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Variation of water quality in Chilika lake, Orissa

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The water quality parameters such as *p*H, salinity, DO, BOD, PP, nutrients (NH_3-N, NO_2-N, NO_3-N, PO_4-P, Total P), and chlorophyll *a*, *b* and *c*, were studied for the entire Chilika lake from 1998 to 2001 covering a maximum of 23 sampling stations. The *p*H of water was alkaline throughout the lake and both *p*H and salinity varied widely. Higher *p*H with low salinity zones reflected disintegration of submerged weeds. Correlation analysis supported the increase of *p*H, high photosynthetic activity, high nutrients as well as phosphate depletion due to phytoplankton utilization in the fresh water zone. The opening of a new mouth during the study period helped subsequently to bring rise to salinity throughout the lake region, flush out sediment load from lake, disintegrate weeds, increase biodiversity etc., which would ultimately enhance the fish, prawn and crab catch.

[**Key words**: Water quality, nutrients, correlation analysis, Chilika lake]

Introduction

Chilika lake (19° 28′ to 19° 54′N; 85° 06′ to 85° 35′E) situated in the humid tropical climatic zone along the Orissa coast, on the east coast of India, is connected to the Bay of Bengal (Fig. 1). This is the largest brackish water wetland complex in Asia, declared as a Ramsar site under the convention on "Wetlands of International Importance". Chilika lake is presently under threat from both natural and anthropogenic pressures. The problems are siltation, change in salinity, increase in fresh water weeds, aquaculture activities, decrease in fish productivity, change in species composition of avifauna, eutrophication, excessive exploitation of bio-resources and overall loss of biodiversity which resulted in the degradation of lake ecosystem. Continuous environmental monitoring is required for understanding the impact of natural and anthropogenic processes in the ecosystem of the lake.

A number of researchers have worked on Chilika lake regarding hydrography, geology, sedimentology, flora and fauna, productivity, fishery and economic activities. Annadle & Kemp[1] initiated the investigation in Chilika particularly on hydrography. Similar line of work was carried out by Banerjee & Roychoudhury[2], Venkataratnam[3], Sarkar[4] and Subba Rao *et al*.[5] Panda *et al*.[6] studied the distribution of nutrients and Panda *et al*.[7] described the geochemical fractionation of heavy metals in Chilika lake. The present work aims at assessing the water quality variation in the entire Chilika lake for the period 1998 to 2001 which includes the impact of opening of new mouth, and understanding the processes by applying correlation analysis that will be helpful in studying the socio-economic change of the area reflected in fish catch, sea water intrusion, flushing of sediment load etc.

Materials and Methods

The investigated area comprised of 23 sampling stations and the work covered the period 1998 to 2001. The exact sample locations were fixed by using Global Positioning System (GPS). All the sample locations (Fig. 1) have been projected on a SW-NE line passing through the centre of the lake and the variations of different parameters have been plotted on these projected locations for 14 common sampling stations covering all the periods to understand the major variations from south to north in the lagoon, seasonal changes and local fluctuations. Only surface water samples were collected from the lagoon, as the depth of water is very less (< 5m). During sample collection in the lake, necessary precautions had been taken to collect undisturbed water samples. Analyses of several parameters of water samples like *p*H, salinity, DO (dissolved oxygen), BOD (biochemical oxygen demand), PP (primary productivity, gross), nutrients (NH_3-N, NO_2-N, NO_3-N, PO_4-P, Total P),

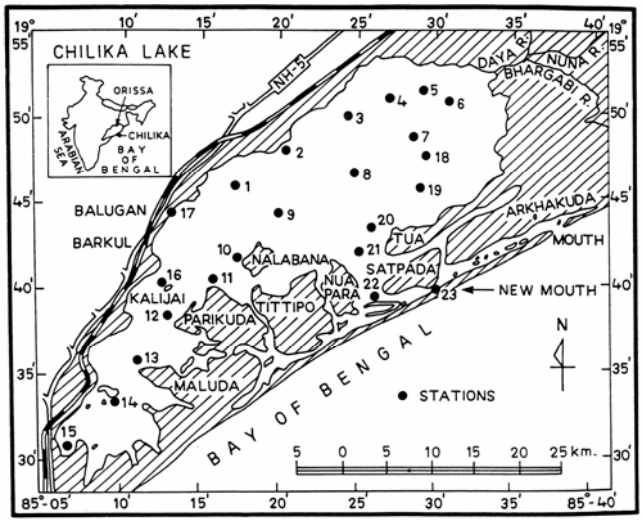

Fig. 1—Map of Chilika lake showing all the sample locations.

and chlorophyll *a*, *b* and *c*, have been carried out using standard procedures[8,9].

Results and Discussion

Water quality

The *p*H of the Chilika water was slightly alkaline (Fig. 2A) which varied from 7.37 to 8.91 in March 98, 7.72 to 9.50 in Nov. 98, 7.40 to 10.20 in Feb. 99, 7.42 to 9.48 in April 99, 7.33 to 9.96 in Jan. 2000 and 8.03 to 8.71 in May 2001. Generally, the high *p*H was found in the northern sector of the lake where larger amount of weeds are present. The photosynthesis of weeds may cause the lake water into slightly higher alkaline wherever they are present[5,6].

The salinity of the lake varied from 0.37 to 10.87‰ in March 98, 0.13 to 8.77 ‰ in Nov. 98, 0.31 to 8.87 ‰ in Feb. 99, 1.12 to 31.16 ‰ in April 99, 0.23 to 7.98 ‰ in Jan. 2000 and 9.46 to 31.73 ‰ in May 2001 sampling period (Fig. 2B). The low salinity value was found in Nov. 98 whereas the higher values were found in April 99 (prior to the opening of the new mouth in Sept. 2000). After the opening of the new mouth the overall salinity has increased through out the lake. Generally, the stations belonging to northern sector are having low salinity values due to the influx of fresh water from Daya, Bhargabi and Nuna rivers. The highest salinity value 31.73 ‰ was found at station 22 in May 2001 indicating the maximum impact of intrusion of seawaters through the new lake mouth into the lake. This is also reflected by very high salinity throughout the lake in this period. A very high value of 31.16 ‰ salinity observed at station 22 in April 99 was prior to the new mouth opening, which could be due to the impact of high tide condition at the time of sampling and at that time the sea impact was very much limited in the lake as observed from the overall salinity value distribution in the lake.

The DO was found to be lower in Feb. 99 and also in April 99 at station no. l7 (Fig. 2C), which may be due to anthropogenic activities in and around Balugaon ghat area. The higher DO values often more than the saturation values were found mostly in the stations where more weeds are present and may be due to their photosynthetic activities.

The high BOD value (Fig.2D) was found at the stations where the decomposition of the weeds occurs which is indicative of assimilation of organic load and occurrence of more microorganisms. Here, as the huge amount of surface vegetation dies, it sinks to bottom and is degraded. The degrading organisms consume a lot of oxygen a feature common to eutrophic ecosystem. The stations in southern sectors have comparatively less BOD.

The primary productivity varies from 0.019 to 0.244 mgC/l/hr in March 98, 0.02 to 0.24 mgC/l/hr in Nov. 98, 0.022 to 0.84 mgC/l/hr in Feb. 99, 0.007 to 0.24 mgC/l/hr in April 99, 0.03 to 0.16 mgC/l/hr in Jan 2000 and 0.051 to 0.460 mgC/l/hr in May 2001 sampling period (Fig. 2E).

The concentrations of nutrients like ammonia (Fig. 3A), nitrite (Fig. 3B), nitrate (Fig. 3C), phosphate (Fig. 3D), total phosphorous (Fig. 3E) were examined for 6 different periods. The high values of nutrients were found at stations 17 and 18 during summer 99. The slightly higher value of nutrient at station no. 17 may be due to the dispersion of pollutants from Balugaon area. Higher amounts of nutrients are found in the northern part of the lake, which are due to the land drainage brought out by river systems through which the inland soil and agricultural fertilizers used for farming are washed out and add to the lake water.

Chlorophyll-*a* revealed wide variation among the stations for all sampling periods i.e. 5.8 to 17.3 mg/m^3, 0.420 to 14.935 mg/m^3, 0.348 to 43.556 mg/m^3, 0.885 to 10.749 mg/m^3, 0.288 to 52.311 mg/m^3 and 1.85 to 54.04 mg/m^3 for March 98, Nov. 98, Feb. 99, April 99, Jan. 2000 and May 2001 sampling period, respectively (Fig. 4A). Chlorophyll-*a* showed much higher concentration in northern part of the lagoon in comparison to the south. Chlorophyll-*b* (Fig. 4B) and *c* (Fig. 4C) are very low in concentration compared to chlorophyll-*a*, so their role in productivity is relatively of lesser importance.

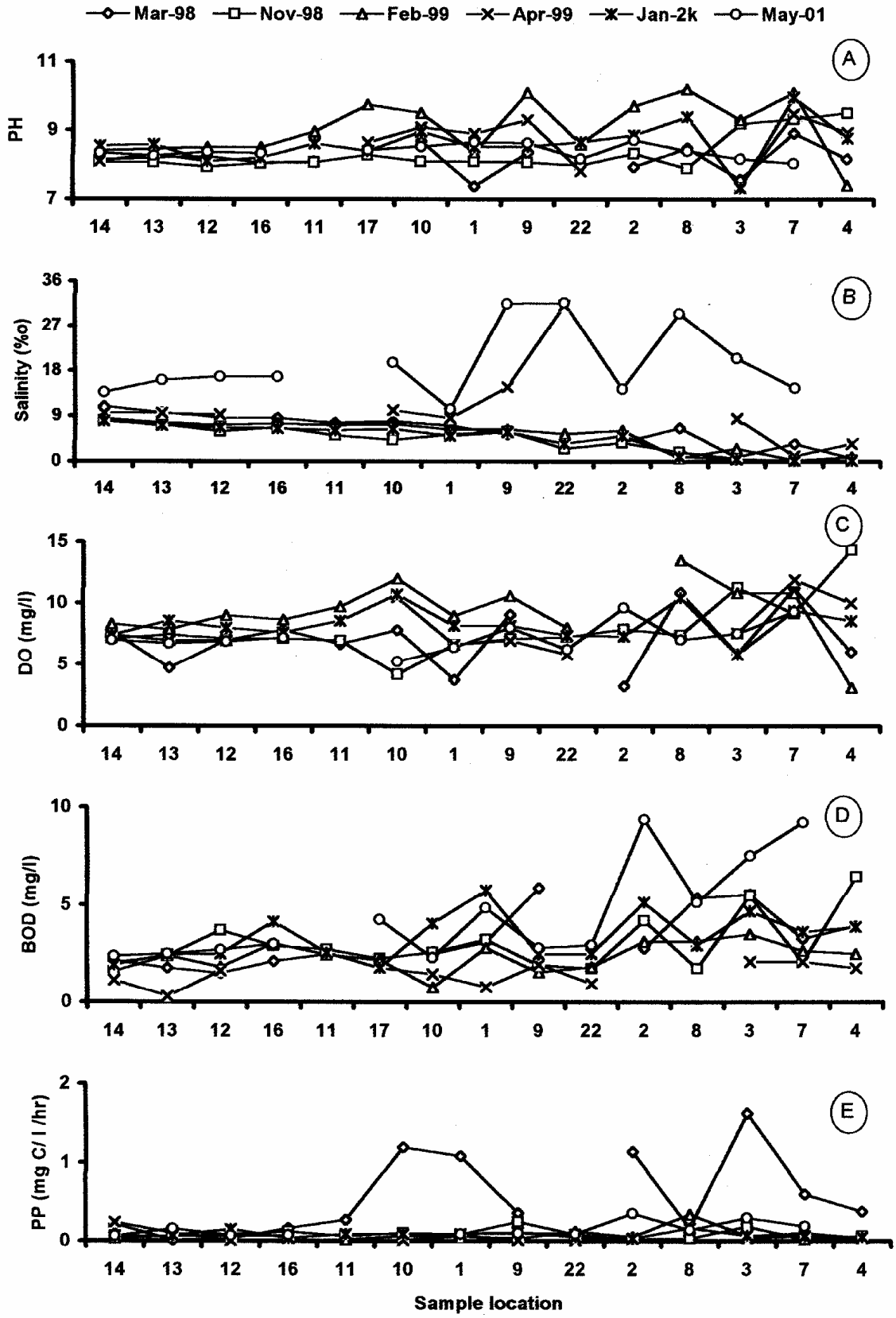

Fig. 2—Variation of *p*H, salinity, DO, BOD and PP in Chilika lake from 1998 to 2001.

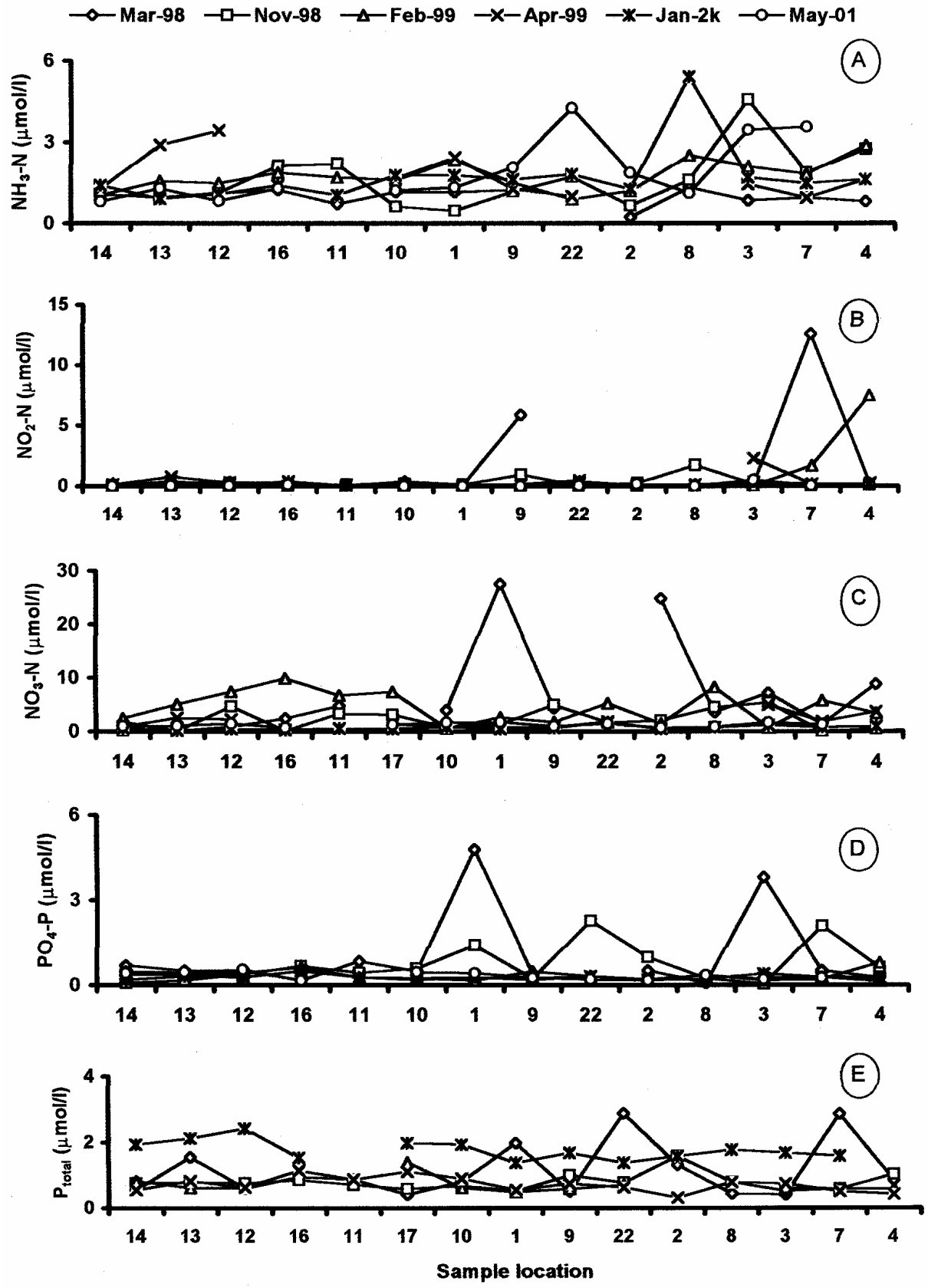

Fig. 3—Variation of nutrients in Chilika lake from 1998-2001.

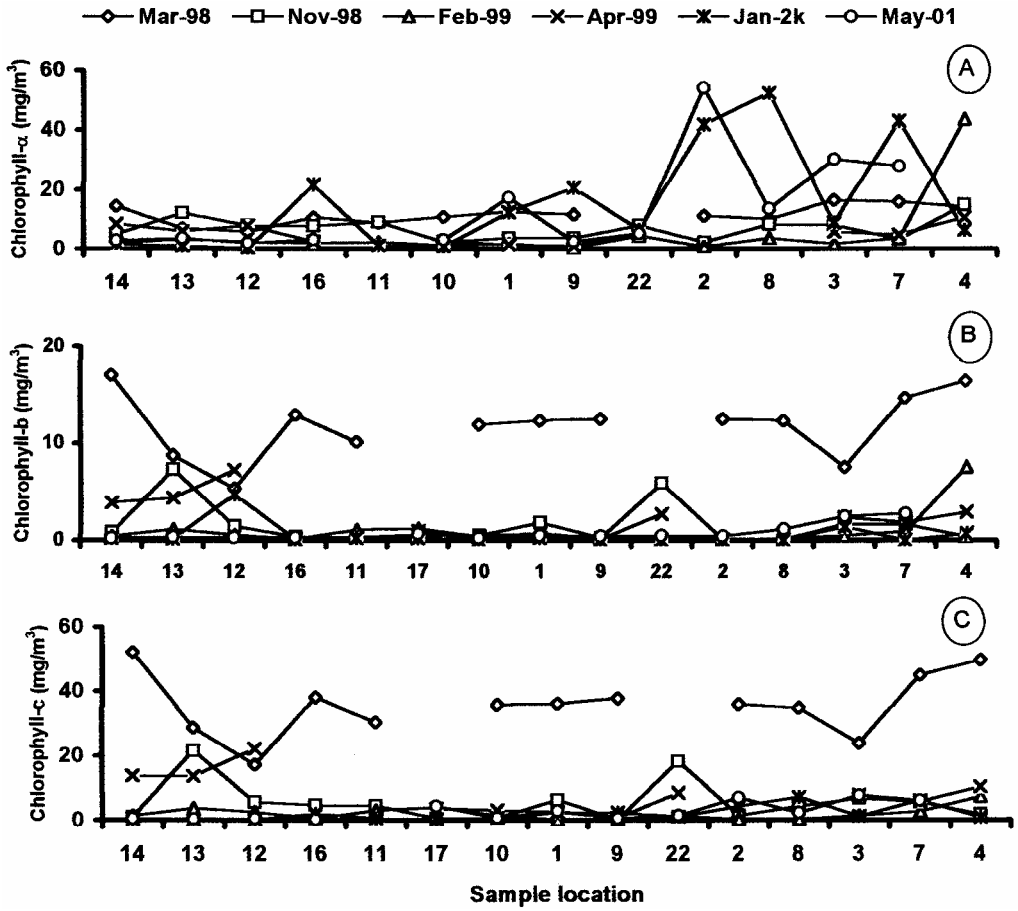

Fig. 4—Variation of chlorophyll-*a*, *b* and *c* in Chilika lake from 1998-2001.

Multiple correlation analysis

Taking the entire Chilika lake as one entity, the water quality data were analysed for multiple correlations among all the 13 variables of the samples collected in a given season. The strong +ve correlation (+0.45 to +0.86) between DO and *p*H in almost all sampling periods indicates the production of dissolved oxygen by photosynthetic activity. The northern sector was enriched with growth of submerged weeds before opening of new mouth due to almost stagnant water condition. Therefore, the depletion of carbon-dioxide due to photosynthesis might have raised the *p*H of water column before new mouth opening. But in May 2001 sampling period the increase of salinity due to opening of the new mouth decreased the growth of weeds in the northern sector. This is marked by a poor +ve correlation between DO and *p*H in May 2001.

Salinity is having poor to moderate –ve correlation with dissolved oxygen indicating the high photosynthetic activities in the fresh water zone. This is supported by the –ve correlation between salinity with primary productivity (max. -0.49) and chlorophyll-*a* (max. –0.67) in the same sampling period. This relationship indicates that salinity is the predominant factor controlling phytoplankton growth and distribution. Similar observations were also reported earlier from Rushikulya estuary[10] and Cochin back water[11]. The –ve correlation between salinity and the nutrients (NH_3, NO_2, NO_3, PO_4) indicates that the fresh water is the source of nutrients that are coming to the lake.

The –ve correlation (max. –0.65) of dissolved oxygen with NO_3 in some cases indicates the conversion of NO_2 to NO_3 with the reaction of oxygen. The +ve correlation (max. +0.73) between BOD and NH_3 in some sampling period indicates the organic source of free ammonia in the lake system. PO_4 concentration is having a moderate –ve correlation with DO indicating consumption of phosphate due to utilization by phytoplankton with the release of oxygen through photosynthesis.

Largescale changes were observed in the Chilika lake after the opening of the new mouth in reference

to the water quality prior to it. After the opening, mainly there were large variation of salinity within the lake due to seawater intrusion, faster declining of weeds and flushing out of silt load, which would help in high fish catch, deepening of lake, dispersion of localized pollution and overall restoration of ecosystem of the wetland.

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