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Impact of Abiotic Factors on Bacterial Population of River Ganga

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Total bacterial density as well as population of coliform, faecal coliform, faecal streptococci and *Escherichia coli* in river Ganga revealed that the *p*H, dissolved O_2, chloride, hardness, bicrabonates and ionic concentration of water had inverse relationship to bacterial population ($p<0.05$ to <0.001). During the monsoon season turbidity and free CO_2 were high and the bacterial density was maximum. The correlation coefficient of bacterial concentration as influenced by the physico-chemical quality of river water was also determined.

Key Words : Bacteria, Physico-chemical characteristics, River water, Correlation-coefficient, Ganga

Introduction

Pressure on riverine ecosystems is enormously increasing due to fast industrial and urban growth. River Ganga is getting ecologically degraded from Patna to Farakka (Bilgrami & Datta Munshi 1985). Pahwa and Mehrotra (1966), Roy and David (1966), Saxena et al. (1966), Singh et al. (1983) and Bilgrami et al. (1985) have recorded deterioration in water quality at several points. Incidence of water-borne deseases among the populations which consume Ganga water in this region is quite high. Systematic studies dealing with the impact of abiotic factors and seasonal fluctuations on the bacterial population of Ganga water are wanting. The present contribution is an attempt in this direction.

Materials and Methods

Physico-chemical and bacteriological analysis of Ganga water is based on the samples collected from six different sites viz., Patna, Mokama, Munger, Sultanganj, Bhagalpur and Farakka (figure 1). Temperature, *p*H, dissolved O_2, free CO_2, corbonates and bicarbonates were recorded at the spot while analysis for other data was done in the laboratory following APHA (1975) and NEERI (1979). The total coliform, faecal coliform, faecal streptococci, *Escherichia coli* and total plate counts were done by the methods recommended by Sirockin and Cullimore (1969), APHA (1975) and Cruickshank et al. (1975). IMViC and physiological tests were done for bacterial identification (Jacobs & Gerstein 1960, Bryan et al. 1962, Seeley & Vandemark 1962, Starr et al. 1981).

Results and Discussion

The primary factor i.e., water temperature had a direct bearing on bacterial concentration (figure 2), perhaps because decomposition rate and bacterial proliferation increased with the rise of temperature. Maximum total coliform count (3,20,000/100 ml) was at Sultanganj during the rainy season when the corresponding water temperature was 30.2°C. The *p*H of Ganga water ranged from 6.5 to 8.2 (figure 3) but during the rains and floods it was limited to 6.9–7.4. This seems to be the ideal *p*H for bacterial growth (figure 4). Klein (1973) found *p*H 6.8–7.4 to be the most suitable for decomposition of organic matter by bacteria while below 6.0 and above

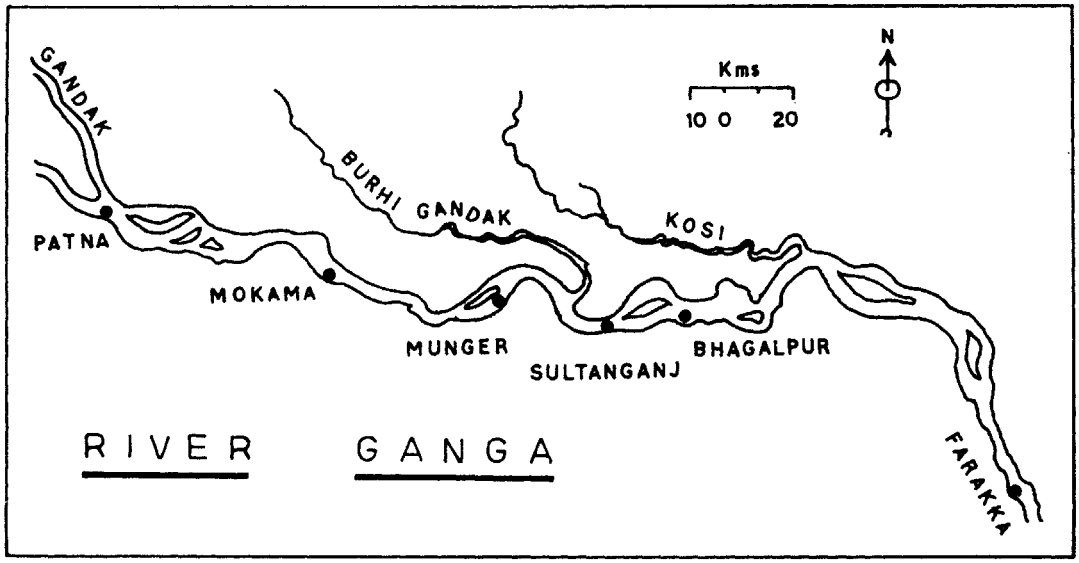

Figure 1 Experimental sites

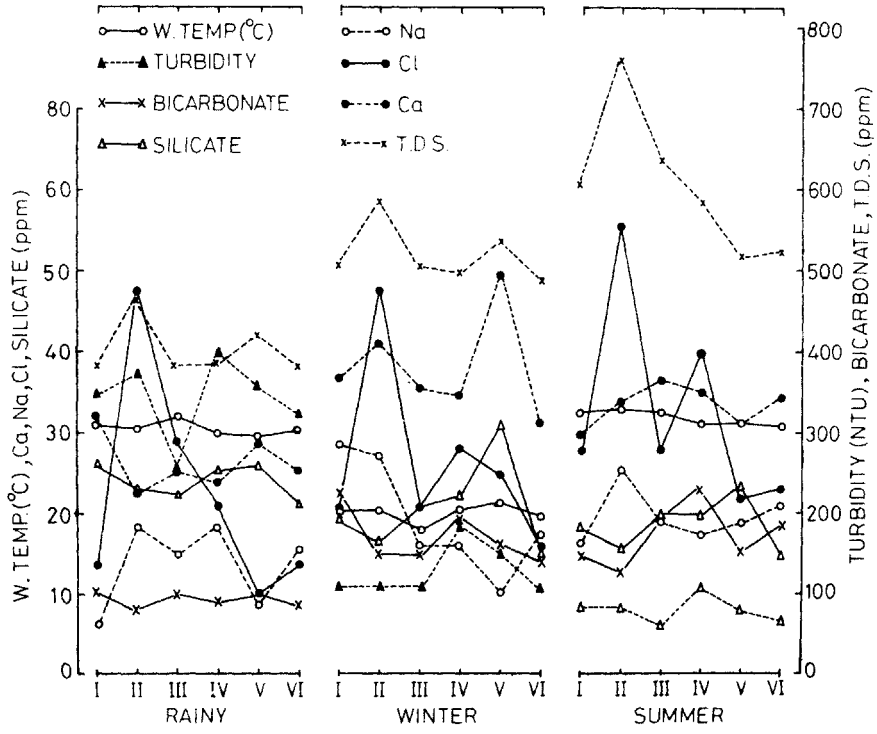

Figure 2 Physico-chemical characters of Ganga water at different sites (I, Patna; II, Mokama; III, Munger; IV, Sultangang; V, Bhagalpur; VI, Farakka)

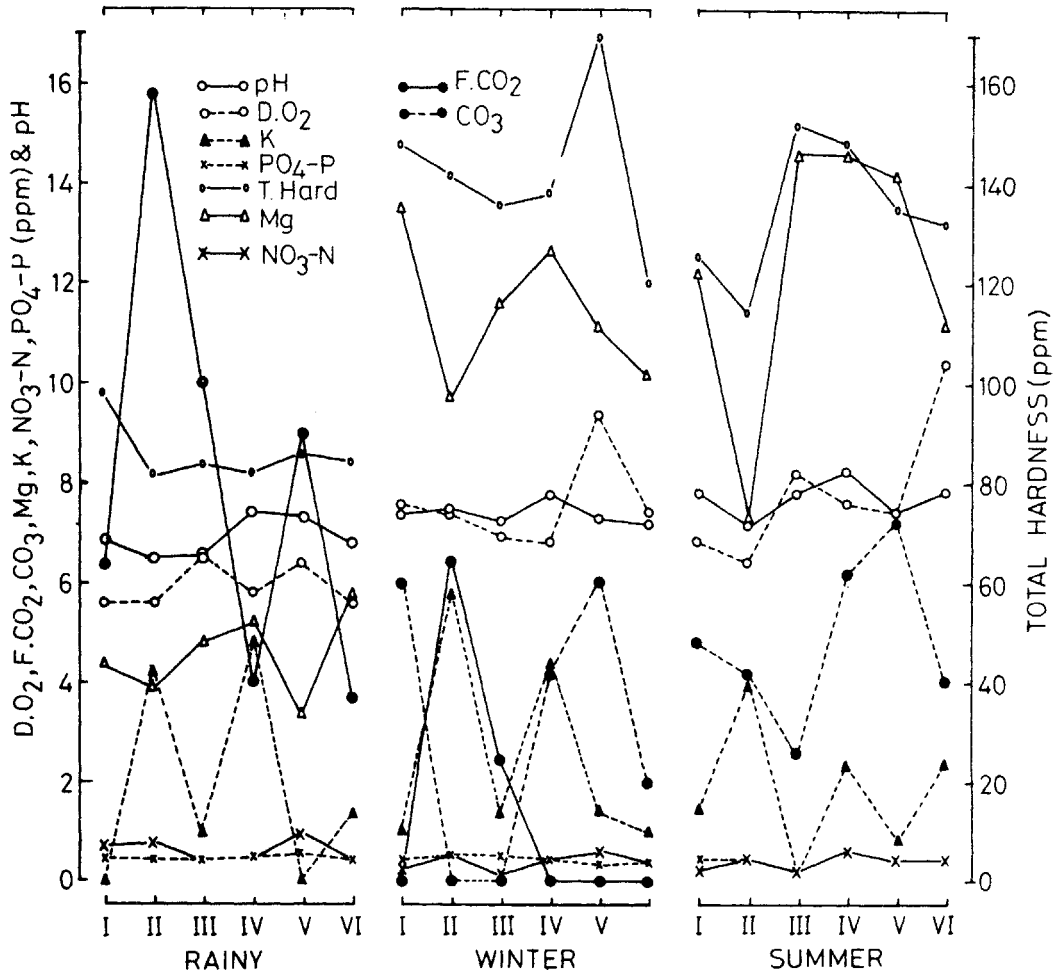

Figure 3 Physico-chemical characters of Ganga water at different sites (I, Patna; II, Mokama; III, Munger; IV, Sultangang; V, Bhagalpur; VI, Farakka)

8.0 the degradational efficiency declined substantially.

The dissolved oxygen contents of water had inverse relationship with total coliform ($r = -0.5258$, table 1). Both *pH* and DO_2 levels were low during the rainy season when bacterial counts were maximum. Substantial addition of allochthonous material in the Ganga system appears to be the major reason for high bacterial concentration in rainy season. The value of methyl orange alkalinity was low during the rains exhibiting an inverse relation to total coliform ($r = -0.3706$). The ionic concentration of sodium, potassium, calcium, magnesium, chloride and hardness also had negative correlation to bacterial counts in the flowing waters (table 1).

Turbidity had a significant positive correlation to the total coliform ($r = 0.6315$). It ranged from 65–400 NTU. Phenolphthalein alkalinity (free CO_2) was highest during the monsoon season exhibiting a positive correlation to the bacterial counts ($r = 0.7566$ and 0.8391 with total and faecal coliforms respectively). Other factors like silica, nitrate nitrogen, phosphate phosphorus and total dissolved solids did not have any significant effect on the bacterial population.

Some of the important bacteria which were encountered in the Ganga waters include *Escherichia coli, Aerobacter aerogenes, A. cloacae, Streptococcus faecalis, Staphylococcus aureus, Micrococcus* sp., *Diplococcus* sp., *Proteus vulgaris, Pseudomonas aeruginosa, Salmonella* sp., *Kleb-*

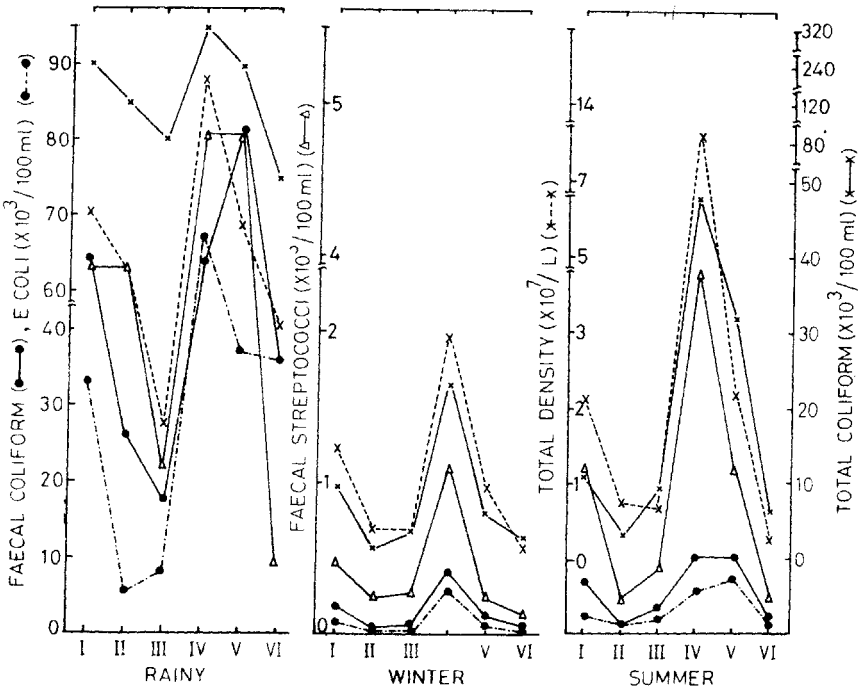

Figure 4 Bacterial counts of Ganga water at different sites (I. Patna; II. Mokama; III. Munger; IV, Sultangang; V, Bhagalpur; VI. Farakka)

Table 1 *Correlation coefficient between physico-chemical and bacterial parameters*

	Total Coliform	Faecal Coliform	Faecal Streptococci	*E. coli*
Water Temp.	0.2733	0.378	0.1138	0.038
*p*H	−0.4914*	−0.0484	−0.4533*	−0.0514
$D.O_2$	−0.5258†	−0.3447	−0.5079†	−0.1506
Free CO_2	0.7566‡	0.8391‡	0.4531*	0.3635
Bicarbonate	−0.3706	−0.2122	−0.3191	−0.0126
Turbidity	0.6315†	0.456*	0.4799*	0.1093
T. Hardness	−0.4995*	−0.585†	−0.3142	−0.1149
Calcium	−0.4379*	−0.4052*	−0.3208	−0.0719
Magnesium	−0.5004*	−0.6504†	−0.2831	−0.1313
Sodium	−0.5705†	−0.154	−0.485*	−0.1372
Potassium	−0.5482†	0.0785	−0.5582†	−0.1112
Chloride	−0.5056*	−0.4773*	−0.4915*	−0.1173
SiO_2	0.2684	0.1546	0.3551	0.0522
NO_3 − N	−0.10004	−0.4216*	−0.0417	−0.0672
PO_4 − P	−0.4495*	−0.0557	−0.0363	−0.2422
T.D.S.	−0.2654	−0.239	−0.3849	−0.0909

‡p<0.001; †<0.01:*<0.05

siella sp., *Clostridium welchii* and *Bacillus anthracis*. Details of colony characters and basis of identification are detailed in table 2. *E. coli. Aerobacter aerogenes, A. cloacae, Proteus vulgaris* and different species of cocci were found at all the sampling sites while species of *Pseudomonas, Bacillus* and *Clostridium* were usually confined to polluted and turbid waters. *Klebsiella* sp. and *Salmonella* sp. were restricted around the sewage disposal points at Patna and Bhagalpur sites.

Total bacterial density and qualitative variations were maximum in the rainy season and minimum during the winters. Turbidity and free CO_2 had significant positive correlation while other factors showed negative correlation to bacterial concentration. The main source of bacterial contamination at most of the sites was from the sewage discharge. Air, marginal soil, decomposing plant materials and cattle washing constituted the other major sources of bacterial contaminaiton.

Acknowledgement

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Table 2 *Colony characteristics and biochemical tests of some bacteria identified from Ganga water*

Bacteria	Colony characters	Gram stain	Indole	Methyl red	V.P.	Citrate utilization	Oxidase	Catalase	Nitrate reductase	H_2S	Glucose	Lactose	Sucrose
Escherichia coli	On MacConkey's agar produces red, non-mucoid, colonies with a greenish tinge	−	+	+	−	−	−	+	+	−	a, g	a, g	a
Aerobacter aerogenes	On MacConkey's agar produces paler mucoid colonies, On EMB agar, large, light brown colonies	−	−	−	+	+	−	+	+	−	a, g	a, g	a
A. cloacae	Light yellow colonies are produced	−	−	−	+	+	−	+	+	−	a, g	a, g	a
Salmonella sp.	Translucent, grey to opaque on nutrient agar	−	−	−	−	−	−	+	+	+	a, g	−	−
Klebsiella sp.	White, smooth, glistening; entire convex on nutrient agar	−	−	−	+	+	−	+	+	−	a, g	a	a
Proteus vulgaris	Grey, opaque, spreading on nutrient agar	−	+	−	−	±	−	+	+	+	a, g	−	a, g
Pseudomonas aeruginosa	Small translucent colonies on EMB agar, colourless at first and creamy white in late stages	−	−	−	−	−	+	+	+	−	a	−	−
Bacillus anthracis	Spreading, dull, opaque in broth culture, turbid and pellicle forming.	+	−	−	+	+	+	−	+	+	a	−	a
Staphylococcus aureus	Yellow, smooth, circular, glistening on nutrient agar	+	−	−	−	−	−		+	±	a	a	a
Staphylococcus faecalis	Development of acid in azide lactose medium When incubated at 45°C for 48 hrs	+	−	−	−	−	−	−			a	a	a
Micrococcus sp.	Small, light yellow, dry, raised, entire on nutrient agar	+	−	−	−	−	−	±	−	−	a	a	−
Diplococcus sp.	White, transparent, raised, smooth on nutrient agar	+	−	−	−	−	−	−	−	−	a	a	a
Clostridium welchii	Circular, raised, opaque, moist, entire	+	−					−	+		a, g	a, g	a, g

a) Acid formation; *g)* Gas formation

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