Rec. zool. Surv. India, 94 (2-4) : 217-231, 1994

OBSERVATIONS ON THE ADYAR ESTUARINE SYSTEM, MADRAS (INDIA) WITH REFERENCE TO RESTORATION OF BIOLOGICAL DIVERSITY

S. KRISHNAN

Marine Biological Station,
Zoological Survey of India,
Madras 600 028.

INTRODUCTION

The forty kilometer long Adyar river which drains its contents into the Bay of Bengal within the southern limits of Madras city is unique in many aspects. The Adyar river, estuary and backwater form a veritable habitat for a number of species of plants and animals. The estuary, which gets cut off from the sea for the major part of the year due to the formation of a prominent sandbar impounding brackish water, is subjected to a lot of environmental variations by nature and urban civilisation. The Adyar estuarine system as a whole not only provides asylum to migrant avifauna but also harbours a host of other forms which may be wiped off from the niches by the way and rate at which the urban civilisation progresses. The few islets projecting out are also under stress. Contributing to the ill-health of the water body on the northern side of the estuary are quite a number of hutments of fishermen, housing board units, shops, small industrial establishments, schools and places of public utility on either side of river.

The most unusual aspect of this urban estuary is the presence of approximately 175 species of birds of which nearly 75 are migrants, 23 species of reptiles, 9 species of amphibians, and 4 varieties of shore crabs including the giant ghost crab which has become a rare sight (Tamilnadu Forest Department Correspondence, 1984). Five species of mammals frequent this area. The olive ridley turtles occasionally lay eggs near the sea-board and the sea eagles could be seen feeding on eggs and vermin.

The Adyar backwater beyond the crossing of Santhome High Road has been reclaimed by filling the area with city refuse, right from waste paper to discarded automobiles, waste coal-tar, wood shavings, slaughter house remains and unwanted domestic materials, etc. The ecological conditions of the Adyar estuarine system are fast changing. Scientific studies on the ecology of the estuary are few and far

between (Panikkar & Aiyer, 1937 ; Chacko & Ganapathi, 1949 ; Chacko *et al.*, 1954 ; Verma & Reddy, 1959 ; Sornavel, 1978 ; Anonymous, 1982 ; Nammalwar, 1984). Hence it becomes necessary at this stage a comprehensive study to find out the extent of alteration in the physicochemical and biological aspects in the last five decades and to suggest remedial measures to stall the rot and to restore optimal conditons for sustained living.

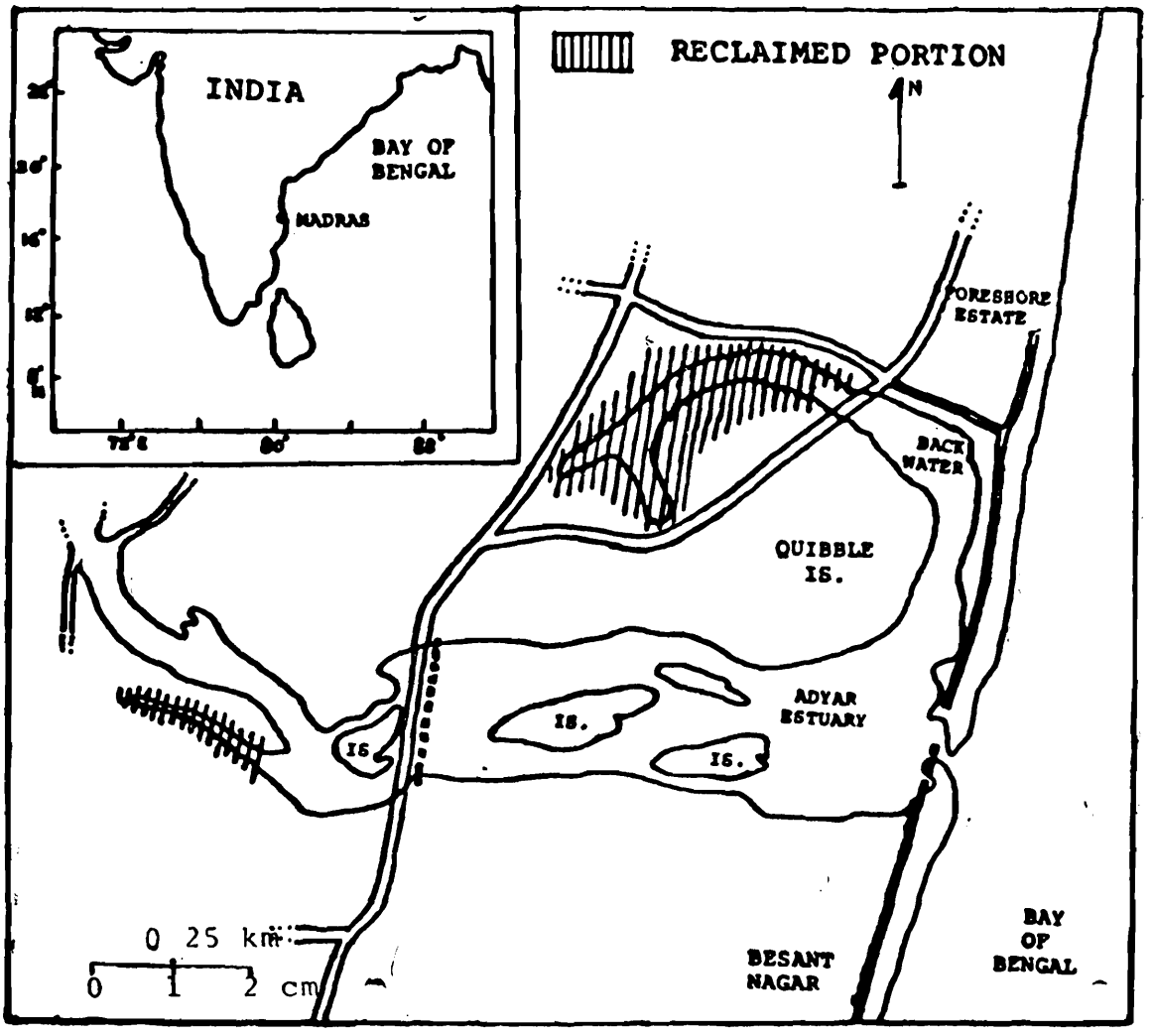
Materials and Methods

Extensive study on the hydrological conditions and faunistics has been conducted by this station for over a decade. This has been supplemented by analysis of physicochemical parameters of water and sediments by the DOEn Pollution project from 1983 to 1986. Faunistic and floristic data enumerated by various agencies including Madras Naturalist's Society and the Tamilnadu Forest Department have been analysed. Hydro-biological readings consisting of phyto- and zooconstituents of plankton have been taken at irregular intervals for a period of five years from 1986 to 1991. Hydrological parameters have been worked out on a Hach-Europe water analysis kit. BOD and COD were found out according to standard methods. The distribution of heavy metals in brackish water biota and sediments has been analysed on IL 480 AAS. The species distribution and identification have been worked out and cross-checked with the available literature (Jones, 1937 ; Panikkar & Aiyer, 1937 ; Chacko & Subramaniam, 1947 ; Chacko *et al.*, 1954 ; Krishnamoorthy, 1963 ; Evangeline, 1967 ; Chacko, 1969 ; Srinivasan & Raghunathan, 1981 ; Nammalwar, *et al.* 1991).

DESCRIPTION OF THE AREA

The Adyar estuary is located within the South Madras urban limit (13°4′N and 80°17′E). The Adyar river in its northern course flows into the backwater of about two square kilometer area (Map 1). Geologically, Adyar estuary has the sandy soil characteristics of the Coromandel coast. Most of the topographic conditions have changed during the last sixty years. The Elphinstone Bridge has been replaced by another 20 mts. west of it. Quibble island in the Adyar estuary is a misnomer presently as the isolating water masses have been filled with sand and clay. The tail-end of Adyar backwater has been filled and land reclaimed. The mud flats and sandy islets remain exposed except during the north-east and south-west monsoon

regimes. For many years the monsoons were a failure and the river has been reduced to a languid line of water of sewage and sullage. Brackish water conditions are felt up to four kilometers in the river from the sea-board. The whole backwater's edge is muddy with inclines of clay up to the sides of Quibble island cemetery. The entire eastern sea-board of Adyar estuary is sandy. The sand bar raised by



Map 1. Adyar estuarine system.

breakers cuts off the river from the sea for major part of the year excluding monsoon period, if any, and when the authorities manually remove the sand to open the river mouth. During the last decade, for many years, both the summer and winter monsoons have failed virtually impounding the brackish water of this estuary in lentic state.

HYDROLOGICAL FEATURES

The various hydrological parameters analysed during 1985-86 are presented in Table 1. Some of these parameters for Adyar estuary studied by earlier authors are given in Table 2 for comparison.

Temperature : In the Adyar estuary, surface water temperature fluctuated between 24.2°C (Oct. 1986) and 32°C (Jun. 1985) whereas the maxima and minima in backwater were at the lower level. Scrutiny of previous and present data pertaining to surface temperature of water in the Adyar estuary leads one to deceptively feel that there is a remarkable increase by more than 5°C over a 50 years' time in the middle zone. As Adyar river is too shallow and at the estuarine zone the maximum depth known is less than 2·5 meters excepting for a few days during monsoons, the surface water temperature has to be more or less in conformity with the atmospheric temperature. It is true that the atmospheric temperature has gone up even to 41°C on a few occasions during the past decade and such increase will be reflected by water temperature.

Salinity : Salinity of this brackish water body ranged from 3·0 ppt (Nov. 85) to 32·0 (Apr. 86). The lowest salinity mark of the past sixty years occurred in November 1985 due to heavy rains (1017·4 mm) and breaching of Adyar river. The peaks of salinity appear to have been more or less constant for the entire period.

pH : Water samples collected during 1985-86 indicated alkaline nature (pH 7·32 in Sep. 1986 to 9·19 in Mar. 1985 for estuarine water). Comparison of pH values leads us to believe that the pH range has remained similar over the half-century with the exceptional acidic pH 6·5 during January 1979 reported by Nammalwar (1984).

Dissolved Oxygen : The dissolved oxygen levels were at a minimum of 2·3 ml l^{-1} in Oct. 1985 and maximum of 6·8 ml l^{-1} in April 1986. This is exactly in reverse with the observatons of Chacko *et al.* (1954). There is every possibility that the reversed trend is due to heavy organic and inorganic contaminaton after the rainfall which opens up drainages and the effluent discharge systems directly into the river. Coincident during October-December is the mass fish-kill almost every year in the last decade (Nammalwar, 1984).

Suspended matter : The water samples were always turbid with more suspended matter during the study period whatever the season be. The lowest record of suspended matter is in February 1986 (106 mg l^{-1}) and maximum in July 1986

(939 mg l^{-1}) in the estuary while the range was more in the backwater 141 mg l^{-1} (Jan. 1916) to 1948 mg l^{-1} (July 1986).

Phosphates : In 1985 dissolved phosphate level rose from BDL in February to 10·348 mg l^{-1} in September. Interestingly, in 1986 the peak was at 79.716 mg l^{-1} in April, the reason for such an elevated level is obvious. The only level recorded in February 1949 was at 0·072 mg l^{-1} (Chacko and Ganapathi, 1949).

Nitrates : In the Adyar estuary, nitrate levels fluctuated from BDL in October 1985 to 2·475 mg l^{-1} in April 1986 whereas the level of 0·041 mg l^{-1} in August 1985 rose to 7·425 mg l^{-1} in February 1986 only to fall to BDL in Nov. 1986 in the Adyar backwater. Considering the nature of the water body one can surmise that the levels were quite reasonable.

BOD and COD : In 1986, the Adyar backwaters registered a nine fold increase in BOD level (94·0 mg l^{-1} in August) whereas in the estuary a three-fold increase (54·0 in August) only was perceptible. COD in both the water bodies have been erratic and no acceptable correlation could be made out. The DO, BOD and COD levels were always comparable and explained the physical status of the water body synchronising with temperature, salinity, and pH.

Productivity ; Productivity rate was higher in the lentic backwaters (up to 23·4 mg C l^{-1}) whereas it remained lower and comparatively stable in the Adyar estuary.

BIODIVERSITY

The Adyar estuarine system is known for its biological diversity in general and for its nesting and migrating avifauna in particular, for which it is declared as a protected area. Our observations from 1986 to 1991 and analysis are discussed below.

To avoid voluminous repetition of data, we refrain from giving the complete list of flora and fauna.

Floristics : The Adyar estuarine system holds quantitatively and qualitatively poor vegetation. The macroflora of the shore line mainly consists of *Phoenix* sp., *Prosopis* sp., *Tephrosia* sp., *Indigopia* sp., *Acacia* sp., *Casuarina* sp., and crotons. Marsh plants like *Avicennia* sp. and *Sueda* sp. also occur. The once luxurient growth of algal beds consisting of *Enteromorpha* sp. and *Chaetomorpha* sp. have become sporadic. The fresh water forms, viz. *Spirogyra* sp. and *Ceratophyllum* sp.

have also dwindled. In the last five decades, the greener aspects of the Adyar estuary and backwater have not only been greatly reduced, the species composition also has come down drastically.

The phytoplankton blooms have always resulted in reduction of the holding capacity by anoxic conditions prevailing in nights. Emanation of H_2S on a few occasions during the last decade could be easily noticed by the sudden blackening of silver utensils in the houses located around the estuary.

Adyar estuary is very rich in phytoplankton, which reportedly consists of at least 28 species belonging to diatoms, dinoflagellates and algae. Amongst them *Coscinodiscus* sp., *Asterionella* sp., *Thalasiothrix* sp., *Pleurosigma* sp., *Gyrosigma* sp., *Chaeloceros* sp., *Ceratium* sp. and *Fragilaria* sp. dominated the scene near the sea-board while *Anabaena* sp. and *Oscilatoria* sp. were found more in places where fresh water influx is noticed. During the period of observation in most cases the phytoplankton blooms were dominated by *Nitzschia* sp. and *Pleurosigma* sp.

Faunistics: The animal population of this estuarine system is represented by members of all phyla of the Animal Kingdom except Echinodermata. The surface water zooplankton samples were dominated by Copepods like *Oithona brevicornis*, *Oithona rigida*, *Microsetella* sp. *Macrosetella* sp., *Pseudodiaptomus* sp., *Acartia* sp. and the rotifer *Brachionus rubens* and *B. plicatilis*. Veliger larvae, penaeid prawn larvae and larval forms of some fishes mainly mullets are also found in the samples. But the species composition is relatively poor.

Among the poriferans, *Spongilla* sp. occurs near the Elphinstone Bridge. Coelenterates are mainly represented by hydrozoans especially *Campanularia* sp. and *Obelia* sp. near the sand bar while juveniles of Scyphomedusoid jelly fish *Acromitus flagellatus* move into the estuary when sand bar is open. Anthozoan constituents have become rarer and probably restricted to two species as opposed to the observation of seven species by Panikkar and Aiyer (1937).

Phylum Annelida is represented by mostly *Nereis* sp., *Diopatra* sp., *Polydora* sp., *Pontodrilus* sp., *Marphysa gravelyi*, and the sabellid *Laonome indica* is of rare occurrence; Serpulids are found on the bases of the broken bridge near sea shore. The polychaetes such as *Onuphis eremita*, *Glycera embranchiata*, *Loimia medusa*, *Marphysa gravelyi*, *Diopatra variabilis* and *Clymene insecta* reported by Krishnamoorthi (1963) and *Lumbriconeries* sp., *Prionospio cirrifera* reported by Panikkar and Aiyer (1937) to be present in abundance in this water body have become scarce at present with the lone exception of *Marphysa gravelyi*.

Phylum Arthropoda has major representatives quantitatively and qualitatively in

water, sediments and on shore-line both in the estuary and backwater. The clayey and muddy areas of backwater which have high humus content hold large sympatric populations of *Uca lactea annulipes* and *Uca triangularis bengali.* Pelagic crabs *Scylla serrata*, *Portunus pelagicus* and *Portunus sanguinolentus*, other crabs such as *Ocypoda macrocera*, *Ocypoda cardimana*, *Sesarma* sp., *Metaplax* sp., *Grapsus* sp, *Matuta* sp., *Philyra* sp., and prawn like *Palaemon* sp., *Penaeus* sp., *Metapenaeus* sp., *Alpheus* sp. occur in good number. Other arthropods, for example, *Ligia* sp. *Leander* sp., *Emerita* sp., *Diogenus* sp., and *Clibanarius clibanarius* are also common. Foraging activities, agonistic tendencies and migratory behaviour of the fiddler crabs are noteworthy (Krishnan, 1986).

Phylum Mollusca is also fairly represented and the oyster *Ostrea madrasensis* occurs on rocky substrate where water carries heavy organic contamination. Aplysids have become rarer. The commoner species of *Arca*, *Meretrix*, *Donax*, *Perna* etc. occur always on either banks of the river near the place of confluence. Gastropod juveniles occur at all the stations from where samples have been collected. At least four species of gastropods thrive in this area. *Littorina littorea* could be seen only on the sea-board.

Among the Chordates, Pisces forms the major component. Out of the eighty species of fishes reported by earlier workers (Panikkar & Aiyer, 1937 ; Chacko *et al.*, 1954 ; Nammalwar, 1984 ; Nammalwar *et al.*, 1991) at least 39 have econmic value. However, from the fishery point of view Adyar estuary does not play any pivotal role. Neither the catches are free from contamination nor safely consumable. Introduction of the exotic fish *Tilapia mossambica* into the Adyar estuary has not enriched the fishery ; moreover, commercial catches are dominated by juveniles. The brackish water fish culture farm of the fishery department also does not contribute to any appreciable extent.

About 175 species of birds (approximately 75 migrants) including the rarer species like Frigate bird, greater and lesser Flamingoes, Oyster catcher, Eastern Ringed plover, Avocet. short-eared owl, collared sand Martin, Orange headed Ground-thrush, Forest wagtail, Eastern Grasshopper warbler, short-toed lark have been sighted in this estuary. Stone curlews, larks, pipits, bee-eaters, king-fishers red wattled and yellow wattled lapwings and others have nesting sites in the islets between the bridge and the sea shore and also at the open meadow on the northern pank.

The faunistic spectrum is further widened by the presence of nine species of frogs and toads, twenty three species of reptiles including two species of snakes and five species of mammals,

CONTAMINANTS

During the last two decades the Adyar estuary and backwater have been insulted by industrial effluents and untreated sewage enhancing the risk factors considerably. Approximately, 8 million litres of sewage and 0·75 million litres of industrial effluents are let out into the Adyar estuarine system every day (Sornavel, 1978, Anonymous 1982, Nammalwar, 1984). Heavy metals, organochlorine pesticides and petroleum hydrocarbons have drastically affected the hitherto conducive environment for optimal living. The detergent laden dhobikhana water (laundry effluents), the heavy metal carrying wash waters of paint, electroplating, tanning and chemical industries, sullage from households carrying heavy BOD components and high bacterial count emanating slaughter house remains and public convenience let offs have altered the composition of water and sediments of this estuary.

The five major heavy metals (Cd, Cu, Ni, Pb and Zn) analysed from the water and sediments of the estuary and backwater are presented in Table 3. When compared with available data of 1982-83 (Krishnan, 1992) we infer that the concentrations of these heavy metals have gone up in the Adyar estuary within a period of three years as in Table 4 with an exception for lead.

The organochlorinie pesticides found (not quantified) are DDT, Heptachlore and Lindane from water and sediments. The petroleum hydrocarbons (undifferentiated) were noticed in high concentrations during July and November 1986 (246·33 ug g^{-1} and and 147·15 ug g^{-1}) in water samples from the Adyar estuary.

Total coliform and faecal coliform bacterial counts during 1985-86 have consistently been more than 12,000 colonies per 100 ml and 1000 colonies per 100 ml of water respectively in Adyar estuary rendering water unfit for human consumption.

RESTORATIVE STRATEGIES

In conclusion, I propose a few strategies for restoring optimal ecological conditions for life to survive and sustain in a healthy way.

1. Adyar estuary and the shore line from Foreshore Estate to Besant Nagar should not be developed for tourism purposes since urbanisation will lead to enhancement of stress factor.

2. Simultaneously, people should be prevented from constructing huts and tenaments on either banks of the Adyar river bordering the estuary.

3. Utilisation of the estuary and the backwater for fish culture systems for the reason that the available area is too less and the ecosystem is labile, the cultured fishes also may not be of good quality.

4. Fishing activity should be stopped totally during the period when migratory birds visit and the resident birds breed. During the other seasons indiscriminate fishing of brood stock and juveniles should not be permitted.

5. Prevention of pollution of Adyar estuary by meticulous licensing of industries with continuous monitoring of discharged effluents. Letting out of untreated sewage and sullage into the estuary directly should be prohibited.

6. Opening of sand bar and keeping the estuary open to the sea throughout the year will be the prime factor in keeping the estuary healthy, not only from the ecological point of view but also to limit water borne disease spreading from the stagnant pool. Of late, people inhabiting the banks of the Adyar river are reportedly suffering from cholera, amoebic dysentery, diarhoea, filariasis, etc.

7. Planting of suitable shrubs and trees above the high tide mark on the shore line and on the islets should be encouraged from providing asylum to the birds.

8. Introduction of a ban on grazing by domestic animals and deforestration for firewood by local people recommended.

9. Creating an awareness in the minds of local population and educating them on the uniqueness of the Adyar estuary is necessary.

SUMMARY

The Adyar estuarine system, the urban confluence of the Adyar river within the southern limits of Madras city, India, is unique by every measure. During the last six decades the estuary has changed much in content and complexion. Steep alterations in physicochemical and biological conditions have not only resulted in depletion of biota but also disturbed mankind directly. Available literature has been scrutinised and compared with the results of present study on various parameters. Restorative strategies for survival and sustained life in the estuary are suggested.

ACKNOWLEDGEMENTS

The author is thankful to the Director, Zoological Survey of India, Calcutta and the Officer-in-charge, Marine Biological Station, Z.S.I., Madras for permission and facilities, to all colleagues for help at various stages ; to Mrs. Chitraleka Krishnan for typing this manuscript.

REFERENCES

Anonymous, 1982. Tamilnadu Water Supply and Sewage Board. Annual Report : 1-30.

Chacko, P. I. 1969. Estuarine fishery resources of Tamilnadu. *First All India Symposium on Estuarine Biology, Tambaram, Madras* : 37.

Chacko, P. I. and Ganapathi, S. V. 1949. Some observations on the Adyar river with special reference to its hydrobiological conditions. *Indian Geogr., Journ.*, 24 : 35-49.

Chacko, P. I. and Subramanian, S. 1947. Fisheries of the Adyar river. *Proc. 34th Indian Sci. Congr.*, 3 : 180.

Chacko, P. I., Srinivasan, B., George, S., Krishnamurthi, B. and Ganesan, R. 1954. A study of the hydrobiology and fisheries of the Adyar Estuary with special reference to conservation. *Contn. Freshwater Fish. Biol. Stat. Madras*, 11 : 1-24.

Evangeline, T. G. 1967. Trend in the fisheries of the Adyar estuary April, 1963 to March, 1965. *Madras J. Fish.*, 4 : 1-20.

Jones, S. 1937. Observations on the breeding habits and development of ertain brakish water fishes of Adyar, Madras. *Proc. Indian Acad. Sci.* 5B : 261-287.

Konnur, R. and Azariah, J. 1987. Distribution of rotifer biomass in the estuarine region of river Adyar with reference to suspended particulate matter. *J. mar. biol. Ass. India*, 29 (1&2) : 286-290.

Krishnamoorthy, B. 1963. On the distribution of six species of polychaetes in Adyar estuary, Madras. *J. mar. biol. Ass. India*, 5 (1) : 97-102.

Krishnan, S. 1986. *Studies on some aspects of the biology of the fiddler crabs of the Adyar estuary.* Ph. D. thesis, Univ. of Madras, Madras : 1-165.

Krishnan, S. 1992. Studies on the distribution of heavy metals in the fiddler crabs inhabiting the Adyar estuary and back water. *Proc. Nat. Symp. Environ. Biol.* : 105-110.

Nammalwar, P. 1984. Pollution induced fish kills in Adyar estuary—a case study. *Sci. Cult.*, **60** (2) : 56-61.

Nammalwar, P., Mohanraj, G., Kandaswamy, S. and Sekhar, A. C. 1991. Fin fish seed resources of Adyar Estuary and Kovalam backwater around Madras, India. *J. mar. biol. Ass. India*, **33** (1&2) 59-68.

Panikkar, N. K. and Aiyer, R. G. 1937. The brakish-water fauna of Madras. *Proc. Indian Acad. Sci.*, **6B** : 284-337.

Sornavel, T. 1978. *Development of a water quality modelling programme—a case study.* M. E. Thesis, University of Madras, Madras.

Srinivasan, M. and Raghunathan, M. B. 1981. Observation on the zooplankton and hydrography at Adyar Estuary, Madras during solar eclipse, 1980. *Indian Journ. Zootomy*, **22** (1) : 47-51.

Verma, P. U. and Reddy, C. V. G. 1959. Seasonal variations of the hydrological conditions of the Madras coastal waters. *Indian J. Fish.*, **6** : 298-305.

Table 1 : Hydrological parameter ranges in the Adyar estuary and backwater during 1985-86

Parameters	Adyar estuary		Adyar backwater	
	1985	1986	1985	1986
Temperature	25·0 (Jan) — 32·0 (Jun)	24·2 (oct) — 31·3 (Jun)	26·3 (Sep) — 31·6 (Jun)	22·4 (Jan) — 30·2 (May)
Salinity (ppt)	3·0 (Nov) — 28·4 (Apr)	4·6 (Nov) — 32·0 (Apr)	3·0 (Nov) — 22·0 (May)	3·2 (Dec) — 29·6 (Jul)
pH	7·80 (Nov) — 9·19 (Mar)	7·32 (Sep) — 9·07 (May)	7·49 (Sep) — 9·14 (Jun)	7·55 (Oct) — 9·95 (Nov)
Dissolved oxygen (ml l^{-1})	2·3 (oct) — 5·6 (Apr)	2·4 (Sep) — 6·8 (Apr)	1·2 (Dec) — 6·1 (Apr)	2·0 (Jul) — 5·9 (Apr)
BOD mg l^{-1}	—	19·50 (Jun) — 54·00 (Aug)	—	10·50 (Nov) — 94·00 (Aug)
COD mg l^{-1}	800 (Dec) — 3733 (Sep)	176 (Mar) — 766 (Feb)	609 (Sep) — 2399 (Oct)	267 (Nov) — 905 (Feb)
Suspended matter mg l^{-1}	199 (Jun) — 726 (Dec)	106 (Feb) — 939 (Jul)	192 (May) — 849 (Apr)	141 (Jan) — 1948 (Jul)
Phosphate mg l^{-1}	BDL (Feb) — 10·348 (Sep)	BDL (Feb) — 79·716 (Apr)	1·145 (Jul) — 9·800 (Apr)	0·153 (Jun) — 67·452 (Apr)
Nitrate mg l^{-1}	BDL (Oct) — 0·355 (Nov)	0·005 (Feb) — 2·475 (Apr)	0·041 (Aug) — 1·090 (Sep)	BDL (Nov) — 7·425 (Feb)
Productivity mg l^{-1}	BDL (Jul) — 5·893 (Mar)	BDL (Jan) — 7·147 (Jul)	BDL (Oct) — 11·971 (Nov)	BDL (Mar) — 23·400 (Jul)

Table 2 : Hydrological features of Adyar estuary

Year	Salinity ppt.	Temperature °C	Dissolved oxygen ml l^{-1}	pH	Phosphate mg l^{-1}	Source
1933	16·91 (Jun) to 30·44 (Feb)	25·0 (Jan) to 29·6 (May)	N.A.	8·46 (Mar) to 9·15 (Jul)	N.A.	Panikkar & Aiyer 1933
1949 (Feb.)	N.A.	29·5	2·44	8·1	0·072	Chacko & Ganapathi 1949
1952-53	19·03 (Nov. 52) to 31·5 (Apr. 53)	24·8 (Nov. 52) to 32·0 (Jul. 52)	2·20 (Jan. 52) to 6·90 (Oct. 52)	7·41 (Feb. 53) to 8·80 (Nov. 52)	N.A.	Chacko et al. 1954
1979-80	5·01 (Dec. 79) to 26·05 (Mar. 79)	26·0 (Dec. 79) to 32·9 (Apr. 80)	0·04 (Aug.79) to 4·45 (Feb. 80)	6·50 (Jan. 79) to 8·60 (Oct. 79)	N.A.	Nammalwar, 1984
1985-86	3·00 (Nov. 85) to 32·00 (Apr. 86)	24·2 (Oct. 86) to 35·0 (Jun. 85)	2·30 (Oct. 85) to 6·80 (Apr. 86)	7·32 (Sep. 86) to 9·19 (Mar. 85)	BDL (Feb. 85, 86) to 79.71 (Apr. 86)	Present study

Table 3 : Ranges of concentration of heavy metals in water and sediment samples of Adyar estuary and backwater during 1985-86

		Cd	Cu	Ni	Pb	Zn
Water in mg l^{-1}	Estuary	BDL* to 0·084 (Jun. 85)	0·002 (Dec. 85) to 0·850 (Feb. 85)	BDL* to 0·270 (Jun. 85)	0·002 (Sep. 86) to 0·122 (Aug. 85)	0·007 (Feb. 86) to 1·040 (May 85)
	Backwater	BDL* to 0·006 (Apr. 85)	0·008 (Feb. 86) to 0·850 (Mar.85)	0·003 (Oct & Jul. 86) to 0·002 (Mar. 86)	0·003 (Mar, Jun, Aug. 86) to 0·030 (Jan. 85)	0·019 (May 86) to 1·250 (Feb. 86)
Sediment in ug g^{-1}	Estuary	BDL (Jul. 85) to 2·5 (May 85)	BDL (Jan. 85 & Jun. 86) to 275·5 (Feb. 86)	BDL (Oct. 86) to 20·35 (Aug.85)	0·51 (Feb. 85) to 48·27 (Jul. 85)	BDL (Mar. 85) & Sep. 86) to 216·9 (Feb. 85)
	Backwater	BDL (Jul & Nov 86) to 0·3 (Apr & Dec 85)	BDL (Sep. 86) to 258·8 (Nov.85	BDL (Sep. & Oct. 86) to 23·9 (Jul. 85)	0·375 (Apr.86) to 149·17 (Jan. 86)	BDL (Mar. 85 & May 86) to 458·1 (Nov. 85)

* For atleast 6 to 8 months in a year.

Table 4 : Times of increase in heavy metal concentration from 1982-83 to 1985-86 in the Adyar estuary

	Cd	Cu	Ni	Pb	Zn
Water	2·6	2·4	1·4	0·3	1·4
Sediments	10·8	6·5	3·8	4·5	4·8