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POPULATION AND PRODUCTIVITY OF HETEROTROPHIC BACTERIA IN A FRESHWATER LAKE

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The population and productivity of bacteria has been estimated in a subtropical lake situated at an altitude of 1460 m. The measurements were made on monthly intervals for a period of one year. Spring maxima were observed for both the parameters. The bacterial population varied between $1–300 \times 10^3$/ml and the bacterial production ranged between 15 and 120 mg^{c}/m^{3}/day. Both the estimates were higher in nutrient rich water body as compared to the one containing lesser nutrients.

The heterotrophic bacteria constitute a major component of the decomposer community in the natural waters, and quantitative enumeration of their population and productivity gives a direct measure of the role of bacteria in hydrobiology and trophic metabolism of the system. The functional attributes of heterotrophic bacteria in freshwaters have increasingly attracted the attention of limnologists (Overbeck and Daley 1973; Mason 1977; Overbeck 1979; Jordon and Likens 1980; Tiwari and Mishra 1982) in recent years. A review of literature on Indian limnology reveals that the bacterial population and productivity estimates have received little attention (Gulati and Wurtz-Schulz 1980; Michael 1980; Mishra and Tiwari 1982). The present communication deals with population dynamics and production of heterotrophic bacteria in a small freshwater lake.

The study was conducted in Wards lake, Shillong, India (latitude 25° 34″ N, longitude 91° 52″ E) situated at an altitude of 1460 m. The slopes surrounding the lake are covered with managed grasses and scattered trees predominantly of pine (*Pinus kesiya* Royle). The lake receives water through a perennial stream and has a surface outlet which allows the excess water to flow out during months of May to September when maximum rainfall occurs. Throughout the year the water level does not change appreciably except for January-February when the level drops by approximately 30 cm. Two sampling stations were choosen. In Station 1 the average depth of the lake is 0·80 m and this station is comparatively richer in nutrient content (Fig. 1; Tiwari 1980). Station 2 is situated in the deepest part of the lake and is near to the outlet. The lake bottom at this station is silty and converted with semi-decomposed pine needles. The water depth at this station is 6 m. *Chlorella* sp. and *Microcystis* sp. dominate the phytoplankton community at both the stations. The lake harbours a sizeable community of zooplankton and fishes.

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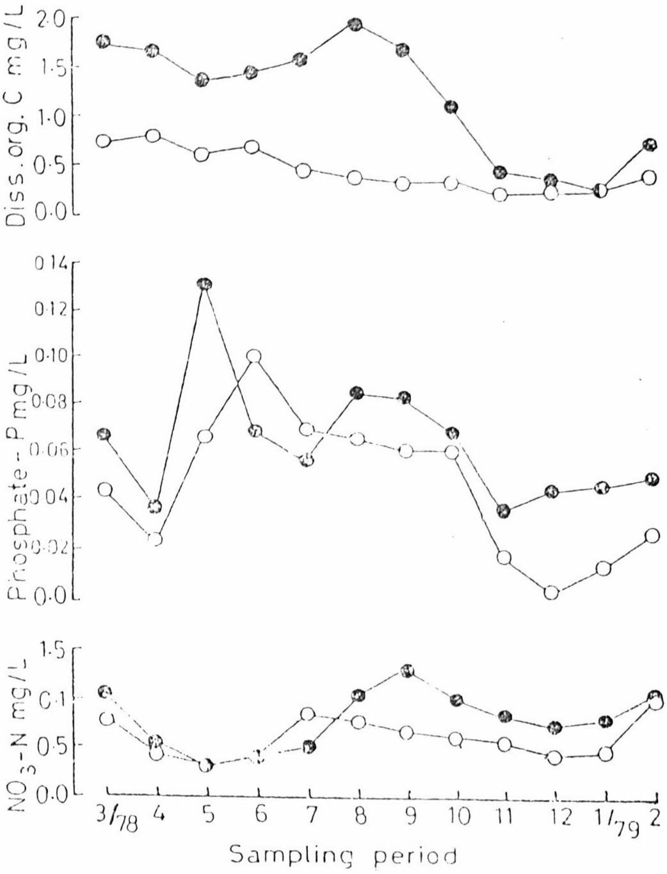

Fig. 1. Nitrate-N, phosphate-P and dissolved organic carbon concentration in the lakewater at two stations, ●—● : station 1 ; O—O : station 2.

MATERIALS AND METHODS

Water samples for bacteriological analyses were collected in sterile glass bottles from 1–2 cm below the surface. Before collection the water surface was disturbed as to avoid contamination by the objects floating on the surface. All samples were taken between 0900–1100 hours. For physico-chemical analyses, water samples were collected in polyethylene bottles of 2 litres capacity. All the water samples were maintained in a dark chamber and transported to the laboratory within 30 minutes of sampling.

Within 3 hours of collection the samples were inoculated for the estimation of bacterial population by spread plate method. Casein Peptone Starch Agar (Collins and Willoughby 1962) was used for the plate count. The composition of the medium was : soluble casein 0·5 g, K_2HPO_4 0·2 g, $MgSO_4$ 0·05 g, $FeCl_3$ trace (4 drops of the 0·01% solution) and agar 15·0 g in 1000 ml distilled water. The medium was autoclaved at 1·4 kg/cm² pressure for 20 mins. Aliquots, each of 0·5 ml in serial dilutions (1 : 10, 1 : 100, 1 : 1000 dilutions) were inoculated on the surface of freshly poured medium in a 100 mm dia Petri plates. Three replicates were maintained for each of the serial dilutions. The plates were kept at 10°C for 12 hours to allow for the absorption of this aliquot and subsequently incubated at 25°C for 7 days. The plates belonging to the serial dilution that contained 30–300 visible colonies were counted and other dilutions were discarded.

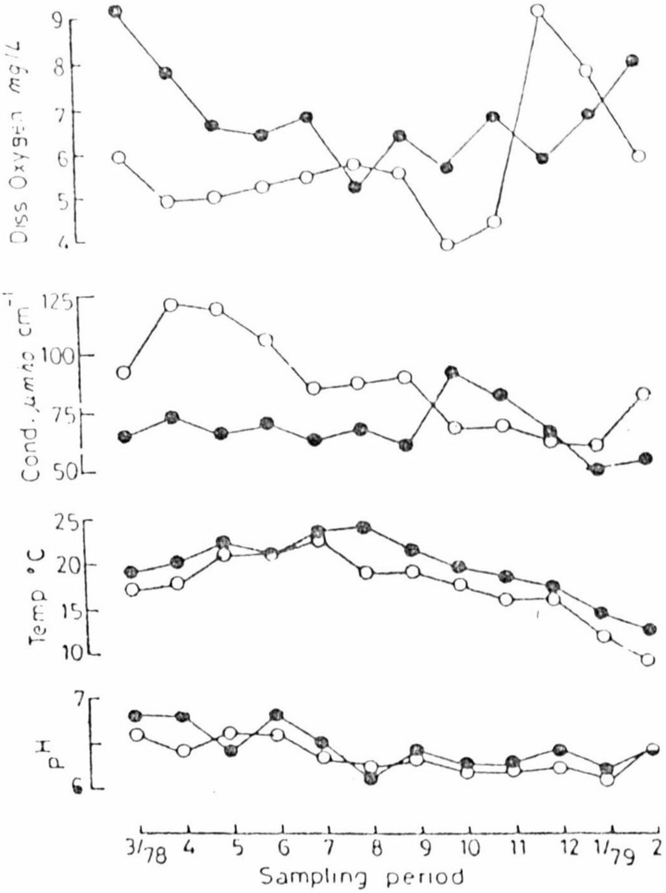

Fig. 2. pH, water temperature, conductivity and dissolved oxygen concentration in the lakewater, ●—● : station 1; 0—0 : station 2.

The bacterial production was estimated by the method described by Romanenko and Sorokin (1972) wherein they gave a relationship between rate of oxygen consumption and rate of bacterial production : P=0·08 D mg C/L/day where P=rate of bacterial production and D=rate of oxygen consumption in mg O_2/L/day. The rate of oxygen consumption was measured *in situ* by dark oxygen bottle method in water previously filtered through 15 µm pore size filter to remove phyto-and zooplankton.

Physico-chemical characters (nitrate-N, phosphate-P, dissolved organic carbon, pH, temperature, conductivity, dissolved oxygen) were measured following APHA (1971).

RESULTS

Figs. 1 and 2 depict dissolved organic carbon, phosphate-P, and nitrate-N, dissolved oxygen concentrations, conductivity, temperature and pH of the lake water collected from two stations. A comparison of the values with similar other studies (Munawar 1970) suggests that the lakewater is nutrient rich particularly at station 1. The water temperature ranged between 10-25°C and pH between 6·3 and 6·8.

In general, bacterial population was high during spring (March–May) and declined to a minimum during winter (December–January). During the remaining part of the year the population remained within a stable range. Station 1 harboured higher bacterial population for most of the periods compared to station 1 (Fig. 3).

Fig. 4 presents bacterial production. The rate of biomass production was greater during the spring and summer months compared to that of winter. The production estimates were greater at station 1 compared to those at station 2.

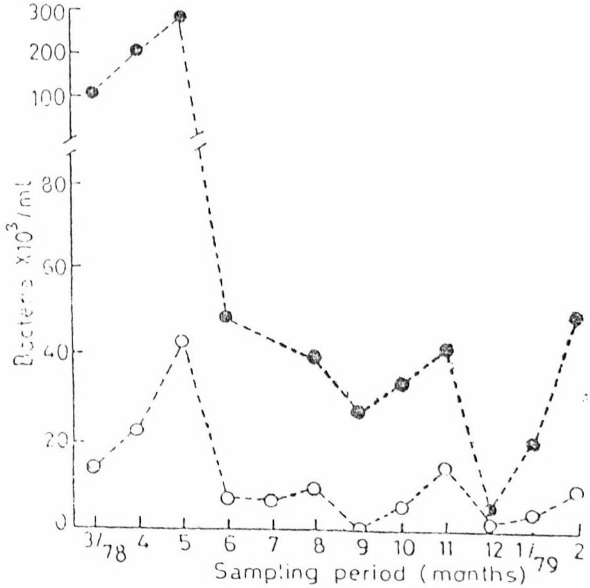

Fig. 3. Bacterial population in the lakewater. ●- - -● : station 1 ; O—O : station 2.

DISCUSSION

A comparison of the data on bacterial population estimates with similar studies (Godlewska-Lipowa 1976) reflects that the present lake can be classified in the

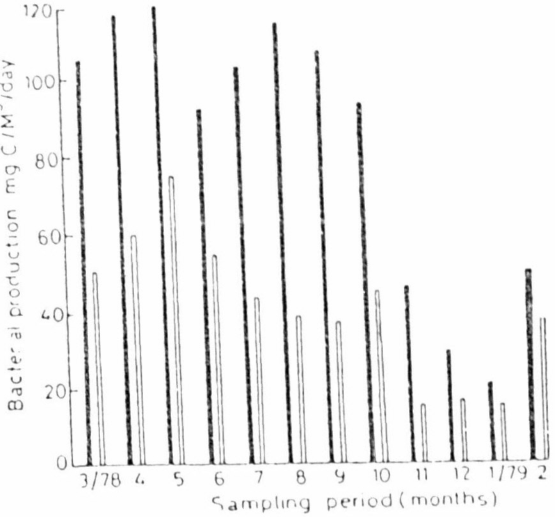

Fig. 4. Bacterial production during the study period. Solid bars : Station 1 ; open bars : Station 2.

mesotrophic category. The seasonality in the bacterial population was comparable with temperate lakes (Jones 1977 ; Mason 1977). The higher population of bacteria during spring can be attributed to the post winter rise in temperature, inflow of leaf litters of the adjoining vegetation, and phytoplankton bloom (Tiwari and Mishra 1982 ; Coveney *et al.* 1977). The higher population and productivity at station 1 may be due to its vicinity to the inlet and higher content of nutrients in the water.

The bacterial production is controlled largely by the same set of factors as the population. The amount of biomass synthesised by the heterotrophic bacteria is of the same order of magnitude as of phytoplankton in this lake (Thapa, unpublished Ph.D. thesis), which clearly demonstrates the contribution of bacterial production towards total productivity of the lake. The bacterial production seems to be of added importance as bulk of the bacterial biomass synthesised comes from the extraneous (pine needles and other leaf litters) dead organic materials which are unavailable to the system (Sorokin and Kadota 1972). The bacterial population values are directly proportional to the dissolved organic carbon content of the water which indicates that the bacteria derived their nutrition from the dissolved organic carbon pool of the lakewater. It appears that the heterotrophic bacteria play a very important role in the aquatic systems receiving large amount of allochthonous organic matter (Mishra and Tiwari 1983). The heterotrophic bacteria convert these organic matters into living biomass which becomes more palatable for the organisms of higher trophic levels. Due to their fast rate of growth under short generation time, the contribution of bacterial production to the total production and the ecosystem function may be as quite significant (Hughes and Rose 1972). The results of the present study emphasise the need for more studies on bacterial production and biomass estimates in diverse environments.

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REFERENCES

American Public Health Association 1971 *Standard Methods for Examination of Water and Wastewater*. Washington : A P H A

Collins V G and Willoughby L G 1962 The distribution of bacteria and fungal spores in Blelham Tarn with particular reference to an experimental overturn. *Arch Microbiol* **43** 294–307

Coveney M F, Cornberg G, Enell M, Larsoon K and Plofsson L 1977 Phytoplankton, zooplankton and bacteria standing crop and production relationship in a eutrophic lake. *Oikos* **29** 5-21

Godlewska-Lipowa W A 1976 Bacteria as indicators of the degree of eutrophication and degradation of lakes. *Pol Arch Hydrobiol* **23** 341–358

Gulati R D and Wurtz-Schulz G 1980 Remarks on the present status of limnology in India based mainly on the Indian publication in Hydrobiologia. *Hydrobiologia* **71** 211–222

Hughes D H and Rose A H (eds) *Microbes and Biological Productivity*. London : Cambridge Univ Press

Jones J G 1977 The effect of environmental factors on estimated value and total populations of planktonic bacteria in lakes and experimental enclosures. *Freshwater Biol* **7** 67–91

Jordon M and G E Likens 1980 Measurement of planktonic bacterial production in an oligotrophic lake. *Limnol Oceanogr* **25** 719–732

Mason C F 1977 Populations and production of bacteria in the plankton of two shallow lakes. *Hydrobiologia* **55** 17–20

Michael R G 1980 A historical resume of Indian limnology. *Hydrobiologia* **72** 15–20

Mishra R R and Tiwari B K 1982 Seasonal variation in the estimated viable population of planktonic bacteria in a small lake. *Trop Ecol* **23** 291–299

Mishra R R and Tiwari B K 1983 Fungi and bacteria associated with pine (*Pinus kesiya* Royle) needles and teak (*Tectona grandis* L.) leaf litters during processing in a freshwater lake. *Hydrobiologia* **122** 123–130

Munawar C F 1970 Limnological studies on freshwater ponds of Hyderabad, India I. The biotope. *Hydrobiologia* **35** 127–162

Overbeck J 1979 Dark CO_2 uptake-biochemical background and its relevance to *in situ* bacterial production. *Arch Hydrobiol Beih Ergn Limnol* **12** 38–47

Overbeck J and Daley R J 1973 Some precautionary comments on the Romanenko technique for estimating heterotrophic bacterial production. *Bull Ecol Res Comm (Stockholm)* **17** 342–344

Romanenko V I and Sorokin Y I 1972 Calculation of rate of microbial production from rate of oxygen consumption. In Y I Sorokin and H Kadota (eds) *Technique for the Assessment of Microbial Production and Decomposition in Freshwaters*, pp 85–86. Oxford : Blackwell Scientific Publications

Sorokin Y I and Kadota H 1972 (eds.) *Techniques for the Assessment of Microbial Production and Decomposition in Freshwaters*. Oxford : Blackwell Scientific Publications

Tiwari B K 1980 *Studies on Microflora of a Freshwater Lake : An Ecological Approach*. Ph. D. Thesis, North-Eastern Hill University, Shillong

Tiwari B K and Mishra R R 1982 A study on biological activity measurements and heterotrophic bacterial populations in a small freshwater lake. *Hydrobiologia* **94** 257–269