

Distribution of macrophytic vegetation in relation to salinity in the Chilka lake, a lagoon along east coast of India

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Growth and distribution of the macrophytic vegetation in the Chilka lake in relation to the distribution of salinity were studied during 1996 to 1998 in order to assess its ecological condition. The lake was found to be highly heterogeneous with regard to the distribution of salinity; its value during summer varied from almost negligible (in the northern sector) to as high as 23.65 ± 8.13 ppt (in the central sector). The inter-seasonal variation of salinity was found to be the highest in the central sector. It was further observed that the western region of the central sector of the lake remained even more saline than the southern sector during summer. Altogether 12 macrophyte species were identified from the lake. The lake, particularly its northern and the central sectors, was found to be extensively colonized by these macrophytes. It was also observed that the distribution of the macrophytes and the massiveness of their colonization were dependent on the salinity condition of the lake. The study suggests that the Lake is threatened to lose its identity, which could be avoided by adopting methods to increase its salinity.

Aquatic ecosystem plays an important role in man's daily life; it not only provides food, but also is of great importance in other aspects such as aesthetic value, tourism, etc. The Chilka lake is one such ecosystem in Orissa (Fig. 1). It is a pear-shaped lagoon, largest in Asia having an average waterspread area of 1054 km^2 , measuring 64.5 km in length with width varying from 5 km in the southern part to 18.5 km in the northern part¹. The livelihood of tens of thousands of fishermen depends on it.

Like all lagoons, the Chilka lake is very dynamic being heavily influenced by marine, fluvial and terrestrial systems. And probably for the same reason the health of the lake over the years has deteriorated greatly. Being an ecosystem of international importance, several studies have been conducted over the past decades to depict its ecological features²⁻⁷. The studies conducted, however, mostly have been of short-term in nature, and in general are too old to reflect the current ecological condition of the lake. Secondly, whatever studies carried out on the lake so far concerning the macrophytes are only of taxonomic significance^{8,9}, throwing no light on its weed infestation problem, which is a major concern today. Keeping these in view, and the fact that salinity constitutes

the most important ecological parameter of a lagoon, the present study has been conducted. The paper reports the distribution of salinity in the lake together with the availability and distribution of the weeds during two seasons spanned over three years.

Materials and Methods

The pear-shaped lagoon (lat. $19^{\circ}28' - 19^{\circ}56' \text{ N}$ and

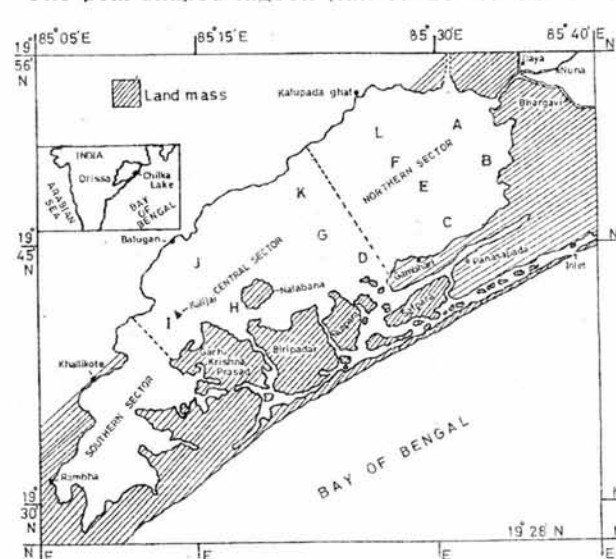


Fig. 1—Location of the Chilka lake and the study regions.

into 3 sectors- northern, central and southern (Fig. 1). It is connected to the Bay of Bengal through a long narrow channel at the northern sector. The rivers Daya, Bhargavi and Nuna enter into the lake from the north. Many small streams also enter into the lake at its western margin.

A preliminary survey of the lake revealed that the weed infestation problem was mostly confined to the northern and the central sectors, the southern sector remaining nearly devoid of vegetation. Hence, we restricted our study only to the northern and the central sectors. The study was conducted in winter -Nov.-Dec. (postmonsoon season) and summer -April-May (premonsoon season) during 1996, 1997 and 1998. July and Aug. represent the most active monsoon period. Water samples were collected from more than 50 locations during each survey, guided by field compass and land markings. The samples were analysed for salinity following standard method¹⁰. The salinity values of the adjacent locations were then grouped together to give the mean salinity values at 12 regions (Fig. 1) each including the salinity value of at least three locations, except the region D in April '96 which represents the salinity of only one location. While collecting the water samples, the availability of the macrophytes was also recorded.

The macrophytes available in the lake were identified following the manual of aquatic plants of Fasset¹¹. A few plant species were also sent to National Botanical Research Institute, Lucknow for identification. The availability of the macrophytes was quanti-

fied in terms of their relative frequency using quadrat¹². This study was, however, carried out only in 6 regions of the lake selected keeping in view the distribution of salinity.

Results and Discussion

With regard to salinity distribution, the lake was found to be highly heterogeneous (Fig. 2); the mean salinity values at different regions of the lake varied from almost negligible (at the region A) to as high as 23.65 ± 8.31 ppt (at the region G). The mean of all the seasons' (months') salinity values at any region was least at the region A and highest at the region K.

The lake also showed great variation in salinity between the seasons (Fig. 2); the variation was maximum at the region L and minimum at I. In general, the maximum fluctuation in salinity was recorded in the northern part of the central sector, or the southern part of the northern sector envisaging regions D, G, K and L. In the northern sector, the regions C, E and F also exhibited great fluctuation in salinity, from almost freshwater condition during the postmonsoon season to as high as 11.50 ± 2.96 ppt (region C, May '98) during the summer season. The level of salinity in between seasons remained quite stable in the southern part of the central sector of the lake encompassing the regions H, I and J.

Altogether twelve major macrophytes were identified from the lake: *Eichornia crassipes*, *Hydrilla verticillata*, *Najas indica*, *Najas graminia*, *Vallisneria spiralis*, *Potamogeton pectinatus*, *Potamogeton*

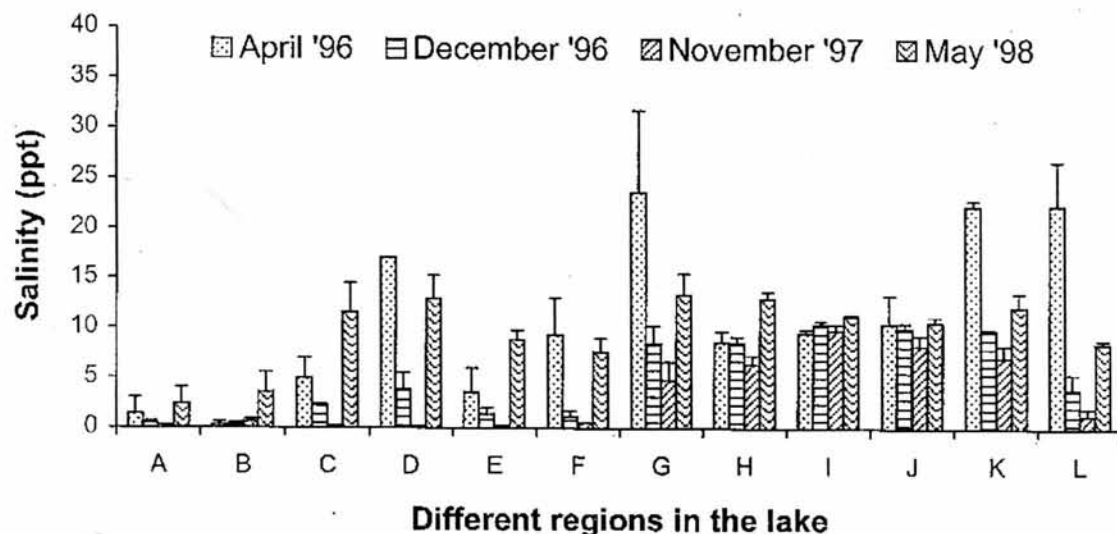


Fig. 2—Salinity (mean $\pm$ sd) at different regions of the lake during two summer and two winter months during 1996 to 1998.

natans, *Potamogeton amplifolius*, *Potamogeton crispus*, *Nymphae odorata*, *Nymphae tetragona* and *Scirpus littoralis*. The northern sector and the north-western part of the central sector encompassing the regions A, E, F, L, and K, respectively were identified as the most weed infested zones. The macrophytes growing were *N. indica*, *P. pectinatus*, *H. verticillata*, *V. spiralis*, *P. amplifolius*, *P. natans*, *P. crispus*, *N. tetragona* and *N. odorata* -all freshwater species. Another prominent weed was *Scirpus littoralis*, which remained mainly confined to the western bank of the northern sector. The availability of the macrophytes in the southern part of the central sector was limited only to *N. gramenia* and *P. pectinatus*, while *P. pectinatus* was the only macrophyte present throughout the weed-infested regions of the lake.

The study of relative frequency of the weeds revealed that *N. indica*, *H. verticillata*, *P. pectinatus*, *P. amplifolius*, *P. natans*, *P. crispus* and *V. spiralis* were the dominant weeds at the region A during the collection periods (Fig. 3A). *Eichhornia crassipes* was available in this region only. In the region E (Fig. 3B), the dominant weeds during the collection periods were mainly two, *N. indica* and *P. pectinatus* followed by *H. verticillata*, *P. amplifolius*, *P. natans*, and *P. crispus*. In May '98, *V. spiralis* was dominant instead of *H. verticillata*. The dominance of these four weeds in the region F (Fig. 3C) was nearly the same except in April '96 when *N. indica* was the most dominant, and in May '98 when *P. pectinatus* was the most dominant. No presence of *S. littoralis*, *N. tetragona* or *N. odorata* (except in Nov. '97) was noted in the region F, unlike that in the region E. These two were also absent in the region L during the collection periods (Fig. 3D). This region exhibited the dominance of *N. indica* and *P. pectinatus* among the five weeds available, similar to that in the region E. However, the presence of *H. verticillata* and *V. spiralis* was distinctly less when compared to that in the region E, as well as F. *Vallisneria spiralis* was totally absent in the region in April '96. Only *N. gramenia* and *P. pectinatus* were available in the regions J and H. While both the macrophytes were equally dominant in the region J (Fig. 3E), the dominance of *P. pectinatus* was more than *N. gramenia* in the region H (Fig. 3F).

Any water body connected to sea at one point, and receiving freshwater discharge at one or more other points ought to show heterogeneous distribution of salinity¹³⁻¹⁵. The same was also observed in the pres-

ent case. Highly heterogeneous distribution of salinity in the Chilka lake has also been reported by many workers, as compiled by Bandhyopadhyay & Gopal¹⁶. More recently, Panda *et al.*⁶ and Raman *et al.*⁷ based on their single postmonsoon survey reported a total south-north gradation of salinity in the lake. Our study, however, revealed the north-western region of the central sector to be the most saline in nature, at least during the summer; water samples collected once (one week after the April '96 survey) from deep water in the southern sector of the lake near Khal-

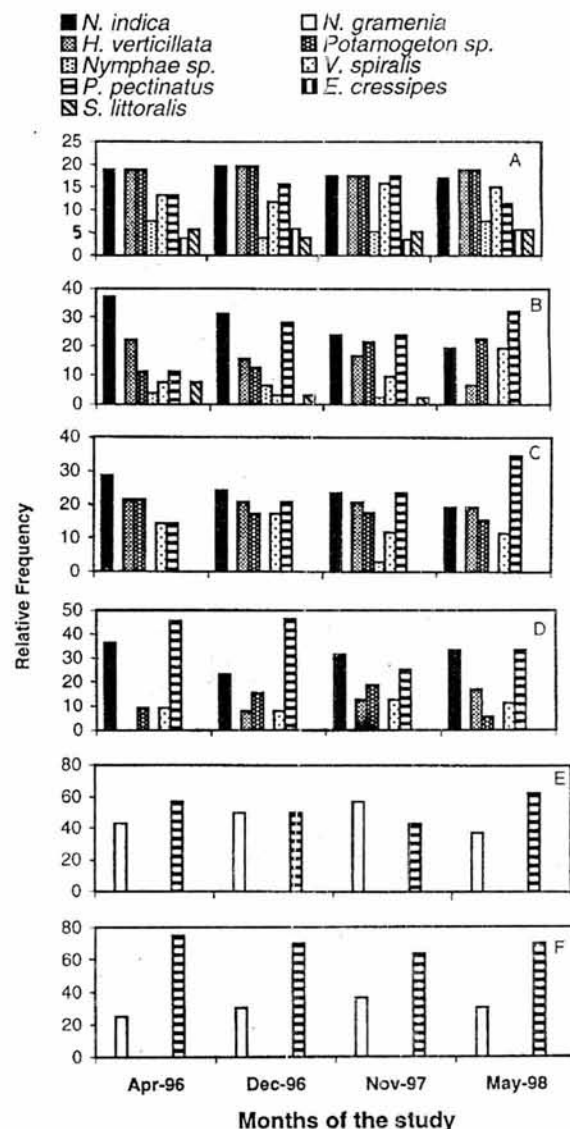


Fig. 3—Relative frequency of the available macrophytes at six selected regions in the lake during 1996 to 1998; Figures A, B, C, D, E and F respectively represent the relative frequency of the macrophytes at the regions A, E, F, L, J and H (as in Fig. 1)

likote and Rambha (Fig. 1) showed salinity of 10.54 ± 0.49 and 10.36 ± 0.39 ppt, respectively. During the postmonsoon seasons also the regions like J and K of the central sector exhibited salinity comparable to those at the southern sector, and much higher than the reported^{6,7} value of about 5 ppt. Low salinity observed in the northern sector, particularly in the postmonsoon season, is in agreement with those reported earlier^{6,7}. However, quite low salinity at most of the regions in the northern sector even during summer (when the discharges from the rivers are almost negligible) is in contrast to the reported¹⁶ salinity values of 20 to 30 ppt for the sector.

The colonization of aquatic body by rooted and/or submerged macrophytes is quite natural, but the extent of colonization and the type of species are determined by various ecological factors. In the present context, salinity seems to be the major factor determining the availability and distribution of the macrophytes in the lake. This is because the extensive colonization of the lake by the weeds was mainly confined to the northern sector and the northwestern part of the central sector, which showed almost negligible salinity, at least during the postmonsoon season. Secondly, all the species available in these regions are the inhabitants of freshwater. Further, the regions in the lake showing salinity greater than 7 ppt during the postmonsoon season remained devoid of freshwater species, except that of *P. pectinatus*. This is in agreement with the observation of Brock¹⁷ that most freshwater macrophytes disappeared from natural wetland system when the salinity was about 4 ppt. Some freshwater species, however, may tolerate higher salinity¹⁸, like *P. pectinatus* in the present case. And more importantly, the sensitiveness of aquatic plants is related to the duration of their submersion in the saline water. For example, James & Hart¹⁸ could notice a decline in *M. crispata* shoot length upon exposure to 7 ppt salinity only after 33 days. This in turn explains why the freshwater macrophytes continue to live and survive at the regions F and L even during the summer season when the salinity rises considerably; the duration of the high salinity condition in these regions might not be long enough to totally eliminate their existence. Comparatively less availability of *H. verticillata*, *P. amplifolius*, *P. natans*, *P. crispus* and *V. spiralis* than of *P. pectinatus* and *N. indica* at the region L, unlike that in the other adjacent regions, might be because of a little higher salinity level in the region when com-

pared to the adjacent regions even during the postmonsoon season and/or longer duration of the raised salinity level during the summer season; *P. pectinatus* is a known facultative halophyte, and *N. indica* has been assessed to be less sensitive to salt than at least *H. verticillata*^{19,20}.

The availability of only *P. pectinatus* and *N. graminea* in the southern regions of the central sector where the water mostly remains saline (Fig. 3E, F) suggests that salinity plays an important role in restricting the number of species of macrophytes in an aquatic body. Besides, salinity probably also reduces the rate of growth of macrophytes in general, even that of salt-tolerant species. This is evident from the fact that the colonization of the saline regions of the lake (Fig. 1, regions H and J) by both the salt-tolerant species available, *P. pectinatus* and *N. graminea*, was very thin when compared to the extent of colonization of the freshwater regions (Fig. 1, region A, and also regions E and F) by the macrophytes, including that by *P. pectinatus*. In fact, photosynthetic study carried out in laboratory on the salt-tolerant *N. graminea* revealed that the rate of oxygen evolution by the plant at 10 ppt seawater salinity was nearly half the rate at 0 ppt salinity²¹. Reduction in the growth rate of both freshwater and saline water macrophytes upon exposure to increasing salinity has also been reported²²⁻²³.

From the present study it is quite clear that the availability and distribution of the macrophytic vegetation in the lake are totally dependent upon its salinity condition; the northern freshwater regions are colonized dominantly by the freshwater species (Fig. 3A and C) while the southern saline regions are occupied only by the salt-tolerant species (Fig. 3E, F), and the regions of the lake where salinity fluctuates greatly in between seasons, e.g. the region L (Fig. 1), show the dominance of facultative halophyte, like *P. pectinatus* and/or a little salt-tolerant species, like *N. indica* (Fig. 3D). The study further indicates that the immediate effect of decrease in salinity of a lagoon is probably intrusion into it of submerged freshwater macrophytes, which may be followed by massive colonization of the freshwater and the less saline regions of the lagoon by the intruding species; submerged aquatic plants show much higher photosynthetic efficiency and better growth rate under low salinity and/or freshwater condition than under high salinity condition²¹⁻²³. In the present case, however, it is difficult to say how and to what extent the availability and distribution of the macrophytes in the lake

might have been affected over the years because of its changing (decreasing) salinity level as the information on the subject from earlier studies is scant. Nevertheless, the decreasing overall average salinity of the lake and its massive colonization by freshwater macrophytes are of great concern, and need immediate attention if the identity of the lake and its aesthetic value is to be preserved. The initiation of creation of a strait-cut by the Chilka Development Authority (CDA), Orissa to facilitate the entry of seawater into the lake is a welcome move in this regard, which may improve the salinity of the lake greatly. However, at the same time, attempt should also be made to reduce the discharge of freshwater into the lake by the rivers for a more promising result of the strait-cut.

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