbiological analysis has been performed in terms of total bacterial content, number of total coliforms and number of faecal coliforms in different river banks in different seasons. Coliforms are termed as indicator microorganism for water pollution. The presence of more coliform indicates more non-potability of water, i.e. water is not safe for human use. The result of the present study is summarized in Table 2. The data revealed that Dakhineswar river bank is the most polluted river bank throughout the year. It exhibited highest count of total bacteria, number of total coliforms as well as the number of faecal coliforms – the indicator pathogenic variety present in Ganga water. All the river banks chosen for the present study have temples in nearby area and posses ferry service. As a result, all the river banks are crowded throughout the year with pilgrim activities like holy bath, immersion of idols, and discharge of wastes from the temples. Therefore, the data exhibited an alarming number of bacterial content in water. Chatterjee et al. (2025) [4], Kumar et al. (2018) [13] and Chauhan (2018) [22] also reported the same in different river banks of Ganga in Uttar Pradesh, Bihar and West Bengal. The findings of Chatterjee et al. in different river banks of Ganga in West Bengal clearly showed that the number of coliforms is beyond permissible limits in all the river banks where they have studied, specially in monsoon. However, the number of coliforms in the present study is more than their findings, as the selected river banks for the present study are overcrowded throughout the year.

Isolation of Heavy metal resistant bacteria

80% of the bacterial isolates of faecal coliforms and 70% of the isolates of the non-faecal coliforms exhibited at least one of the heavy metal resistance among the Pb, Zn, Cd and Cr salts. 25% of the bacterial isolates of both faecal coliforms and non-faecal coliforms exhibited resistance in two heavy metals. Most of the isolates were found to be resistant in Pb and Cr salts. Dakhineswar bank was found to have most heavy metal resistant coliforms with highest MIC of 750, 250, 100 and 500 µg/mL of Pb, Zn, Cd and Cr salts respectively. Five isolates were found to have resistance in all four heavy metals (multiple heavy metal resistance). Two isolates from Sodepur baro mandir bank were found to be resistant in all four heavy metals at MIC of 100 µg/mL. One of the isolates was found to be resistant to Cr at MIC of 500 µg/mL. Nababgunj Bank was found to have Zn resistant coliforms at MIC of 200 µg/mL. Shyamnagar Kalibari bank was found to bear less number of heavy metal resistant coliforms in comparison to other river banks. Heavy metal pollution is very alarming incident in the river banks situated in the industrial belts. Uncontrolled sewage disposal from nearby factories led to the heavy metal pollution in Ganga water. Similar findings were mentioned by Khan et al. (2017) [23] in Ramganga river, a tributary of Ganga river. Paul (2017) [2] and Kumar (1992) [24] also reported the harsh effects of heavy metals like Hg, Pb, Zn, Cr and Ni discharged by the nearby industrial belts into the river Ganga.

CONCLUSION

Present study enlightens about the seasonal alternation of physico-chemical properties like pH, temperature, DO and BOD in most crowded holy river banks of Ganga river in West Bengal. The level of DO and BOD below the BIS standard ensures the degree of pollution in those river banks. The alarming level of microbiological pollution was evident by the coliform content in all the river banks of the Ganga. Bathing of pilgrims, idol immersion and discharge of waste from nearby temples throughout the year increases coliform count at a threatening level. Presence of heavy metal resistant coliforms ensures the water is polluted with the heavy metals discharged by the nearby factories. Prevention of river pollution thus requires well planned and strict rules for not throwing any kind of garbage in river Ganga. Effective monitoring of physico-chemical and microbiological parameters, as well as, execution of strict rules can only minimize the degree of river pollution.

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FIGURES AND TABLES

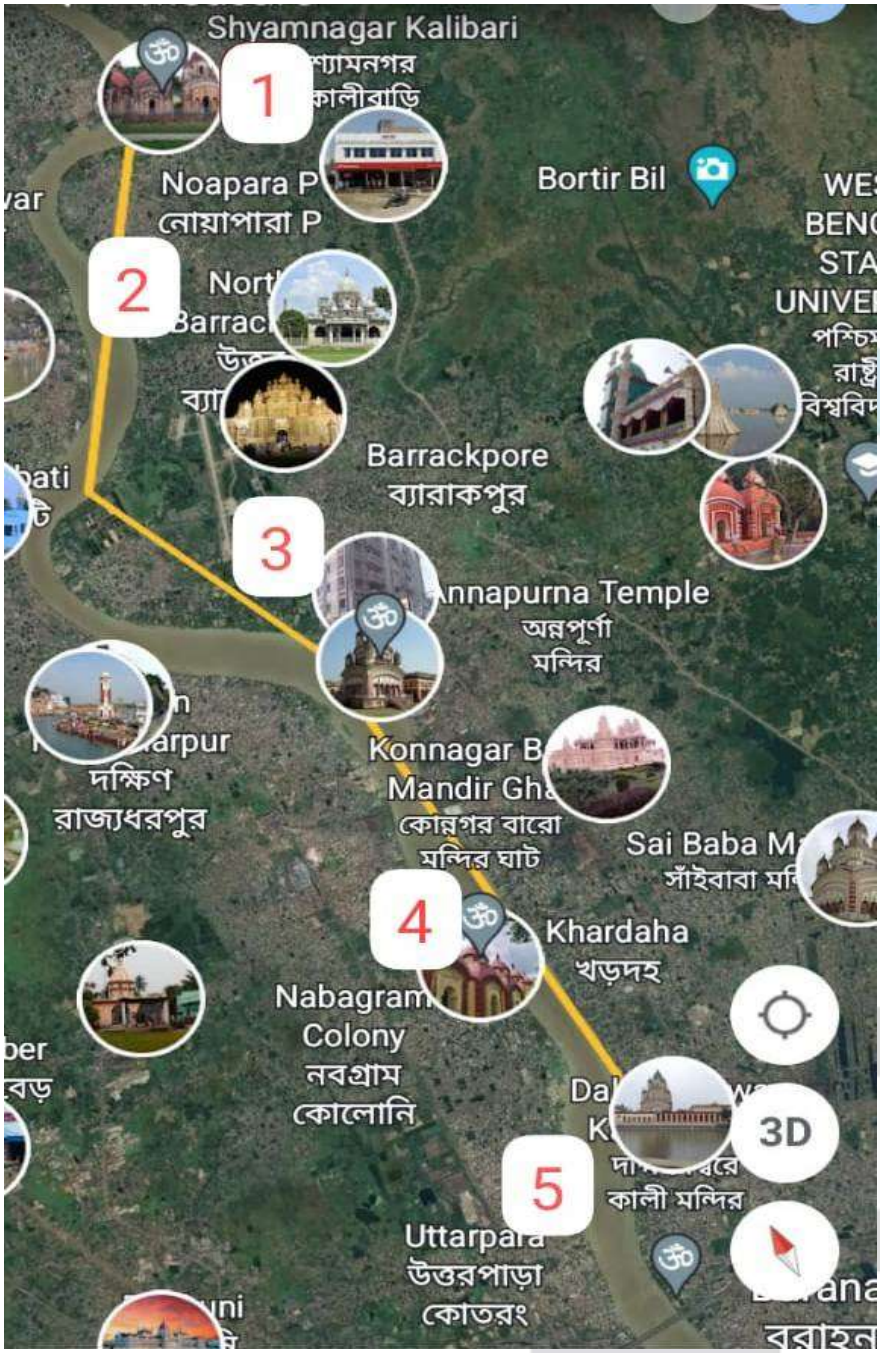

Figure 1: Water sampling area from different river banks of Ganga

1: Shyamnagar Kalibari river bank

2: Nababgunj river bank (North Barrackpore)

3:Barrackpore Annapurna temple bank

4: Sodepur baro mandir river bank

5: Dakineswar Kali temple bank

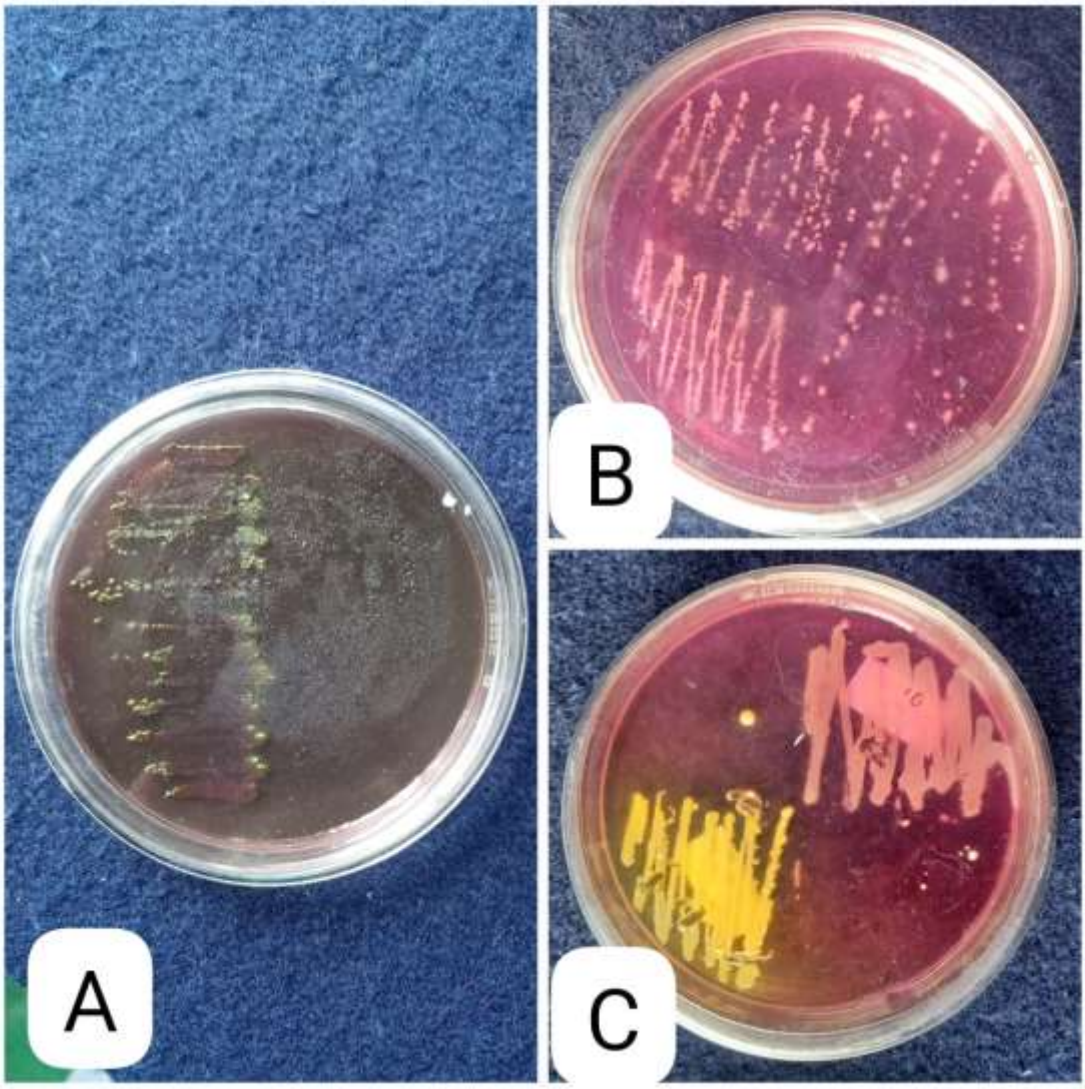

Figure 2: Coliform bacteria isolated from different banks of Ganga river in various selective media

A: Faecal coliforms in EMB agar media

B: Faecal and non-faecal coliforms in MacConkey agar media

C: Faecal and non-faecal coliforms in Mannitol agar media

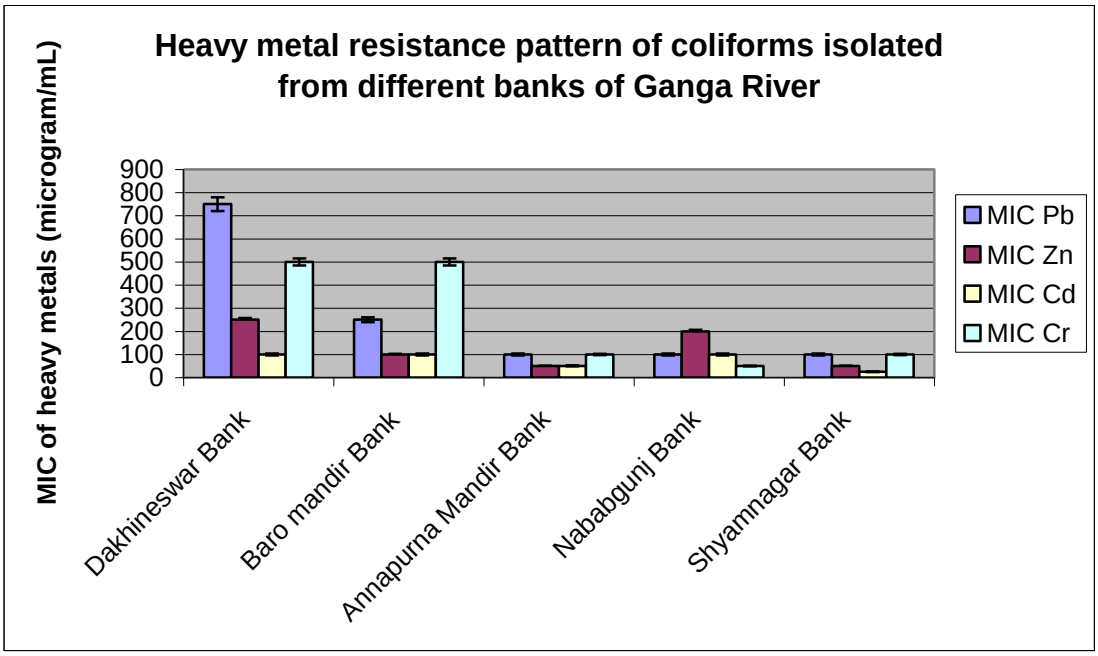

Figure 3: Heavy metal resistance profile of the coliforms isolated from different banks of Ganga river in West Bengal

Table 1: Seasonal variation of physico-chemical properties of Ganga water in different river banks

River bank	Season	Water Temperature* (^{0}C)	pH*	DO* (mg/L)	BOD * (mg/L)
Shyamnagar Kalibari ghat	Pre-monsoon	32±2	8.1±0.3	6.1±0.2	3.1±0.2
	Monsoon	30±1	8.0±0.1	5.0±0.3	2.9±0.1
	Post-monsoon	25±2	8.2±0.2	7.0±0.2	3.4±0.1
Nababgunj ghat (North Barrackpre)	Pre-monsoon	32.5±2	8.2±0.2	6.0±0.5	2.9±0.35
	Monsoon	30±2	8.0±0.3	4.95±0.2	2.68±0.22
	Post-monsoon	26±1	8.2±0.2	7.2±0.3	2.95±0.4
Barrackpore Annapurna temple ghat	Pre-monsoon	33±2	8.1±0.3	6.2±0.3	3.01±0.29
	Monsoon	31±2	8.0±0.2	5.1±0.25	2.75± 0.45
	Post-monsoon	25±1	8.1±0.2	7.0±0.2	3.15± 0.35
Sodepur baro mandir ghat	Pre-monsoon	32±2	8.3±0.1	6.2±0.4	2.85± 0.4
	Monsoon	30.5±2	8.0±0.2	5.1±0.2	2.5 ±0.3
	Post-monsoon	25±1	8.4±0.3	6.9±0.3	3.05± 0.25
Dakineswar Kali temple ghat	Pre-monsoon	33±2	8.1±0.2	6.7±0.4	2.75± 0.15
	Monsoon	31.5±1	7.9±0.1	5.3±0.3	2.4± 0.25
	Post-monsoon	26±1	8.5±0.4	7.2±0.3	2.8± 0.2

[* Experimental data ± Standard deviation]

Table 2: Seasonal variation of total culturable bacteria and coliform bacteria of Ganga water in different river banks

River bank	Season	Total culturable bacteria* (CFU/100 mL)	Total colifom* (MPN/100 mL)	Faecal Coliform* (MPN/100 mL)
Shyamnagar Kalibari ghat	Pre-monsoon	$8.0\pm0.5 \times 10^6$	$2.1\pm0.4 \times 10^5$	$1.2\pm0.1 \times 10^5$
	Monsoon	$1.2\pm0.4 \times 10^8$	$1.5\pm0.3 \times 10^6$	$2.2\pm0.2 \times 10^5$
	Post-monsoon	$6.5\pm0.5 \times 10^5$	$1.5\pm0.2 \times 10^5$	$3.0\pm0.4 \times 10^4$
Nababgunj ghat (North Barrackpre)	Pre-monsoon	$8.5\pm0.2 \times 10^6$	$2.6\pm0.2 \times 10^5$	$1.3\pm0.3 \times 10^5$
	Monsoon	$1.6\pm0.4 \times 10^8$	$1.9\pm0.3 \times 10^6$	$8.0\pm0.5 \times 10^5$
	Post-monsoon	$3.5\pm0.2 \times 10^5$	$1.2\pm0.3 \times 10^5$	$6.7\pm0.5 \times 10^4$
Barrackpore Annapurna temple ghat	Pre-monsoon	$7.2\pm0.4 \times 10^6$	$2.2\pm 0.2 \times 10^5$	$1.2\pm0.4 \times 10^5$
	Monsoon	$5.6\pm0.4 \times 10^8$	$2.5\pm0.3 \times 10^6$	$5.0\pm0.3 \times 10^5$
	Post-monsoon	$4.8\pm0.2 \times 10^5$	$1.7\pm0.1 \times 10^5$	$8.2\pm0.3 \times 10^4$
Sodepur baro mandir ghat	Pre-monsoon	$5.3\pm0.3 \times 10^6$	$2.5\pm0.2 \times 10^5$	$1.0\pm0.5 \times 10^5$
	Monsoon	$4.9\pm0.5 \times 10^8$	$2.0\pm0.3 \times 10^6$	$9.5\pm0.3 \times 10^5$
	Post-monsoon	$4.6\pm0.3 \times 10^5$	$1.4\pm0.3 \times 10^5$	$6.5\pm0.2 \times 10^4$
Dakineswar Kali temple ghat	Pre-monsoon	$1.0\pm0.4 \times 10^7$	$2.9\pm0.2 \times 10^5$	$1.3\pm0.6 \times 10^5$
	Monsoon	$5.5\pm0.2 \times 10^8$	$3.0\pm0.1 \times 10^6$	$1.1\pm0.4 \times 10^6$
	Post-monsoon	$5.0\pm0.4 \times 10^5$	$1.8\pm0.2 \times 10^5$	$7.6\pm0.3 \times 10^4$

[* Experimental data ± Standard deviation]