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Fish Mortality From Anoxia and Sulphide Pollution

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KEY WORDS Retting. Anoxia. Sulphide Pollution. Water.

ABSTRACT The estuaries *(kayals)* of Kerala are of late, becoming increasingly polluted due to persistent retting of coconut husk for the manufacture of coir. The estuaries of Kerala are extensively utilised for the processing of coconut husk in this traditional method and the shores of these estuaries are famous as important coir fibre production centres in the world. Depletion in dissolved oxygen and production of large amounts of hydrogen sulphide and ammonia were observed in the retting zones and that had a detrimental effect on the fish and shell fauna of the Kadinamkulam kayal. As a result, mass mortality of fishes occurred in the retting zones of the Kadinamkulam estuary during the pre-monsoon period. A large number of fishes of different varieties, of which majority were euryhaline, were seen floating and also strewn all along the sides of the estuary and adjacent areas. The effect of anoxia and sulphide pollution on the ecosystem is discussed.

INTRODUCTION

Coir industry is one of the most well organised cottage industries in Kerala, offering direct employment to over half a million people in the State. Retting of coconut husk is brought about by the pectinolytic activity of micro-organisms like bacteria, fungi and yeast releasing large quantities of organic substances such as pectin, pentosan, polyphenols, tannins etc. into the medium. As a result kayals of Kerala became increasingly polluted, causing extensive damage to the biotic communities in these zones.

Earlier investigations on retting practice in the kayals by Abdul Azis and Nair (1986), Bijoy Nandan et al. (1989) and Bijoy Nandan and Abdul Azis (1990) has revealed that the water quality of estuaries has further deteriorated with the simultaneous depletion in the fish and shell fish resources of the region. The present investigation deals with the impact of coconut husk retting on fish and shell fish fauna of the Kadinamkulam estuary.

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STUDY AREA

The investigation was conducted in the Kadinamkulam kayal (lat. 8°35' 8°40' N and long. 76°45'-76°52'E) Kerala, India (Fig. 1). Two stations representing different ecological conditions were selected. Station I (Kotrakiri) represented a polluted zone, which is an interior bay of the kayal used entirely for the retting of coconut husk. Station II (Perumathura) is an area free from retting activity and is exposed to fresh water influx and sea-estuary mixing. The Vamanapuram river empties into the estuary at its northern extremity at Perumathura.

MATERIALS AND METHODS

Fortnightly field collections were made from the four stations for a period of one year from October 1987 to September 1988. Surface and bottom water samples were taken from both the stations, in replicate, for the estimation of pH, salinity, dissolved oxygen, hydrogen sulphide and ammonia and were analysed according to Standard Methods (APHA 1980). Bottom water was taken with a locally designed bottom water sampler of 1 litre capacity. pH was measured with the help of Elico pH meter model (LI-120). Specimens for the present study were collected at random from the local fishermen during the same period. Amongst the cast nets and seine nets used commonly, the latter accounts for the major share of the catch. Identifications of fishes and shell fish fauna were carried out following Day (1988), Munro (1967), Whitehead (1972) and Jhingran (1975).

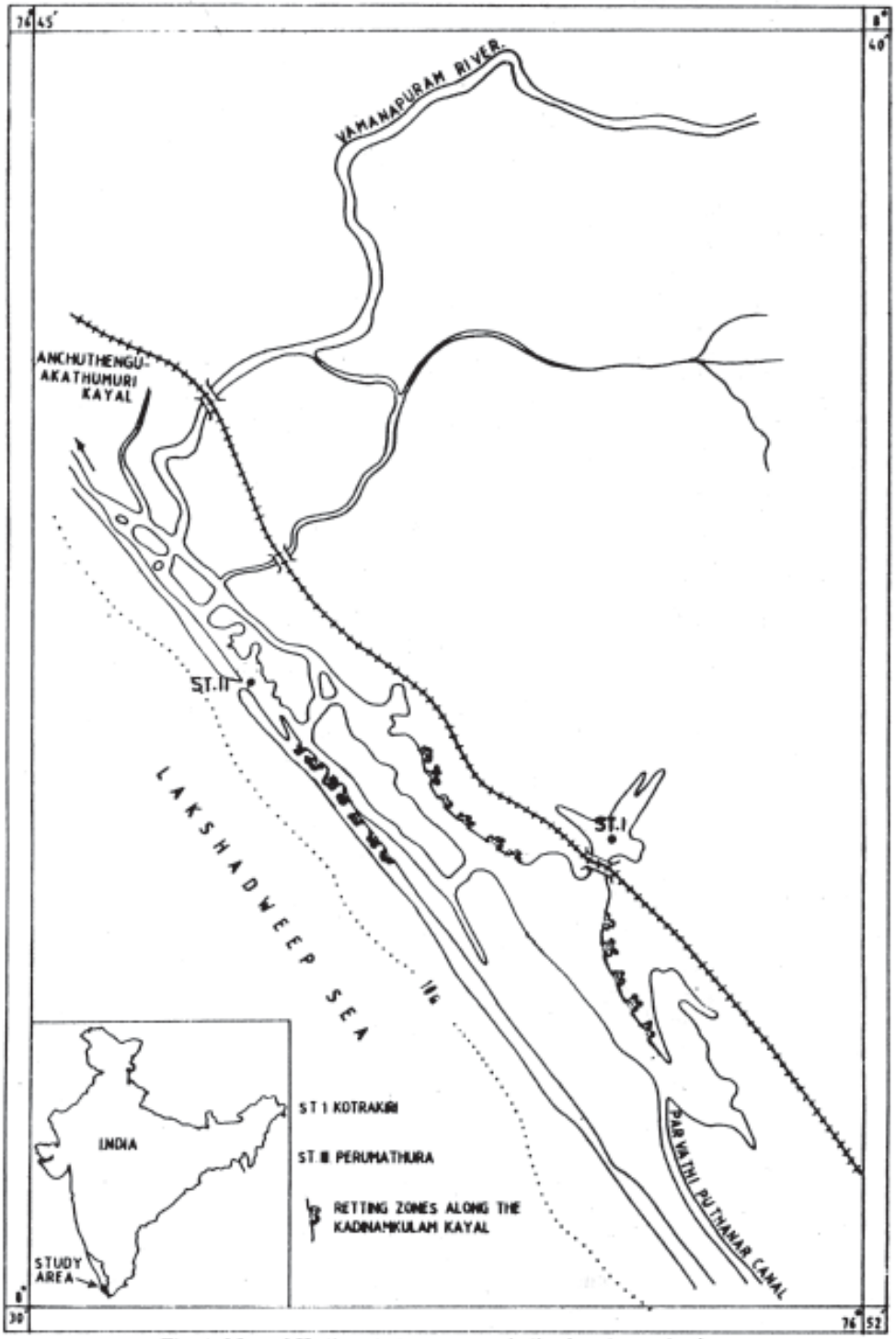

Fig. 1. Map of Kadinamkulam estuary indicating the study sites

RESULTS AND DISCUSSION

Water Quality of the Retting and Non-retting zones

The pH in the surface and bottom water at the retting zone ranged from 5.48 to 7.97 and that at the non-retting zone from 6.62 to 7.92. Acidic nature of the water in the retting zone was a notable aspect of the present study, particularly during the post-monsoon and pre-monsoon periods. Salinity at the retting zone varied from 2.5 to $28x10^{-3}$ in the surface and bottom waters whereas, at the non-retting zone from 11.36 to $31.70x10^{-3}$. Low concentrations of dissolved oxygen coupled with the production of large quantities of hydrogen sulphide was an outstanding feature of the quality of water in the retting zone. Dissolved oxygen concentration in the surface and bottom waters ranged from 0 to 0.72 mgL^{-1} and 1.97 to 6.21 mgL^{-1} at the retting and non-retting zones, respectively (Fig. 2). Hydrogen sulphide varied from 7.60 to 40.20 mgL^{-1} at the retting zone and from 0 to 3.60 mgL^{-1} at the non-retting zone (Fig.3). Depletion of dissolved oxygen and production of hydrogen sulphide accompanied with the retting of coconut husk has been reported earlier from the Edava-Nadayara estuary by Abdul Azis and Nair (1986). Presence of hydrogen sulphide has been reported from several marine and estuarine areas of the world. Ivanenkov and Rozanov (1961) have noticed such areas from the north-eastern part of the Arabian sea and the north-west part of the Bay of Bengal; Dauer and Ranasinghe (1992) from Chesapeake Bay and Stanley and Nixon (1992) from the Pamlico river estuary. Large scale production of hydrogen sulphide has been observed in the Chesapeake Bay by Officer et al. (1984). The sulphide biomes created by retting in the kayals of Kerala are thus quite unique. The decomposition of the organic matter in the retting zones by bacteria results in the utilisation of dissolved oxygen. The organic load at the retting zones are always high resulting in greater microbial decomposition leading to depletion of oxygen which eventually led to a state of anoxia.

Ammonia (NH_3-N) in the surface and bottom waters varied from 6.78 to 36.70 µg at/1 and from 0 to 11.70 µg at/1 at the retting and non-retting zones, respectively. It exhibited a maxima during the pre-monsoon followed by the post-monsoon and monsoon periods in the suface and bottom water at both stations.

Fish and Shell Fish Fauna

A total of 37 species of fishes belonging to 26 families, 5 species of prawns, 2 species of crabs and 2 species of bivalves were collected from the non-retting zone (Tables 1 and 2). Of the 20 species of fishes recorded from the retting zone none of them survived and were collected dead. No shell fish forms were recorded from the polluted retting zone. Majority of the fishes were euryhaline forms having a wide distribution in the estuarine and contiguous water. *Megalops cyprinoides* and *Gerreomorpha setifer* are the true estuarine forms occurring in the Kadinamkulam kayal. It is thus evident from the present study that 50% of the fishes in the Kadinamkulam estuary are marine which migrate into the kayal when hydrobiological conditions are favourable as was observed in other kayals of India by Jhingran and Gopalakrishnan (1973).

Fish Fauna in Relation to Water Quality Condition

Sporadic instances of fish mortality has been observed in the retting zones of the Kadinamkulam estuary particularly during the pre-monsoon period when the dissolved oxygen concentration falls leading to an anoxic condition concomittant with the production of large amounts of hydrogen sulphide and ammonia.

Bass-Becking (1925) for the first time coined the term "sulphureta" to describe

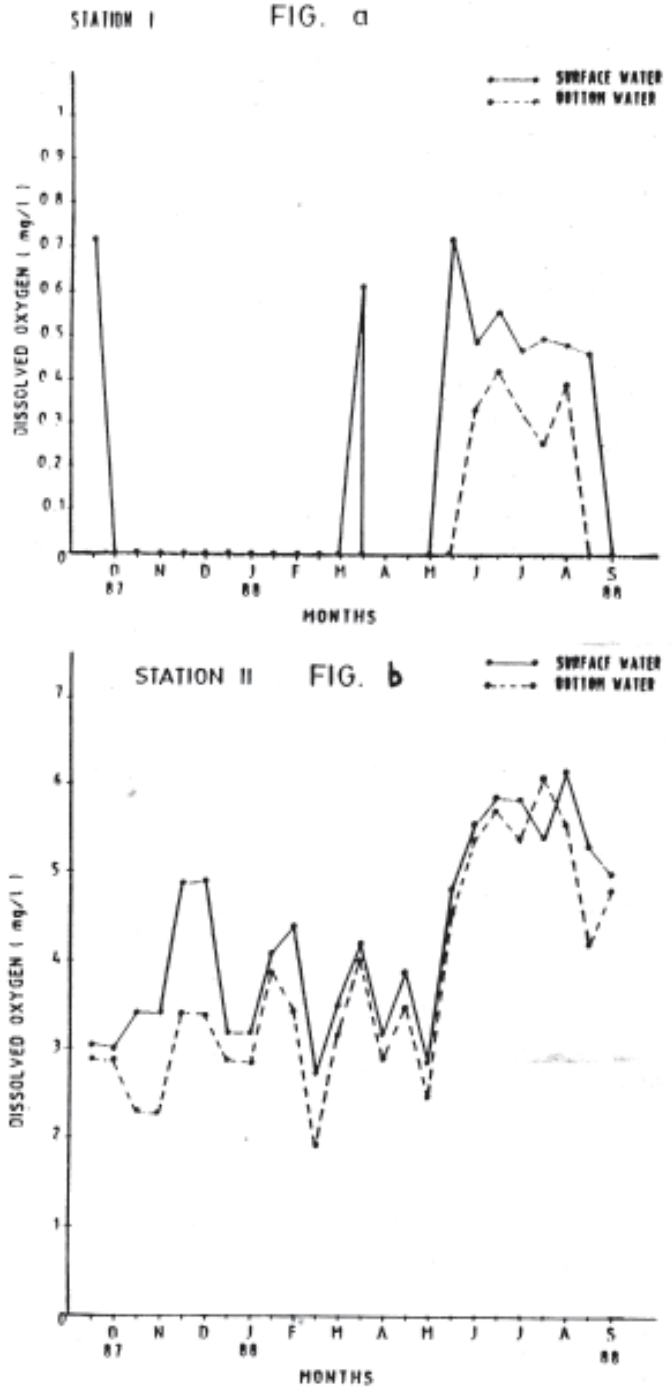

Fig. 2. Graphs depicting variation in dissolved oxygen in the Kadinamkulam estuary

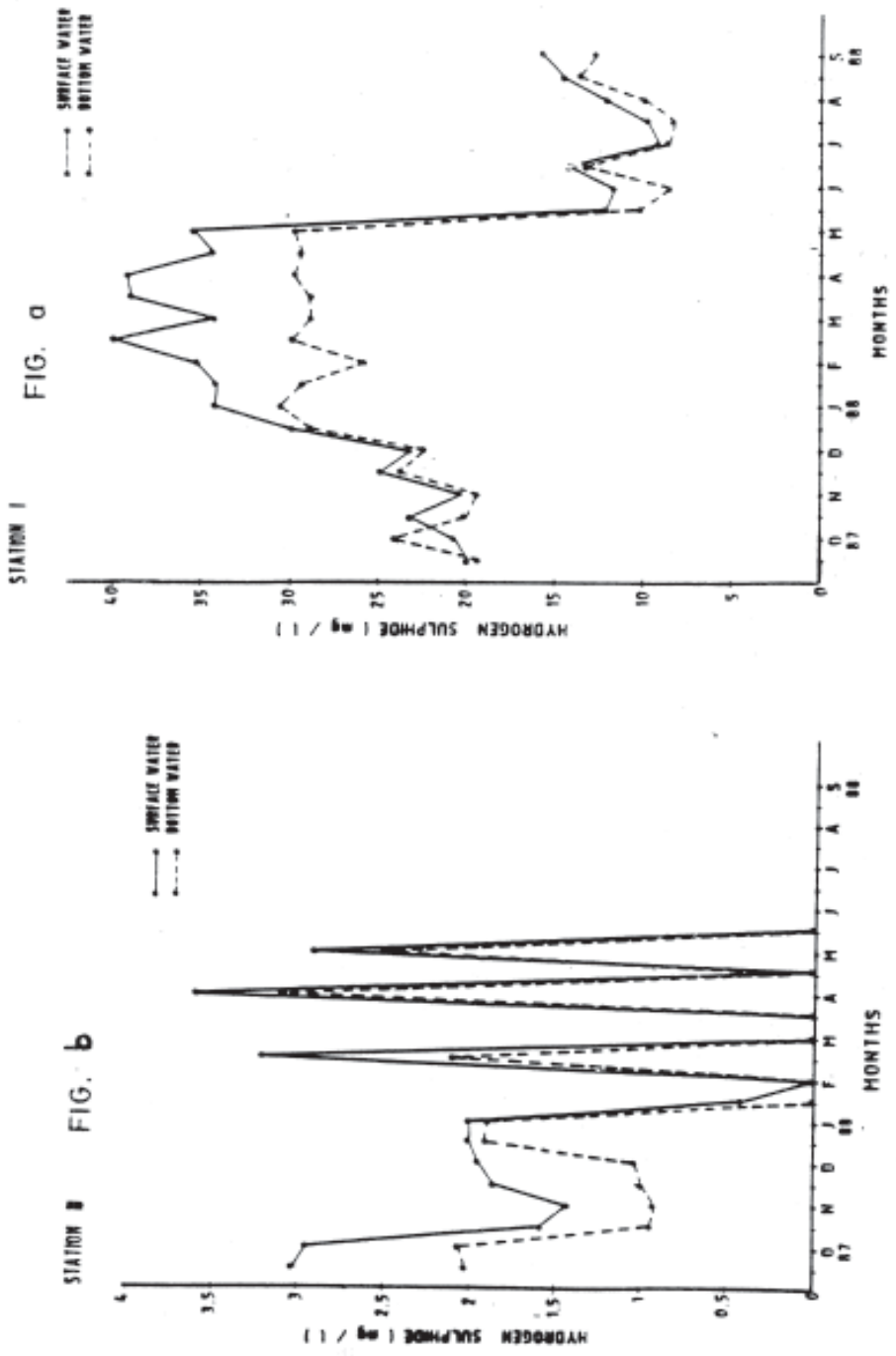

Fig. 3. Graphs depicting variation in hydrogen sulphide concentrations in the Kadinamkulam estuary

Table 1: List of fishes of the retting and non-retting zones in the Kadinamkulam Kayal

Family	*Species*	*Local name*	*Habitat (Munro 1967)*	*No. collected*	
				Non-retting	*Retting*
Megalopidae	*Megalops cyprinoides*	Nunna Chankanni	E	10	6
Clupeidae	*Sardinella sp.*	Chaala		7	2
Engraulidae	*Stolephorus indicus**	Netholi	M	9	7
Chanidae	*Chanos chanos**	Poomeen	M	15	2
Tachysuridae	*Tachysurus maculatus***	Koori Thedu	M,E	3	1
Hemiramphidae	*Hyporhamphus limbatus**	Koralan	M,E	9	—
	Hemiramphus cantori		M,E	12	4
	*Rynchoramphus gerorgi**			7	2
Sphyraenidae	*Sphyraena jello**	Cheelavu	M	16	7
Mugilidae	*Mugil cephalus**	Kanambu		22	12
	*Liza macrolepis***		M,E	12	8
	*L. parsia***		M,E	17	8
	*Valamugil scheli**		M	7	—
Atherinidae	*Pranesus duodecimalis**	Kayal Netholi	M,E	12	—
Centropomidae	*Chanda commersonii***	Nulli Nandal	E,R	16	—
Serranidae	*Epinephelus tauvina*	Azhutha	M	9	—
Theraponidae	*Therapon jarbua**	Keeli	M,E	13	4
Sillaginidae	*Sillago sihama**	Ocli	M,E	13	—
Carangidae	*Caranx sexfasiatus**	Paara	M	10	—
Lutjanidae	*Lutjanus fulviflamma**	Chemballi	M,E,R	9	—
Gerridae	*Pertica filamentosa**	Praachi	M	8	—
	*Gerres oyena**		M	7	2
	*Gerreomorpha setifer**		E	3	1
Leiognathidae	*Leiognathus equulus**	Kaaral	M,E,R	8	—
	*L. splendens**		M	1	—
Mullidae	*Upeneus sulphureus**	Navara	M	1	—
Scatophagidae	*Scatophagus argus**	Marappi	M,E	3	—
Cichlidae	*Tilapia mossambica**	Tilapi		16	9
	*Etroplus suratensis***	Karimeen	E,R	21	10
	*E. maculatus***	Pallathi	E,R	20	4
Eleotridae	*Eleotris fusca**	Karimpoonthi	E,R	12	—
Gobiidae	*Glossogobius giuris**	Poonthi	M,E,R	6	2
	Pseudogobius javanicus		M,E	8	—
Platycephalidae	*Thysanophrys indicus**	Oratha	M	8	—
Soleidae	*Brachirus orientalis**		M	8	—
Cynoglossidae	*Cynoglossus lida**		M	1	1
Tetradontidae	*Chelondon patoca**	Oothaampetti	M,E	2	1

*-Commercially important species (Jhingran, 1975)
**- Species substantially contributing to fisheries
M-Marine, E-Estuarine, R-Riverine

habitats containing large amounts of hydrogen sulphide. The sulphureta observed from the retting zones of the present study showed that it protends to the adjacent regions of the Kadinamkulam kayal. According to Metelev et al. (1983) increase in sulphide content in a water body (salts of hydrosulphuric acid) is an extremely unfavourable index of

Table 2: Shell fish fauna of the retting (St.I) and non-retting (St.II) zones in the Kadinamkulam kayal

Species	*St. I*	*St. II*	*Local name*	*No. Collected (non-retting zone)*
Penaeus indicus	–	+	Naran	17
Penaeus monodon	–	+	Karat	9
Metapenaeus dobsoni	–	+	Poovalan or Thelly	8
Metapenaeus monoceros	–	+	Choodan	12
Macrobrachium idilla	–	+		10
Scylla serrata	–	+		16
Neptunus pelagicus	–	+		12
Villorita cyprinoides	–	+		69
Crassostrea madrasensis	–	+		14

-Absent + Present

hydrochemical regime. According to them, hydrogen sulphide is formed by the decomposition of organic substances and is very toxic to fishes when exposed to a concentration of 1.0 mgL^{-1}. In the present study also, it was noticed that, in the retting zone the rate of respiration dropped and respiratory movements become arhythmic in the fishes. Metelev et al. (1983) have also stressed that toxicity of sulphides decreased with increase of pH. Hydrogen sulphide penetrates living cells at a pH of less than 6.00. In the present investigations the higher concentration of hydrogen sulphide can also be attributed to acidic conditions prevailing in the retting zones.

Earlier reports from Kerala on fish mortality are by Unnithan et al. (1975) and Nair et al. (1981) from impacted areas of industrial effluents in the Cochin backwater. American Public Health Administration and Water Pollution Control Federation (1980) have classified "fish kills" as 'minor' (1-100 dead or dying fish confined to small area of stream stretch), 'moderate' (100-1000 dead or dying fish of various species in a kilometer or equivalent area of a lake or estuary) and 'major' (1000 or more dead or dying fish of many species in a reach of a stream upto 16 kilometer or more of a lake or estuary). Accordingly, a 'major kill' of fishes could be considered from the retting zones of Kadinamkulam kayal, "Minor Kills" have earlier been reported by Silas and Pillai (1976) from the Cochin backwater.

The I.S.I (1983) standard for the concentration of dissolved oxygen is 3 mgL^{-1} and that of hydrogen sulphide is 2 mgL^{-1} for inland surface water, whereas the ICMR (1986) standard proposes 5 mgL^{-1} for dissolved oxygen in inland waters. The present data when compared with the above mentioned standards, the quality of water in the retting zone can be rated as polluted.

The high concentrations of ammonia (NH_3 -N) in the retting zone could be attributed to the introduction of raw coconut husk and their subsequent decomposition in the kayal. The denitrification process taking place as a part of the nitrogen cycle leads to a steady decline in the nitrate-nitrogen accompanied by a progressive increase in ammonia (Mechalas, 1974). The anoxic condition at a pH between 5.48 and 7.97 in the region plays a catalytic role in the evolution of ammonia. The retting zones in the Kadinamkulam kayal was thus ideally placed for the production of large quantities of ammonia, which was also detrimental to the fish and shell fish fauna. The ISI (1983) has set a tolerance limit of 1.2 mgL^{-1} of ammonia for shell fish and commercial fish culture.

Retting of cocount husk thus, characteristically brought by the pectinolytic activity of microorganisms, degrade the fibre binding materials of the husk liberating large quantities of organic matter like pectin, pentosan, polyphenol, tannin etc. into the environment. Consequently hydrogen sulphide and ammonia increases while the dissolved oxygen decreased in the ambient water. Therefore, the cumulative

effect of anoxia coupled with the presence of large amounts of hydrogen sulphide, ammonia and organic chemicals had a lethal effect on the biotic communities in the retting zones of the Kadinamkulam kayal.

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REFERENCES

Abdul Azis, P.K. and Nair, N.B.: Ecology of the coconut husk retting grounds in Kerala. *Proc. Symp. Coastal Aquaculture*, **4**: 1115-1130 (1986).

APHA.: *Standard Methods for the Examination of Water and Waste Water. Am. Pub. Health Assoc.* Washington. D.C., 15th Edition (1980).

Bass-Becking, L.G.M.: Studies on the sulphur bacteria. *Ann. Bot.*, **39**: 613-650 (1925).

Bijoy Nandan, S., Abdul Azis, P.K. and Natarajan, P.: Water quality and faunal depletion in the retting zones of the backwaters of Kerala. *Proc. First Kerala Science Cong.* (1989).

Bijoy Nandan, S. and Abdul Azis, P.K.: Studies on BOD_5 and dissolved oxygen in the Kadinamkulam kayal, Southern Kerala. *Mahasagar*, **23**: 95-101 (1990).

Dauer, D.M. and Ranasinghe, J.A.: Effects of low dissolved oxygen events on the macrobenthos of the Lower Chesapeake Bay. *Estuaries*, **15**: 384-391 (1992).

Day, F.: *The Fishes of India.* Bernard Quaritch, London (1878).

Indian Council of Medical Research (ICMR): *Annual Report*, **10**: 20-30, (1986).

Indian Standards Institution (ISI) IS:10500: *Specification for Drinking Water.* Indian Standards Institution, Manak Bhavan, New Delhi (1983).

Ivanenkov, V.N. and Rozanov, A.G.: The hydrogen sulphide contamination of the intermediate water layers of the Arabian Sea and the Bay of Bengal. *Oceanologia*, **1**: 443-449 (1961).

Jhingran, V.G.: *Fish and Fisheries of India.* Hindustan Publishing Corporation, Delhi (1975).

Jhingran, V.G. and Gopalakrishnan, V.L.: Estuarine fisheries resources of India in relation to adjacent seas. *J. Mar. Biol. Ass. India*, **15**: 323-334 (1973).

Mechalas, B.J.: Pathways and environmental requirements for biogenic gas production in the ocean, pp. 11-25. *Natural Gases in Marine Sediments.* I.R. Kaplan (Ed.). Plenum Press, New York (1974).

Metelev, V.V., Kenav, A.I. and Ozasekhova, N.G.: *Water Toxicology.* Amerind Publishing Co. Pvt. Ltd., New Delhi (1983).

Munro, I.S.R.: *The Fishes of New Guinea.* Department of Agriculture, Stock and Fisheries, Port Moresby, New Guinea (1967).

Nair, P.V.R., Pillai, V.K., Ponniah, A.G. and Vincent, D.: Fish mortality from ammonia pollution. *Proc. Seminar Status Env. Studies in India*, 342-344 (1981).

Officer, C.B., Biggs, R.B., Taft, J.K., Cronin, L.E., Tyler, M.A. and Boynton, W.R.: Chesapeake Bay anoxia: Origin, development and significance. *Science*, **223**: 22-27 (1984).

Silas, E.G. and Pillai, V.R.: Water pollution and fish mortality in the Cochin backwatrs. *Proc. Nat. Sem. Env. Poll.*, Cochin, 323-326 (1976).

Stanley, D.W. and Nixon, S.W.: Stratification and bottom water hypoxia in the Pamlico river estuary. *Estuaries*, **15**: 384-391 (1992).

Unnithan, R.V., Vijayan, M. and Remani, K.V.: Organic pollution in Cochin backwaters. *Indian J. Mar. Sci.*, **4**: 39-42 (1975).

Whitehead, P.J.P.: A synopsis of the Clupeoid fishes of India. *J. Mar. Biological Ass. India*, **14**: 160-256 (1972).