Journal of the
Marine Biological Association of India

ABBREVIATION : *J. mar. biol. Ass. India*

Vol. 29 June & December 1987 No. 1 & 2

ALGAE OF INDIAN ESTUARIES

M. UMAMAHESWARA RAO

Department of Botany, Andhra University, Waltair

ABSTRACT

Types of estuaries occurring along the Indian shores and composition and distribution of macro-algae and phytoplankton of some Indian estuaries are given in this review, together with some observation made on algae of the Godavari delta. Information available is very meagre to classify the Indian estuaries based on the occurrence of algae and on their distribution in relation to salinity gradient.

INTRODUCTION

ESTUARIES are highly variable and interesting ecosystems, where a strong transition exists between the sea and the freshwater. The river and tidal currents produce complicated effects on water mixing, sedimentation processes, nutrient levels and productivity in the estuaries. Though there are several major and minor estuaries all along the coasts of India, the macro-and micro-algae adapted to these dynamic ecosystems have not received much attention. An attempt is made here to describe the different types of estuaries in India and to review the available work on the composition and distribution of estuarine algae. Some data collected on algae of the Godavari delta complex are also presented in this account.

Plankton samples in the shelf area off Godavari were collected in an NIO cruise (No. 121). I am thankful to the Director, National Institute of Oceanography, Goa for permission to participate in the cruise. Work on Godavari Estuary was done in a project sanctioned by the Department of Environment, Forests and Wild Life, New Delhi and the financial assistance received from the department is gratefully acknowledged,

ESTUARIES

For the purpose of this review, the estuary is defined as a basin where one or more rivers or coastal streams introduce freshwater into the sea. Creeks, backwaters and lagoon-like coastal water bodies which are separated by barriers from the sea are not considered here as estuaries. Estuaries are formed by geological processes like submergence and emergence of shores and depending on the shape of the basin

and other parameters, they are classified into drowned valleys, kayals and deltas (Ahmed, 1972). Reid and Wood (1976) classified the first two types as simple and irregular estuaries and Ahmed (1972) used the term *Ria* for the drowned river valley type of estuary.

Drowned river valley estuaries : Simple estuaries of this type are most common on the west coast between Gujarat and Mangalore. The river mouth areas of Mahe, Sabarmati, Kim, Narmada, Tapti (Tapi), Purna, Ambica, Mandovi-Zuary, Kali and Damanganga are geomorphologically identified as river valley estuaries (Fig. 1). Many of these are associated with extensive mud flats and salt marshes. The small rivers between the Hooghly and the Godavari on the east coast, such as the Suvarnarekha, Vamsadhara and the Nagavali also have simple estuaries (Ahmed, 1972).

Kayals or irregular estuaries : The backwaters on the west coast between Kanyakumari and Mangalore are locally called *Kayals*. This type of estuary is very irregular and separated from the open sea by long spits of offshore bars. There are 30 Kayals on the southeast coast of India (Nair *et al.*, 1983) and Vembanad Lake is the largest (75 km long and 5-10 km broad) Kayal in Kerala (Fig. 1). Its bar mouth is situated at Cochin. The central part of the Vembanad Lake is known as Cochin Backwaters. The second largest Kayal is the palmleaf like Ashtamudi Estuary (Fig. 1).

Deltas : Deltas are triangular area broadening from the river valley towards the mouth. They are associated with land projecting from the sea in the form of proturberances. The tributaries and main branches of the river divide further into narrow channels and mangrove forests and marshy tidal flats usually occur on the seaward side of the deltas. Deltas largely occur on the east coast of India and the prominent ones are those of the River Ganga (Hooghly), the Mahanadi, the Godavari (Fig. 1), the Krishna and the Cauvery.

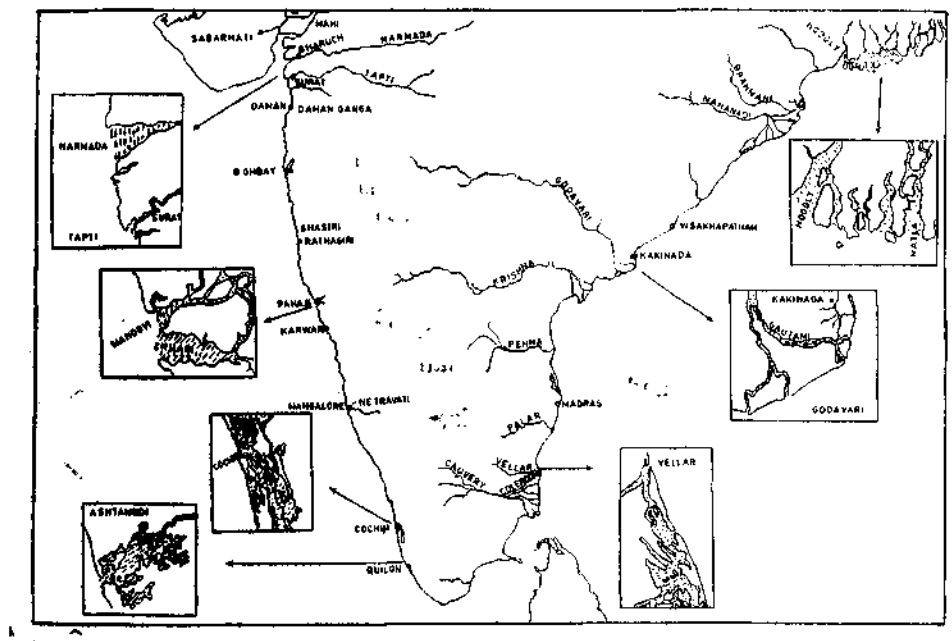

FIG. 1. Estuaries along Indian Coast.

Indian estuaries: About 2,14,500 ha of estuarine areas (including lagoons and lakes) are available in India (Jhingran and Gopalakrishnan, 1973). Many of the Indian estuaries are positive type with myxo-haline conditions (30-0.5‰). The force of the tidal inflow is felt upto 295 km in the Ganga-Hooghly estuarine complex and upto 65 km in small rivers like Mandovi-Zuari. The shape of the basin (Fig. 1) and the quantity and season of freshwater outflow in a year vary markedly in different estuaries. Though these parameters alter the chemical nature, circulation patterns and distribution of biological populations, detailed investigations were not made on many important estuaries in India. Even the distribution and mixing pattern of salinity were studied so far in the Godavari (Ganapati and Ramasarma, 1965), Vellar (Ramamoorthi and Venugopalan, 1976) and Mandovi-Zuari (Qasim and Sengupta, 1981) estuaries. Hydrobiological work done upto 1980 on Indian estuaries was given in a report published by the National Institute of Oceanography (NIO, 1982) and this report clearly shows that only three estuaries (Vellar, Vembanad and Mandovi-Zuari) have been investigated in detail in our country. Our knowledge of the composition and distribution of phytoplankton and macro-algae is limited to eleven estuaries and summary of the work done so far is given in Table 1.

TABLE 1. *Work done on macro-algae and phytoplankton of Indian Estuaries*

Estuary	Author(s)
Narmada	Ragothaman & Patil (1986)
Tapti (Tapi)	Ragothaman & Reddy (1982)
Damanganga	Sitaramaiah (1975)
Kajvi-Shastri	Achutankutty *et al.* (1981)
Mandovi-Zuari*	Devassy & Bhargava (1978); Jagtap (1985)
Vembanad	Kumaran & Rao (1972); Devassy & Bhattathiri (1974); Gopinathan (1974)
Ashtamudi*	Mathew & Nair (1980); Nair *et al.* (1982)
Coleroon	Jagadeesan & Ayyakkannu (1985)
Vellar*	Kannan & Krishnamurthy (1978); Krishnamurthy & Santhanam (1980)
Godavari*	Umamaheswara Rao (present study)
Hooghly-Matlah	Dutta *et al.* (1954)

* Macro-algae

COMPOSITION AND DISTRIBUTION OF MACRO-ALGAE

Benthic macro-algae of Vellar (Kannan and Krishnamurthy, 1978; Krishnamurthy and Jayaseelan, 1984), Mandovi-Zuari (Jagtap, 1986) and Ashtamudi (Nair *et al.*, 1982) Estuaries have been studied. From the data given by these workers and from the observations made in the Godavari Estuary, the composition and relative frequency of macro-algae populations found in the high salinity or mouth zone and in the brackishwater or upstream zones are shown separately in Tables 2 and 3 and in Fig. 2. In all these estuaries plants belonging to Classes Chlorophyceae, Florideophyceae and Cyanophyceae were found and their composition varies with the distribution of salinity. The salinity of the narrow mouthed Vellar Estuary near Porto Novo was low during the monsoon period from September to October or November (Ramamoorthi and Venugopalan, 1976). In the adjoining backwater (Fig. 1) the salinity was comparatively higher than in the estuary due to entry of sea water through another opening near Chinnavaikkal. In view of these differences in the environment, macro-algae which grow in open coastal waters such as *Gracilaria* sp., *Hypnea* sp., *Acanthophora spicifera* and *Enteromorpha compressa* were recorded in the backwater area by Kannan and

Krishnamurthy (1978). In the estuary proper, only members of Chlorophyceae like *Enteromorpha* and *Chaetomorpha* were collected by them (Table 2). In Mandovi-Zuari estuarine system, the waters are well mixed from surface to bottom near the mouth (Qasim and Sengupta, 1981) with high salinity for most part of the year and the low salinity period extends from June to August/September. Working in this estuary Jagtap (1986) collected open shore macro-algae like *Ulva fasciata, Enteromorpha intestinalis, Chaetomorpha linum, Gracilaria verrucosa, Hypnea musciformis* from the mouth or marine zone and other forms like *Enteromorpha compressa, Rhizoclonium* sp., *Catanella impudica, Caloglossa liprieurii* and *Bostrychia tenella* from the mangrove areas of low salinity zone (Table 2). From Ashatamudi Estuary Nair *et al.* (1982) reported intertidal algae like *Ulva lactuca, Chaetomorpha media, Grateloupia lithophila, Centroceras clavulatum* and *Acanthophora spicifera* in stations around bar mouth, where the salinity of the water ranged from 27-35‰ (Table 3). In the

TABLE 2. *Composition of macro-algae in Vellar and Mandovi-Zuari Estuaries*

Class	VELLAR (Kannan & Krishnamurthy, 1978)		MANDOVI-ZUARI (Jagtap, 1985)	
	Backwater	Estuary	Mouth region	Upstream
Chlorophyceae	*Enteromorpha clathrata* *E. compressa* *Chaetomorpha* sp.	*E. clathrata* *E. compressa* *Chaetomorpha* sp.	*Dichotomosiphon salina* *Ulva fasciata* *U. lactuca* *Monostroma* sp. *Enteromorpha intestinalis* *E. flexuosa* *Chaetomorpha linum* *Cladophora* sp.	*E. clathrata*
Florideophyceae	*Gracilaria* sp. *Hypnea* sp. *Polysiphonia* sp. *Ceramium* sp. *Acanthophora spicifera*	..	*Gracilaria verrucosa* *Hypnea musciformis*	*Catanella impudica* *Caloglossa leprieurti* *Polysiphoni lanosa* *Bostrychia tenella*
Cyanophyceae	*Oscillatoria* sp.	*Oscillatoria* sp. *Lyngbya* sp.	*O. nigroviredis* *O. annae* *O. martinii* *Phormidium fragile*	*O. earlai* *O. princeps* *O. limosa* *Phormidium* sp. *Microcoleus chthanoplastes* *Spirulina* sp. *Schizothrix* sp. *Anabaena* sp.

* Not recorded.

interior brackishwater area of the estuary (10-34‰) species of *Enteromorpha, Cladophora, Gracilaria, Hypnea, Polysiphonia* and *Caloglossa liprieurii* were found by these authors. In the Godavari Estuary, *Chaetomorpha* sp., *Caloglossa liprieurii, Catanella impudica, Bostrychia tenella, Polysiphonia* sp. and blue green algae were collected (Table 3) and the composition of algae resembled that of low salinity areas of Ashtamudi and Mandovi-Zuari Estuaries.

The relative frequency values (Fig. 2) of the three classes of macro-algae growing in the saline and brackishwater areas, also varied in the four estuaries investigated. Though these observations were not made along the gradient of the estuary, members of Florideophyceae were more abundant in high salinity zones of Vellar (Backwater) and Ashtamudi estuaries, than the members of Chlorophyceae. As the salinity decreased, there is reduction in the members of red algae and the Chlorophyceae

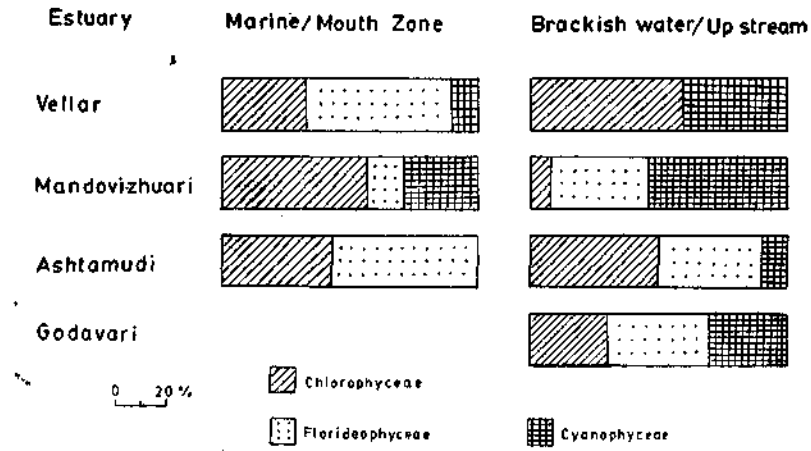

FIG. 2. Relative frequency of macro-algae collected from the high saline and brackishwater zones of Indian estuaries.

TABLE 3. *Composition of macro-algae in Ashtamudi and Godavari Estuaries*

CLASS	ASHTAMUDI (Nair *et al.*, 1982)		GODAVARI
	Mouth zone	Brackishwater zone	Brackishwater zone
Chlorophyceae	*Ulva lactuca* *Chaetomorpha media*	*U. lactuca* *Enteromorpha linza* *E. flexuosa* *Entermorpha* sp.	*Chaetomorpha* sp. *Protoderma* sp. *Phaeophila* sp.
Florideophyceae	*Grateloupia lithophila* *Centroceras clavulatum* *Acanthophora spicifera*	*Caloglossa leprieurii* *Caloglossa* sp. *Polysiphonia* sp.	*C. leprieurii* *Catanella impudica* *Polysiphonia* sp. *Bostrychia tenella*
Cyanophyceae	*	*Microcoleus* sp.	*Microcoleus* sp. *Oscillatoria* sp. *Lyngbya* sp.

* Not recorded.

have become more abundant in the low salinity or upstream zones. Similarly members of Cyanophyceae were not observed or less abundant in the marine zones and there was progressive increase in their number in the upstream areas (Fig. 2).

Information on seasonal changes in estuarine algae is very limited (Jagtap, 1986). In Mandovi-Zuari Estuary Jagtap (1986) observed only *Enteromorpha clathrata*, *Catanella impudica* and *Caloglossa leprieurii* throughout the year. The other algae were found in certain months of the year and in general their abundance increased during the drought season (high salinity period) than in the monsoon season.

Vertical Distribution of Macro-Algae

Vertical distribution or zonation of algae and animals can be seen on hard substrata or on basal parts of the mangrove vegetation, since tidal influence is observed in estuaries. However, a well defined zonation as observed on intertidal rocky surfaces of open coasts (Umamaheswara Rao and Sreeramulu, 1964) may not occur in estuaries and fluctuations in salinity, tidal range and heavy sediment load or turbidity of the water modify the zonation in these areas. The preliminary data collected on the vertical distribution of algae and a few animals in the Godavari Estuary is summarised in Table 4. The tidal range is about 80 cm in the Coringa area of the Godavari Estuary and the three major zones of Stephenson and Stephenson (1949) can be recognised on the pneumatophores of *Avicennia*, proproots of *Rhizophora* and other mangrove plants. Members of Florideophyceae (Tables 3 and 4) were found in the infra-littoral fringe and only *Chaetomorpha* spp. were seen in the midlittoral zone of about 30 cm. Algae are absent in the supra-littoral fringe and the zone indicating *Littorina* species occurred on the upper parts of stems and leaves of small mangrove plants facing the channels.

Composition and Distribution of Phytoplankton

As in neretic or coastal waters, diatoms and dinoflagellates are the most common groups in the phytoplankton of estuaries. In addition to these major components, members of Chlorophyceae, Cyanophyceae and Euglenophyceae occur in relation to salinity changes in the estuarine ecosystems. Relative frequency of the members of these major classes reported from Narmada, Tapi, Mandovi-Zuari, Shastry-Kajvi and Godavari estuaries is shown in Table 5. As detailed information is

Table 4. *Vertical zonation of algae and animals in the channels of Godavari delta complex*

Zone	Organisms
Supra littoral fringe	No algae *Littorina* sp.
Midlittoral zone (width *ca.* 30 cm)	*Chaetomorpha* sp. Blue green algae *Chthamalus* sp.
Infralittoral fringe	*Caloglossa leprieurii* *Catanella impudica* *Bostrychia tenella* *Polysiphonia* sp. Blue green algae

available from Vellar, Vembanad, Ashtamudi and Hooghly Estuaries, the relative frequency of phytoplankton recorded from different areas are diagramatically represented in Fig. 3 to show how salinity influences the composition of phytoplankton. Members of green and blue green algae were not seen in the phytoplankton of Mandovi-Zuari Estuary (Table 5) collected mainly from the mouth area (Devassy and Bhargava, 1978). In Tapi and Narmada Estuaries 12 to 25% of green and blue green algae were observed since these observations were made in the upstream areas where the salinity was low (Ragothaman and Reddy, 1982; Ragothaman and Patil, 1986). In Shastri and Kajvi Estuaries green algae were

not found (Achutankutty *et al.*, 1981), whereas Euglenoids occurred in the water samples analysed from Godavari (Table 5) and Narmada (Ragothaman and Patil, 1986) Estuaries.

TABLE 5. *Relative frequency of different groups of phytoplankton in some Indian Estuaries*

Group (%)	Mandovi Zuari*	Shastri-Kajvi	Tapi	Narmada	Godavari-Gaderu channel
Diatoms	92.9	60.0	56.4	67.1	70.0
Dinoflagellates	2.5	20.0	..	..	5.0
Green algae	..	..	25.6	15.1	5.0
Blue green algae	..	10.0	12.8	12.9	10.0
Euglenoids	..	..	..	4.9	10.0
Others	4.6	10.0	5.2	..	..

.. Not recorded. * Based on cell number.

salinity altered the composition of phytoplankton examined near the bar mouth (Gopinathan, 1974) and in the inner parts of the backwater (Devassy and Bhattathiri, 1974). As shown in Fig. 3, abundance of planktonic green and blue green algae was more in the interior parts of the backwater than at bar mouth. In Ashtamudi Estuary (Mathew and Nair, 1980) green and blue green algal groups were more numerous (Fig. 3) in the brackishwater stations and multicellular algae like *Enteromorpha. Ulothrix*, *Oedogonium*, *Spirogyra* and *Rhizoclonium* were recorded in large numbers in the plankton in this area. In Hooghly-Matlah and Vellar Estuaries (Dutta *et al.*, 1954; Krishnamurthy and Santhanam, 1980), similar variations were found between the brackishwater and marine or high salinity zones (Fig. 3).

As in macro-algae populations, progressive

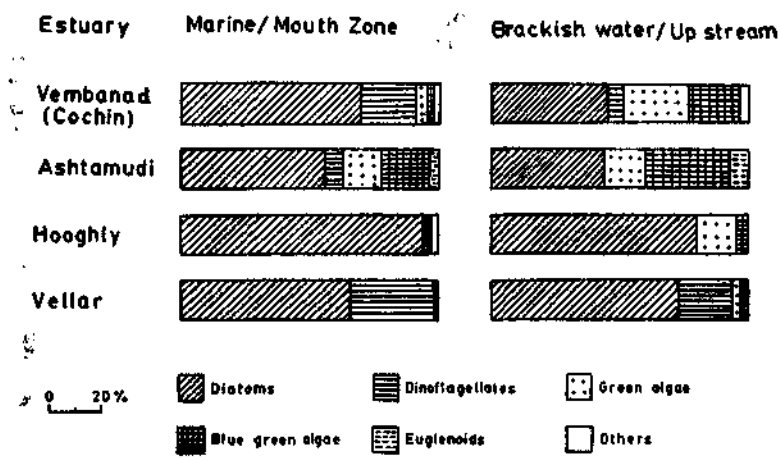

FIG. 3. Relative frequency of different phytoplanktonic population in the high saline and brackishwater zones of four Indian estuaries.

In Vembanad Lake (Cochin Backwater) except for the premonsoon increase in salinity, freshwater conditions prevailed throughout the year in the northern and southern parts of the backwater (Lakshmanan *et al.*, 1982) and in areas near the bar mouth, surface salinity ranged from 10-30‰. These differences in reduction was observed in the number of species of diatoms and dinoflagellates from marine to brackishwater zones and this reduction was more prominant in dinoflagellates. Interesting data collected by Krishnamurthy and Santhanam (1980) on species abundance in four different habitats at Porto Novo are

given below to show the reduction in species number from neritic to mangrove habitats. The salinity of the water decreased from neritic to mangrove zones of this area.

	Diatoms	Dinoflagellates
Neritic	81	40
Backwater	63	19
Estuary	52	15
Mangrove area	50	8

Krishnamurthy *et al.* (1974) determined the salinity limits and other environmental conditions needed for the distribution of phytoplankton of Vellar Estuary. These authors found *Melosira dubia, Hemiaulus sinensis* and *Rhizosolenia calcar-avis* only in the estuary and not in other areas, Planktonic diatoms tolerating estuarine conditions occurred sometimes in large numbers or in blooming proportions. Devassy and Bhattathiri (1974) and Mani *et al.* (1986) reported *Nitzschia sigma, Skeletonema costatum, Asterionella glacialis, Cylindrotheca closterium, Thalassionema nitzschioides, Thalossiothrix frauenfeldii* as bloom forming species in Vembanad (Cochin Backwater) and Vellar Estuaries, especially during the low salinity periods.

The relationship between species numbers and individuals was not studied in Indian estuaries. Data collected for three months (May, June and August 1985) from the Godavari Estuary and from the continental shelf area off Goutami Godavari are presented in Fig. 4, to show the differences in the structure of phytoplankton in the estuary and coastal waters. The species number was more and the number of individuals was less in the coastal area off Godavari, whereas reverse trend was seen in the estuary with less number of species and more number of individuals of certain tolerant species (Fig. 4). Detailed studies are needed on indicator species adapted to estuarine conditions and on the structure on the phytoplankton communities to compare the composition and distribution of phytoplankton of different estuaries.

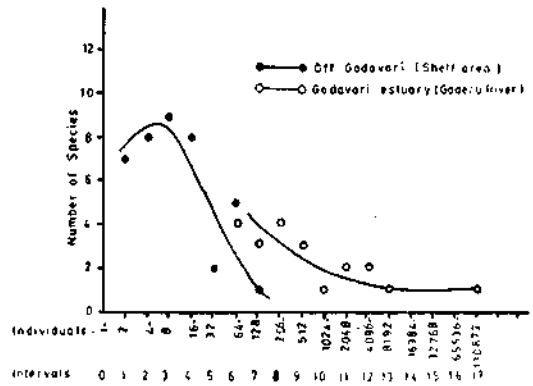

FIG. 4. Differences in the structure of phytoplankton in the estuary and coastal waters of Godavari.

POLLUTION IN ESTUARIES

In polluted estuaries wastes released are often retained and recycled leading to eutrophication and increased growth of phytoplankton. In addition to changes in species number or diversity, some tolerant species of green and blue green algae and Euglenoides occur as common inhabitats both in the polluted as well as unpolluted estuaries. Though the plant life of Indian estuaries was not studied in detail, more number of blue green algae as also Euglenoides were recorded in some of the estuaries investigated such as Hooghly (Dutta *et al.*, 1954) and Ashtamudi (Mathew and Nair, 1980). Krishnamurthy *et al.* (1974) and Kannan and Krishnamurthy (1983) reported low species diversity of phytoplankton in certain parts of the Vellar Estuary and mangrove habitat, where the concentrations of copper, sewage, pesticides and insecticides were high.

CONCLUSION

From the foregoing discussion it is evident that many major and minor estuaries of India

have not been studied and much work remains to be done on the composition and distribution of benthic macro—and micro-algae and phytoplankton in normal as well as polluted estuaries. Though reduction in species and certain other variations were seen in the composition and distribution of macro-algae and phytoplankton, existing information is not sufficient to compare and classify the Indian estuaries either on the basis of algae present or on their distribution in relation to salinity gradient. Laboratory experiments must be conducted to study the tolerance levels of algae to estuarine conditions and to provide evidence on factors regulating their distribution in estuaries.

References

ACHUTANKUTTY, C. T., S. R. S. NAIR, V. P. DEVASSY AND V. R. NAIR 1981. Plankton composition in two estuaries of the Konkan coast during premonsoon season. *Mahasagar*, N. I. O. Bull., **14** : 55-60.

AHMED, E. 1972. *Coastal Geomorphology of India*, Orient Longman, New Delhi.

DEVASSY, V. P. AND P. M. A. BHATTATHIRI 1974. Phytoplankton ecology of the Cochin Backwater. *Indian J. Mar. Sci.*, 3 : 46-50.

——— AND R. M. S. BHARGAVA 1978. Diel changes in phytoplankton populations in the Mandovi and Zuari Estuaries of Goa. *Mahasagar*, N.I.O. Bull., **11** : 195-199.

DUTTA, N., J. C. MALHOTRA AND B. B. BOSE 1954. Hydrology and seasonal fluctuations of the plankton in the Hooghly Estuary. *Proc. Indo-Pacific Fish. Counc., Bangkok*, pp. 35-46.

GANAPATI, P. N. AND D. V. RAMASARMA 1965. Mixing and circulation in Gautami-Godavari Estuary. *Curr. Sci.*, **34** : 631-632.

GOPINATHAN, C. P. 1974. Seasonal abundance of phytoplankton in the Cochin back waters. *J. mar. biol. Ass. India*, **14** : 568-577.

JAGTAP, T.G. 1986. Studies on the associated flora of the mangrove environment. *Proc. Natl. Symp. Biol. Util. Conr. Mangroves, Kolhapur*, pp. 180-187.

JHINGRAN, V. G. AND V. GOPALAKRISHNAN 1973. Estuarine fisheries resources of India in relation to adjacent seas. *J. mar. biol. Ass. India*, **15** : 323-334.

KANNAN, L. AND K. KRISHNAMURTHY 1978. A survey of the algae of Porto-Novo region (Coramandal Coast, Bay of Bengal). *Seaweed Res. Util.*, 3 : 1-4.

——— AND ——— 1983. Diatoms as indicators of water quality. *All India Phyco. Congr., Kanpur*, pp. 87-91.

KRISHNAMURTHY, K. AND M. J. P. JAYASEELAN 1984. Human's impact on the Pichavaram mangrove ecosystem : A case study from Southern India. *Proc. As. Symp. Mangr. Env. Res. Mang.*, pp. 624-632.

——— AND R. SANTHANAM 1980. Species distribution of phytoplankton of Porto Novo region (India). In : T. V. Desikachari and V. N. Raja Rao (Ed.) *Taxonomy of Algae*. pp. 707-732.

———, ——— AND V. SUNDARARAJ 1974. Species distribution in aquatic environment. *Indian J. Mar. Sci.*, 3 : 135-138.

LAKSHMANAN, P. T., C. S. SHYNAMMA, A. N. BALACHAND, P. G. KURUP AND P. N. K. NAMBISAN 1982. Distribution and seasonal variation of temperature and salinity in Cochin Backwater. *Ibid.*, **11** : 170-172.

MANI, P., K. KRISHNAMURTHY AND R. PALANIAPPAN 1986. Ecology of phytoplankton blooms in the Vellar Estuary, east coast of India, *Ibid.*, **15** : 24-28.

MATHEW, T. AND N. B. NAIR 1980. Phytoplankton of the Ashtamudi Estuary, Kerala. *Ibid.*, **9** : 253-257.

NAIR, N. B., V. SOBHA AND M. ARUNACHALAM 1982. Algae from South Kerala Coast. *Ibid.*, **11** : 266-269.

———, P. K. A. AZIS, K. DHARMARAJ, M. ARUNACHALAM, K. KRISHNAKUMAR AND N. K. BALASUBRAMANIAN 1983. Ecology of Indian estuaries : Part I. Physicochemical features of water and sediment, nutrients of Ashtamudi Estuary. *Ibid.*, **12** : 143-150.

N. I. O. 1982. *Estuarine Research in India : State of the art report*. National Institute of Oceanography, Dona Paula, pp. 1-75.

QASIM, S. Z. AND R. SENGUPTA 1981. Environmental characteristics of the Mandovi-Zuari estuarine system in Goa. *Estn. Coast Shelf. Sci.*, **13** : 557-578.

RAGOTHAMAN, G. AND Y. R. REDDY 1982. Hydrobiology of Tapi Estuary, Surat. *Indian J. Mar. Sci.*, **17** : 256-257.

——— AND T. S. PATIL 1986. Hydrobiology of Narmada Estuary. *Natl. Symp. Estu. Biol., Parangipettai* (Abstract).

RAMAMOORTHI, K. AND V. K. VENUGOPALAN 1976. Distribution of salinity and mixing pattern in the Vellar Estuary. *J. mar. biol. Ass. India*, **18** : 461-468.

REID, G. K. AND R. D. WOOD 1976. *Ecology of inland waters and estuaries*. D. Van Nostrand Co., New York.

STEPHENSON, T. A. AND A. STEPHENSON 1949. The universal features of zonation between tide marks on rocky coasts. *J. Ecol.*, **37** : 289-305.

UMAMAHESHWARA RAO, M. AND SREERAMULU 1964. An ecological study of some intertidal algae of the Visakapatnam Coast. *J. Ecol.*, **52** : 595-616.