SOME LIMNOLOGICAL OBSERVATIONS ON RIVER GANGA

G. K. M. TRIPATHI

Fermentation Technology Division, Central Drug Research Institute, Chhattar Manzil, Lucknow 226 001, India

Abstract

The paper records the biological and physico-chemical investigations on Ganga River at Varanasi. Studies reveal that phytoplankton community structure is satisfactorily expressed and physico-chemical parameters are within permissible limits. The river thus maintains favourable conditions for the development of biotic components.

Introduction

Several limnological surveillances on Indian rivers have been conducted (Rai 1978; Agarwal *et al.*, 1976; Lakshminarayana, 1965). River Ganga significantly differs from other rivers, especially at Varanasi, on account of geological and geographical reasons. Studies on phytoplankton community and its structure, applied as a biological parameter, were conducted for two and half year to see seasonal variation and find out correlations in different biological as well as physico-chemical factors pertaining to the quality of water.

Material and methods

In middle of the Gangetic plain river Ganga at city Varanasi lies at 25°18' N (lat.) and 83° 1 E (long.)

Samples were collected from totally undisturbed area of mid river in the morning hours and subjected to biological and physico-chemical analysis.

For biological analysis samples were collected with the help of a net of 22 no. bolting silk and filled in one litre capacity bottles. Samples were centrifuged and phytoplankton cells were counted in Haemocytometer for quantitative studies. On the basis of quantitative and qualitative analysis of phytoplanktons its community structure was studied. Species diversity (H) was calculated by using Shannon and Weaver's formula (1949). Equitability index (J) was calculated with the help of Pielou's formula (1966).

Diversity index is expressed as bids per individual, whereas equitability index has no unit since it is a ratio.

For studying physico-chemical factors estimations of water temperature, transparency, dissolved oxygen (DO), carbondioxide, hardness, alkalinity, total solids. nitrate, free and saline ammonia, phosphate, silicate and chloride were done in accordance with the recommendation of APHA (1971). Temperature, transparency, and D. O. were measured at the sampling spot immediately.

Results and discussion

Mean and range values of physico-chemical and biological observations are given in Table 1. Phytoplankton species diversity is recorded to vary from 0.49 to 3.44 in river (Pfiiester *et al.*, 1980) and from from 1.79 to 4.88 and 0.6 to 4.0 in other lakes (Koivo, 1978; Bartha & Hajdu, 1979). The equitability index values range from 0.33 to 0.82 in these lakes. These authors observed high diversity and equitability values in the areas witnessing no external factors where as, in the areas under the influence of external factors these values are lower. In perturbed environments the natural ecological balance is disturbed and the causative physico-chmical or biological factor (s) tends to influence the number and size of ecological niches eventually leading to a shift in biological make up of a particular

Geophytology, **19**(1) : 4-9, 1989.

Table 1—Mean values of physico-chemical and biological analysis of water sample

	Range	Mean
Phyto. standing Crop (N) (No/lit)X10^3	164—319	284.75±61.21
Diversity index (H)	1.01—4.89	3.65±0.82
Total species (S)	11—42	23.15±8.64
Equitability (J)	0.51—0.92	0.79±0.07
Water temp. (°C)	17—31	24.80±6.21
Transparency (cm)	6.8—98.6	61.28±32.82
Alkalinity (ppm)	110—361	276.31±86.28
Hardness (ppm)	65—181	121.71±25.01
Solids (ppm)	359—5130	1819.06±1129.21
D. O. (ppm)	4.1—12.6	8.27±3.11
CO_2 (ppm)	1.78—5.1	4.12±0.15
Nitrate (ppm)	0.06—0.31	0.12±0.10
Nitrite (ppm)	0.02—0.12	0.07±0.05
Ammonia (ppm)	0.01—0.15	0.08±0.04
Phosphate (ppm)	0.08—0.20	0.11±0.08
Silicate (ppm)	18—33	21.74±8.27
Chloride	22—56	36.32±11.71

habitat. Wall and Briand (1980) observed that nutrient addition in lake resulted in niches overlap probably due to interspecific competitions. They further noted that at species level only few species did not expand their niches with fortification. Thus different species respondd differently to the given external environmental factor and the altered biological profile of the habitat. On account of introduction or obliteration and widening or narrowing of ecological niches, represents an index to measure the extent and persistence of the factors other than that of natural habitat.

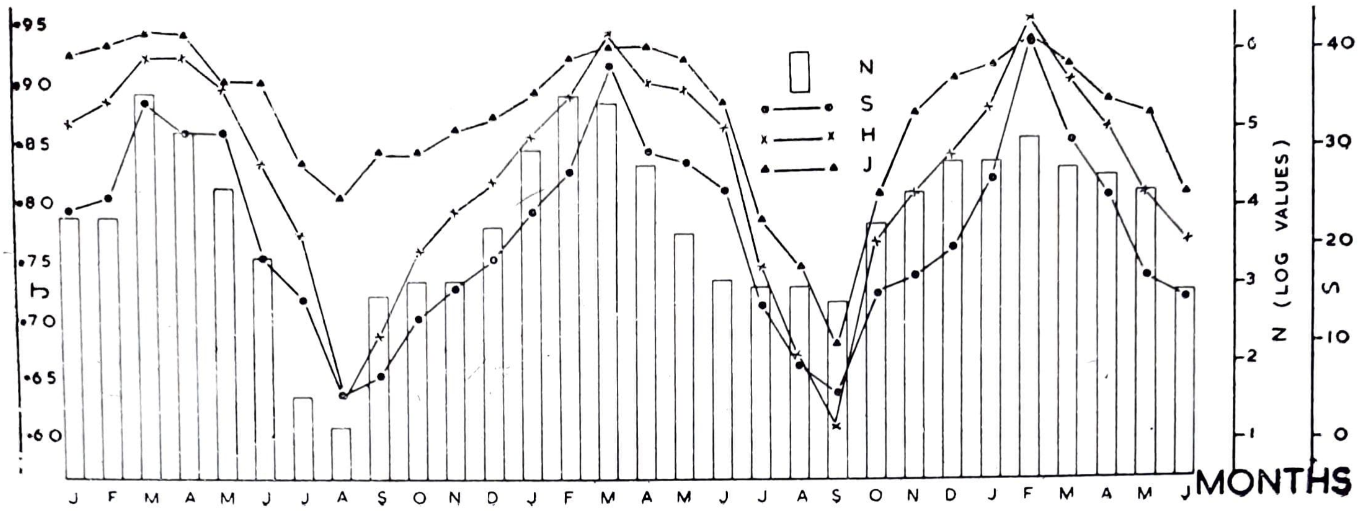
While studying phytoplankton community structure Sagar and Hesler (1969) noted that equitability (distribution of individuals among different taxa) dispensed among 10 to 15 dominant species of any habitat which retain the accountability of species diversity (H) and further addition of species with low individuals casts little influence. A distinction in natural environment and a physically stressed environment on the basis of studies on bird population has been made (Tramer, 1969; Kircher, 1972). Equitability (J) exercises more influence on species diversity in perturbed environments where as in natural environments species content(S) exercises stronger influence over species diveriity. In our study, as indicated in Table 2 both speacies number and evenness influence the species diversity which is indicative of existence of undisturbed environment. Wilhm and Dorris (1968) during their studies on benthic microinvertibrates of steam demonstrated that diversity index values less than one was obtained in heavily polluted localities where as it was up to three in moderately polluted habitats and above three in clean habitats. So according to this comparison the river Ganges shows fairly good water quality (Text-fig. 1).

Interrelationship among the different physico-chemical and biological factors has been investigated by many workers (Moore, 1979; Walker & Donell, 1981; Watling *et al*, 1979). Table 2 shows the correlation coefficient values (gamma) with each other. Figures 2-5 show seasonal variation in phytoplankton population. Total phytoplankton standing crop (N) has got strong positive correlation with S, H, J and transparency and strong negative correlation with temperature, total solids, nitrate and ammonia. Bierhuisen *et al.* (1985) studied correlation among phytoplankton standing crop and other factors and concluded that there exists significant positive correlation between Chl and Ca^{+2} and total phosphate whereas, a negative correlation with Chl and conductivity, pH, Na^{+2}, Mg^{+2}, SO_4^{-2}, $1+CO_3^{-2}$ and CO_3^{2}. Marton *et al.* (1981) found a direct correlation between phytoplankton biomass and phosphate and nitrate concentration. While studying seasonal changes in Phytoplankton community Fedorov *et al.* (1975) recorded positive correlation between biomass and species diversity (H) of individual species to total standing crop was equal during beginning and end of spring. However, with the dominance of certain species in peak of spring leading to an increase in biomass and these two factors showed negative correlation. In our study H shows strong positive correlation with biomass as dominance of certain species seasonally casts little impact. Total number of species (S) is strongly positively correlated with N, J, transparency and D O and nega-

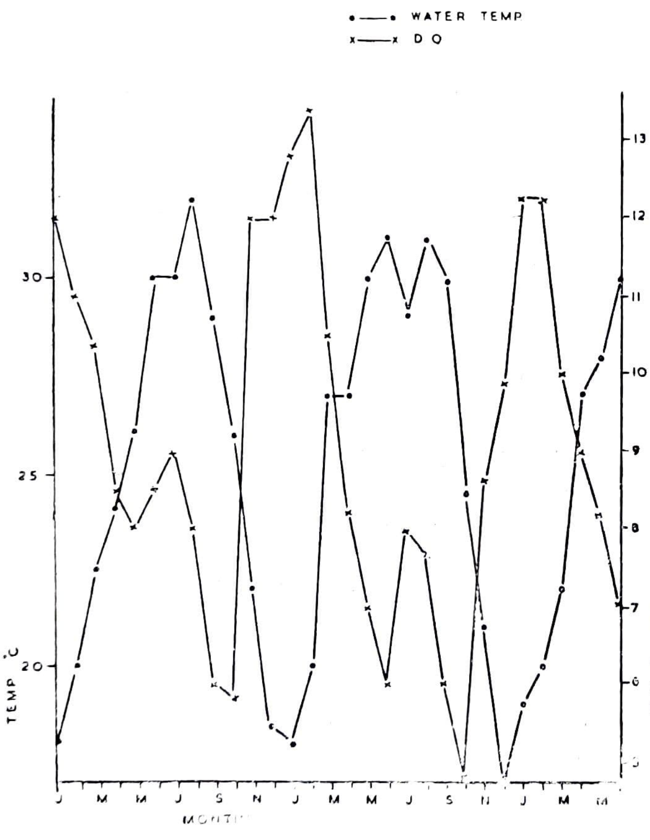
Table 2—Correlation Co-efficient values (r) among physico-chemical parameters

N	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S	.90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
H	.85	.97	—	—	—	—	—	—	—	—	—	—	—	—	—	—
J	.84	.87	.91	—	—	—	—	—	—	—	—	—	—		—	—
Temp.	—.68	—.64	—.68	.77	—	—	—	—	—	—	—	—	—	—	—	—
Alkalinity	.08	.32	.27	.20	.24	—	—	—	—	—	—	—	—	—	—	—
Hardness	.41	—.32	—.41	—.58	.71	.19	—	—	—	—	—	—	—	—	—	—
Transparency	.67	.83	.90	.93	—.73	.37	—.51	—	—	—	—	—	—	—	—	—
Solids	—.71	—.76	—.87	.85	.69	—.14	.60	—.85	—	—	—	—	—	—	—	—
CO_2	.29	.27	.26	.04	—.20	—.19	.34	—.06	—.15	—.24	—	—	—	—	—	—
Nitrate	—.82	—.83	—.81	—.74	.55	.01	.08	—.63	.59	—.39	—.50	—	—	—	—	—
Nitrite	—.48	—.60	.66	—.39	.27	.03	.11	—.43	.50	—.36	—.61	.63	—	—	—	—
Ammonia	—.68	—.85	.85	—.81	.81	—.30	.47	—.91	.76	—.85	.12	.60	.40	—	—	—
Phosphate	—.47	—.48	.35	—.24	—.08	—.39	—.46	—.13	.05	.28	—.38	.62	.20	.19	—	—
Silicate	—.44	—.57	.51	—.39	—.12	—.73	—.41	—.42	.30	.13	—.34	.55	.29	.34	.81	—
Chloride	—.53	—.75	—.77	—.71	.71	—.29	.41	—.87	.61	—.86	.11	.51	.50	.90	.01	.24

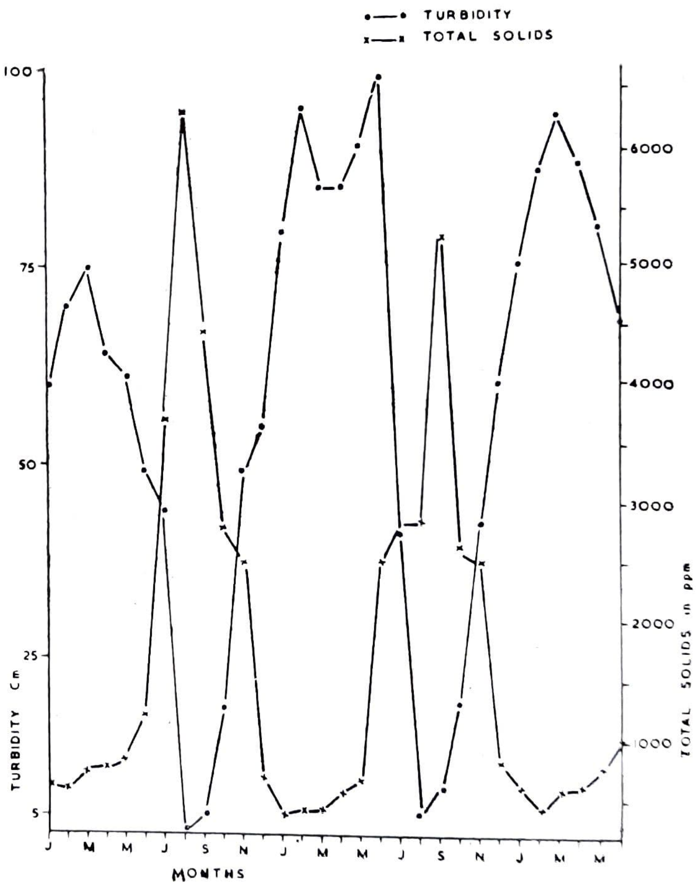
The correlation is significant at 1% level (r values of .68 and above) and at 5% level (r values of .55 and above).



Text-figure 1

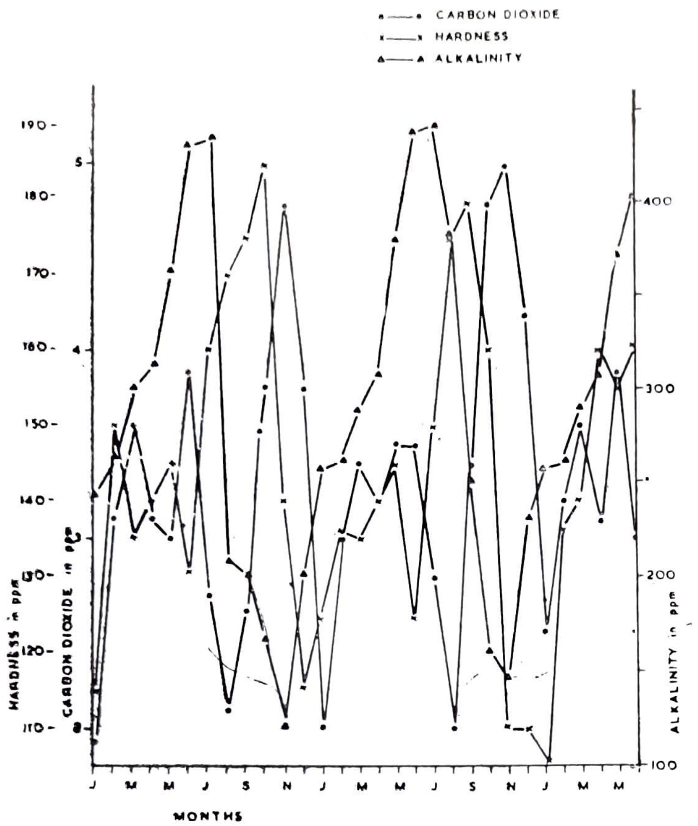


Text-figure 2

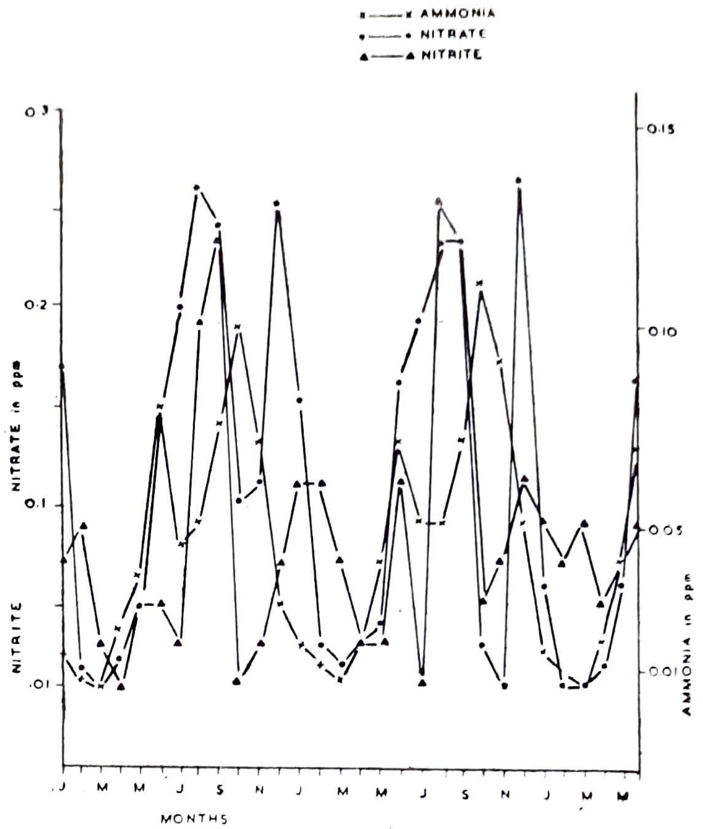


Text-figure 3

tively with temperature, total solids, nitrate and ammonia. Moor (1979) concluded that temperature was the factor influencing the diversity while other physical and chemical factors influence it little. On the contrary maximum densities of several common species increased significantly with high concentration of total phosphorus and total hardness. In our study of J, transparency and D O show strong positive correlation with diversity index whereas, temperature, total solids, nitrate, nitrite, ammonia and chloride show strong negative correlation with species diversity. Rince (1979) also found that



Text-figure 4



Text-figure 5

temperature and light conditions directly influence species diversity. Fagerberg and Arnott (1979) correlated light intensity and duration with species diversity of blue-green algae, while J shows strong positive correlation with transparency, D O and strong negative correlation with temperature, total solids, nitrate, ammonia and chloride. It is apparent that dominance of species is influenced considerably by these physico-chemical factors. Temperature shows strong positive correlation with hardness, total solids, ammonia and chloride and strong negative correlation with transparency and D O Alkalinity has strong negative correlation with silicates only. Walker and Donnel (1981) found strong correlation between nitrate, phosphate concentrations and transparency shows strong negative correlation with chloride, ammonia, nitrate and total solids, and positive correlation with D O other correlations presented in Table 2 are not very significant.

It is observed that the river is maintaining fairly good quality of water as far as biological parameters are concerned. According to the report of Royal Commission (1972) concentrations of D O, CO_2, hardness, alkalinity, nitrate, nitrite, ammonia and chloride should not exceed the recommended limit of 4 ppm, 6 ppm, 500 ppm, 2.2 ppm, traces, 0.2 ppm and 50 ppm respectively. Therefore the river maintains excellent Physico-chemical conditions for the proper development of biological communities. These physico-chemical and biological parameters show well demarcated seasonal variations and influence each other in permissible range as shown in Table 2.

Acknowledgements

The author is grateful to Dr J. N. Misra for valuable suggestions and guidance.

References

Agarwal, D. K., Gaur, S. D., Tiwari, I. C., Narayanaswami, N. & Marwah, S. N. (1975). Physicochemical characteristics of Ganges water at Varanasi. *Indian J. Environ. Health*, **18** : 201-206.

American Public Health Association et al. (1971). *Standard methods for the examination of water and waste water*. Amer. Public Health Assoc. Inc., New York.

Bartha, Z. S. & Hajdu, L. (1979). Phytoplankton

Community structure studies of lake velence, Hungary, I Diversity. *Acta bot. Acad. Scient. Hungaricae* **25** : 187-222.

BIERHUISEN, J. F. H. & PREPAS, E. E. (1965). Relationship between nutrient domination and phytoplankton standing crop in prairie saline Lakes. *Can. J. Fish Aquat. Sci.*, **42** : 1588-1593.

FAGFRBERG, W. R. & ARNOTT, H. J. (1979). Seasonal changes in structure of a submerged blue green algae/bacterial community from a geotherma hot spring. *J. Phycol.*, **15** : 445-457.

FEDOROV, V. D., KONOPHYLA, L. A. & KOKIN, K. A (1975). Seasonal changes in diversity of specie set composition in white sea plankton. *Obsoch. Biol.* **36** : 389-396.

KIRCHER, J. C. (1972). Bird species diversity : The effect of species richness and equitability on diversity index. *Ecology*, **53** : 275-282.

KOIVO, L. (1978). Species diversity in net diatom plankton of some lakes of Prairie, deciduous forest and coniferous-deciduous forest regions of central North America. *Ann. Bot. Fennici*, **15** : 138-146.

LAKSHMINARAYAN, J. S. S. (1965). Studies on the phytoplankton of the river Ganges Varanasi, India. *Hydrobiologia*, **15** : 119-127.

MARTON, A., BUCUR, N., KENEL, M. & CARANS, I. (1981). Dependence of photosynthesis and repiration on certain physico-chemical factor in several entrophic aquatic ecosystem. *Rev. Roum. Biol. Ser. Biol. Veg.*, **26** : 3-9.

MOOR, J. W. (1979). Factors influencing the diversity, species composition and abundance of phytoplankton in twenty one arctic and subarctic lakes. Int. Rev. Gesamtem. *Hydrobiologia*, **64** : 485-499.

PFIESTES, A. L., LYNCH, R. & WRIGHT, T. L. (1980). Species composition and diversity of phytoplankton in the river Dam area Oklahoma. *Proc. Okla. Acad. Sci.*, **60** : 63-68.

PIELOU, E. C. (1975). *Ecological diversity*, pp. 165, New York.

RAI, L. C. (1978). Ecological studies of algal communities of the river at Varanasi. *Indian J. Ecol.*, **5** : 1-6.

RINCE, Y. (1979). Seasonal cycles of phytoplanktonic and benthic diatoms in oyster ponds near Bay of Bourgneut. *Rev. Algol.*, **14** : 297-303.

Royal commission on sewage disposal (1912). 8th report, Vol. 1. report Omd. 6464. HMSO. London.

SAGER, P. E. & HASLER, A. D. (1969). Species diversity in Lacustrine phytoplankton. I. The components of the index of diversity from Shannon's formula. *Amer. Nat.*, **103** : 51-59.

SHANNON, G. E. & WEAVER, W. W. (1949). The mathematical theory of Communication, 117 pp. Urbana.

TRAMER, E. J. (1969). Bird species diversity components of Shannon's formula. *Ecology*, **50** : 927-931.

WALL, D. & BRIAND, F. (1980). Spatial and temporal overlap in lake phytoplankton communities *Arch Hydrobiol*, **88** : 45-47

WALKER, T A. & DONNEL, G. O. (1981). Observation on nitrate, phosphate and silicate in Cleveland Bay. *Aust. J. Mar. Fresh Water Res.*, **32** : 877-887.

WATLING, L., BOLLCM, D., PEMBROKE, A. & MAURER, D. (1979). Seasonal variation in Delaware Bay phytoplankton community structure. *Mar. Biol.*, **52**(3) : 207-215.

WILHM, J. L. & DORRIS, T. C. (1968). Biological parameters for water quality criteria. *Biosci.*, **18** : 447-480.