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Density of Pollution Indicator Bacteria in Relation to Physicochemical Factors During Diel Cycle of River Ganga at Ichapore, West Bengal, India

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Abstract: A diurnal study was undertaken in April 2014 to record the bacterial density and some of the physicochemical factors of the river Ganga near Ichapore, West Bengal, India. The pollution indicating bacteria (total coliform, faecal coliform and faecal streptococci) were found in maximum numbers at 14.00 hrs and minimum at 20.00 hrs. All the bacterial populations were abundant and showed diel rhythm. The physicochemical parameters (temperature, pH, dissolved oxygen (DO), bicarbonate, total hardness, calcium hardness and electrical conductivity) also showed diurnal fluctuation pattern. The total coliform showed significant positive correlation with temperature, pH and electrical conductivity whereas the faecal coliform showed significant inverse correlation with DO. On the other hand, faecal streptococci showed significant positive correlation with temperature, pH and electrical conductivity and significant inverse correlation with DO. The river water in this areas needs a substantial degree of purification treatment before use.

Keywords: Pollution, Diel Cycle, River Ganga, Physicochemical Factors, Pollution Indicating Bacteria

1. Introduction

Ichapore town (22.8000° N, 88.3667° E) of West Bengal, India lies on the eastern bank of the river Ganga. It serves as mother dustbin for several industries and town sewage throughout the range in plains. At Debitala ghat near about 10 to 20 megagallon per day of domestic sewage from township is dumped regularly. The town serves a load of more than two lakhs of people while urbanization in all fronts are increasing day by day.

Little information is available on the pollutional load contributed by the drain water to the riverine ecosystem in this area. Several studies are conducted in India and abroad on different riverine ecosystem threatened with sewage pollution [1-4]. The aim of the present study was assess the degree of contamination by estimating the physicochemical properties and bacterial pollution load of the drain water caused by the continuous discharge of the raw effluents into the river.

Figure 1. *Stretch of the river Ganga (Hooghly river) showing sampling site.*

2. Materials and Methods

2.1. Sampling

After the preliminary survey of the Ganga river, the spot was selected keeping in mind its accessible position at night for the study of diel fluctuations. The water samples were collected from Debitala ghat, a sewage outfall area of river Ganga at Ichapore town, West Bengal (fig 1). For the investigation of fluctuation in physico-chemical and bacterial parameters, water samples were collected at few hours interval for 24 hrs, i.e. 9.00 hrs, 12.00 hrs, 14.00 hrs, 17.00 hrs and 20.00 hrs. Water samples were collected in sterilized glass bottles aseptically and transported to the laboratory in an ice bucket.

2.2. Analysis of Physicochemical Parameters of Water Samples

Physico-chemical parameters of the water were analyzed following standard methods [5]. Parameters like temperature, pH, Dissolved oxygen (DO), bicarbonate, total hardness, calcium hardness and electrical conductivity were measured in the laboratory.

2.3. Bacteriological Analysis

The various pollution indicating bacteria were isolated on selective medium such as eosine methylene blue medium [6] for total coliform and faecal coliform (FC), and sodium azide medium [7] for faecal Streptococci (FS). For isolation of total coliform incubation were done at 37°C whereas for faecal coliform and faecal Streptococci incubation were done at 44.5°C.

2.4. Enumeration of Bacteria

Bacterial counts were made following five tube most probable number (MPN) method [6].

2.5. Statistical Analysis

All experiments were carried out in triplicate, and the results were expressed as the mean. Experimental data were analyzed by using the SPSS 13.0 software package.

3. Results and Discussion

The results indicated that the river water temperatures showed a definite diurnal trend (fig 2). An increase in temperature during the daytime and decrease in the night hours was observed. The lowest water temperature (18°C) was recorded at 20.00 hours in the night. The maximum temperature (29°C) was noted at 14.00 hours. The river water was alkaline throughout the diel cycle ranging between 7.2 and 8.2 pH (fig 3). Usually lower pH was observed during night. This might be due to the appearance of free CO_2. It also increases the bicarbonae concentrations [8]. The conversion of CO_3 to free CO_2 depicts the change in the buffer system which lowers the pH.

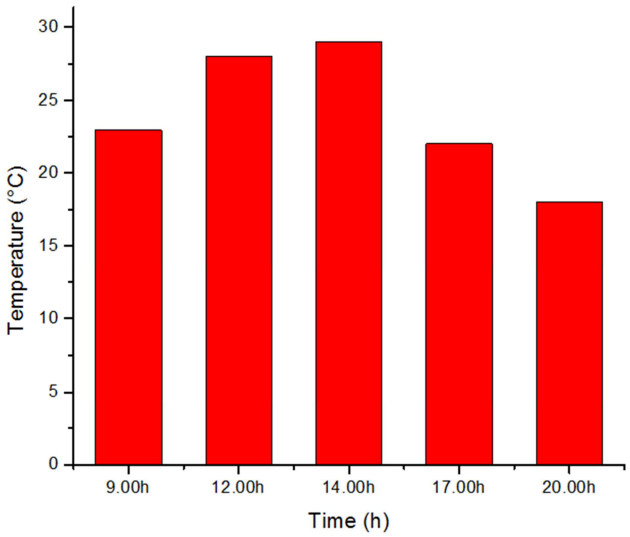

Figure 2. *Diurnal variation in temperature of the river Ganga.*

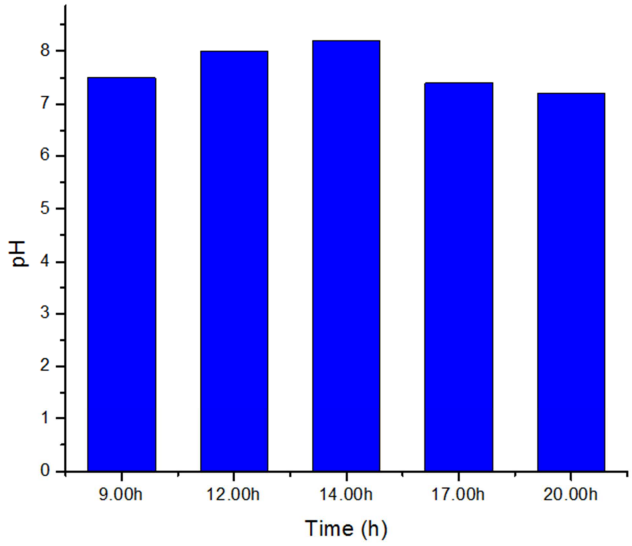

Figure 3. *Diurnal variation in pH of the river Ganga.*

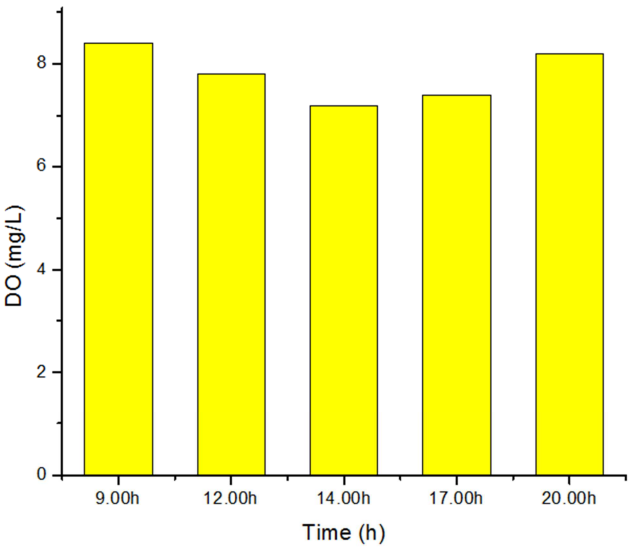

Figure 4. *Diurnal variation in DO of the river Ganga.*

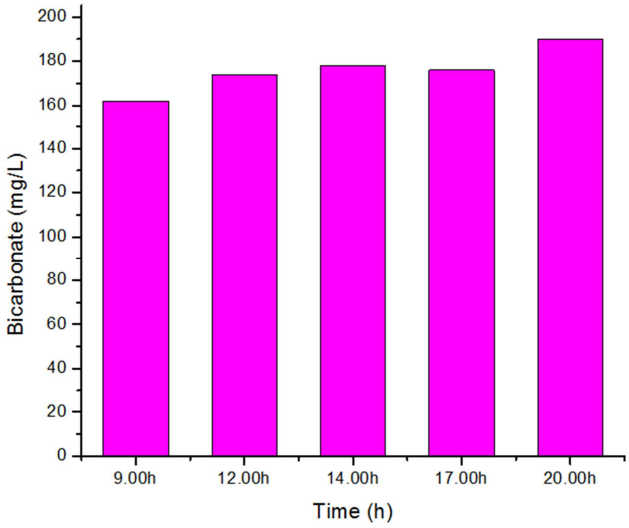

Figure 5. *Diurnal variation in bicarbonate of the river Ganga.*

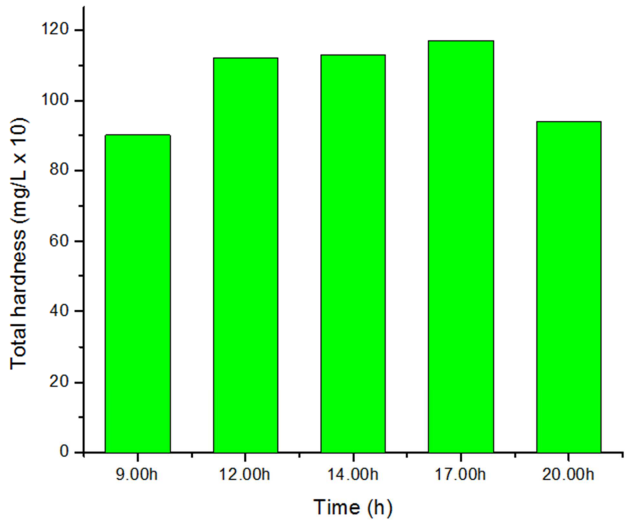

Figure 6. *Diurnal variation in total hardness of the river Ganga.*

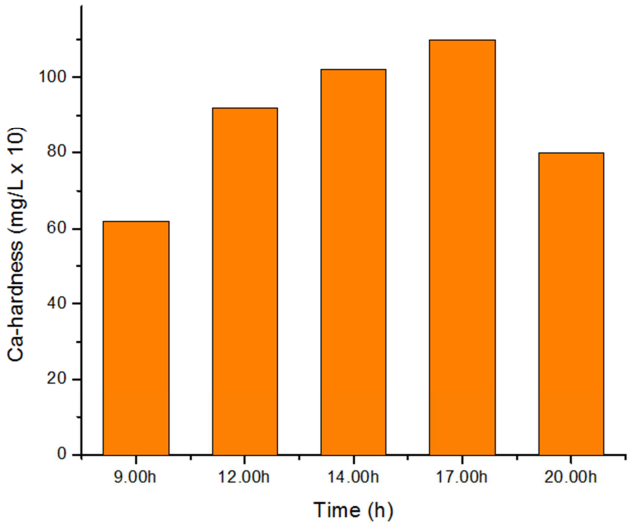

Figure 7. *Diurnal variation in Ca-hardness of the river Ganga.*

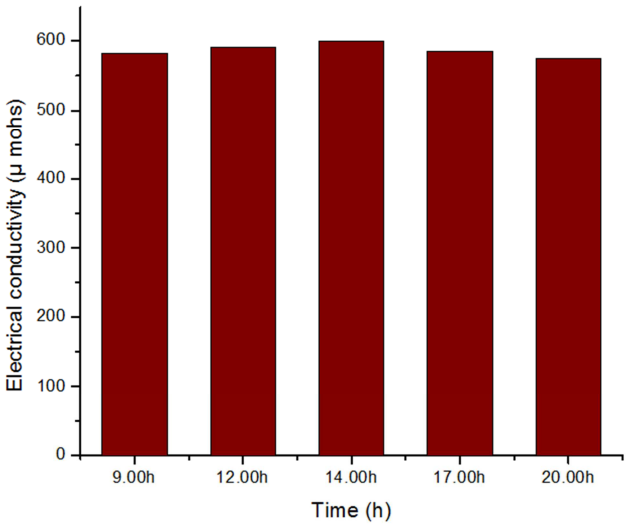

Figure 8. *Diurnal variation in electrical conductivity of the river Ganga.*

The DO ranged from 7.2 to 8.4 mg L^{-1} (fig 4). It was recorded maximum at 9.00 hours (8.4 mg L^{-1}) and minimum at 14.00 hours (7.2 mg L^{-1}). The high concentration of DO in the morning is due to low temperature which enhances the oxygen dissolving capacity [9]. During daytime, the higher dissolved oxygen might be due to increased photosynthetic activity [10]. The increase in temperature degraded the DO concentration at 12.00 hours which showed the inverse relation between temperature and DO (Table 1).

Bicarbonate values ranged between 162-190 mg L^{-1} (fig 5). The total hardness (900-1170 mg L^{-1}) and calcium hardness (620-1100 mg L^{-1}) showed significant variation during diel cycle (fig 6 and 7). The electrical conductivity of water varied narrowly (575-600 µmhos) (fig 8).

Table 1 showed correlation among different physicochemical parameters throughout the diel cycle. Significant positive correlations were noted between pH and temperature, electrical conductivity and temperature, pH and electrical conductivity, and total hardness and calcium hardness. On the contrary, significant inverse correlations were noted between total hardness and DO, and calcium hardness and DO. The correlation coefficient between physicochemical parameters and pollution indicator bacteria were presented in Table 2. The total coliform showed significant positive correlation with temperature, pH and electrical conductivity whereas the faecal coliform showed significant inverse correlation with DO. On the other hand, faecal streptococci showed significant positive correlation with temperature, pH and electrical conductivity and significant inverse correlation with DO.

The variation in bacterial load suggested distinct diurnal fluctuation. At 14.00 the MPN of coliforms remain at peak ($30x10^4$ MPN/100 ml) (fig 9). The MPN of faecal coliform and faecal Streptococi also recorded high ($12x10^4$ MPN/100 ml and $8.2x10^4$ MPN/100 ml) (fig 9). The ratio of faecal coliform and faecal streptococci is always more than one throughout the diurnal cycle depicting the faecal nature of sewage which is more hazardous (Table 3). When the faecal

coliform to faecal streptococci ratio is below 0.7, the contamination is said to be from nonhuman sources, and when the ratio is over 4.3, it indicates anthropogenic contamination [11]. Therefore, the use of faecal coliform to faecal streptococci ratio may further define possible sources of faecal discharge to a stream. The results indicated the pollutional nature of river water caused by faecal matter. The capacity of high dilution capacity of river Ganga round the year is responsible for reduction of pollutional status of drain water in some extent.

Table 1. *Simple correlation matrix among different physicochemical parameters. Values were significant at 1% (**) and 5% (*) level.*

	Temp	pH	DO	TH	Bicarbonate	Ca-hardness	EC
Temp	1						
pH	0.982**	1					
DO	-0.563	-0.581	1				
TH	0.562	0.533	-0.919*	1			
Bicarbonate	-0.375	-0.225	-0.196	0.118	1		
Ca-hardness	0.339	0.346	-0.934*	0.949*	0.360	1	
EC	0.934*	0.944*	-0.777	0.673	-0.209	0.537	1

Table 2. *Simple correlation coefficient (r) between physicochemical parameters and bacteriological parameters. Values were significant at 1% (**) and 5% (*) level.*

	Total coliform	Faecal coliform	Faecal streptococci
Temperature	0.932*	0.493	0.944*
pH	0.947*	0.521	0.910*
DO	-0.710	-0.933*	-0.770*
TH	0.577	0.731	0.800
Bicarbonate	-0.256	0.099	-0.271
Ca-hardness	0.439	0.782	0.614
EC	0.992**	0.765	0.942*

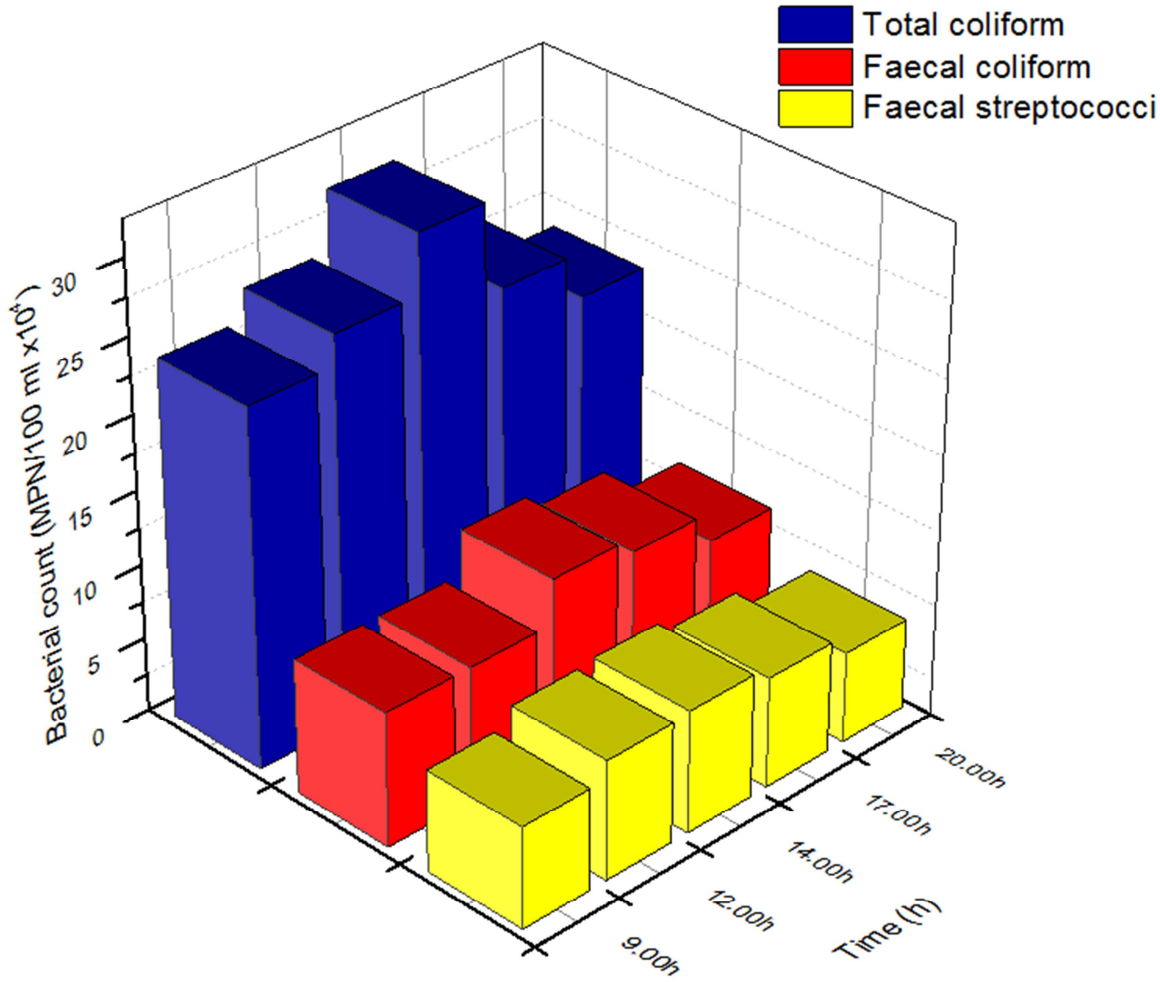

Figure 9. *Diurnal variation in total coliform, faecal coliform and faecal streptococci count of the river Ganga.*

Table 3. *Ratio of faecal coliform to faecal streptococci (FC/FS).*

Time (hr)	FC/FS ratio
9.00	1.323
12.00	1.125
14.00	1.463
17.00	1.486
20.00	1.475

4. Conclusion

It was concluded from this study that a marked diel variations were observed in selected physiological and bacteriological parameters during 24 hours. It was observed that river Ganga in this stretch is being heavily polluted by the discharge of sewage. It can thus be suggested that the water treatment plant should be installed in this area where the huge amount of sewage is being discharged continuously in the river.

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