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Mud of a Mud Bank in Kerala, South-West Coast of India

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Fine particles of mud measuring <1 to 300 µm constitute the mud of the Alleppey mud bank. These particles, with some variations in their size, occur throughout the year in the region of the mud bank. Total phosphorus content of the mud is high and its carbon content is related to the texture of the mud. Mud, largely composed of very fine particles, has a relatively high organic carbon content. Plant pigments and carbohydrate occur in very low concentrations and the caloric value of the mud is also low indicating that the mud is of poor nutritional value. Fish and prawns caught from the region of the mud bank contain large quantities of mud in their guts suggesting that mud is ingested when probably other food organisms are not readily available.

GOPINATHAN and Qasim[1] have reported the formation and characteristics of the mud banks of Kerala. They have defined the mud bank as "an inshore region where the sea bottom generally has a small elevation of 1-2 m due to the presence of consolidated mud". According to this definition, mud banks are not really formed every year; they only get activated during the SW monsoon. The process of activation includes stirring up of consolidated mud from the bottom because of forceful wave action and the formation of a thick colloidal suspension of fine clay particles in which waves get continuously damped. When the force of waves begins to decline, the suspended mud settles to the bottom and the mud bank becomes passive. Those mud banks which become active almost every year have been termed as persistent mud banks[1].

These features clearly indicate that perhaps one of the most important components underlying the entire phenomenon of visual appearance and disappearance of the mud bank — once known to be mysterious — is the mud itself, which demands a detailed study. In this paper, some information on the mud which constitutes the mud banks is presented.

Studies on the mud were carried out from the Alleppey mud bank. This is a persistent type of mud bank. Fig. 1 gives a profile of this mud bank together with its cross-section after it becomes fully active. In this state it has a semicircular appearance and occupies a stretch of about 6 km into the sea along the EW direction and about 4 km along the NS direction (Fig. 1). Its dimensions, however, vary from year to year. The mud bank gets beautifully demarcated by the calmness of its water. The wave action along its 240 m wide periphery is strong which makes the boundary of the mud bank fairly distinct and picturesque. The remarkable feature of the mud bank is the suddenness with which it appears as an area of calm water in the turbulent Arabian Sea.

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Materials and Methods

Mud samples were collected using a van Veen grab from 4 different stations of the mud bank. The position of these stations is shown in Fig. 1. All the stations were inside the periphery of the mud bank. The collected mud was immediately trans-

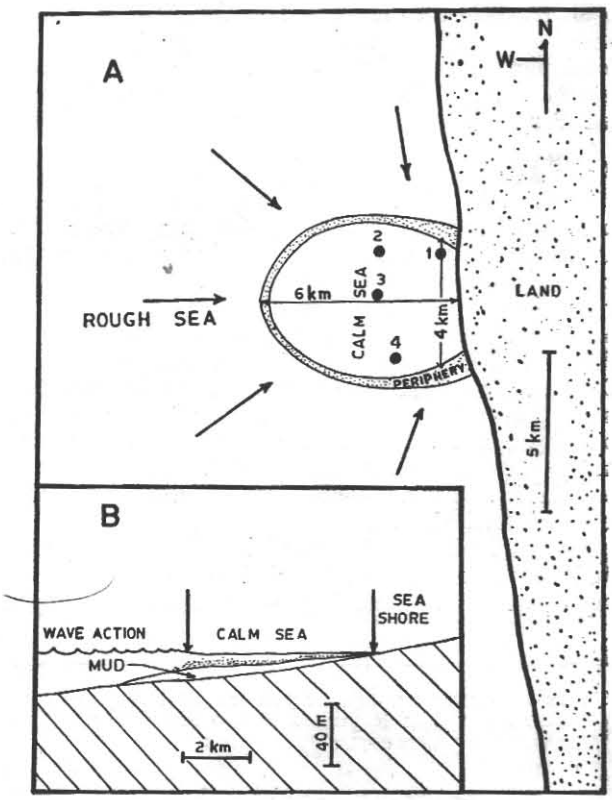

Fig. 1 — (A) Profile of the Alleppey mud bank when it gets clearly demarcated during the SW monsoon [A periphery appears in which waves are damped and calm water gets enclosed. 1 to 4 indicate the 4 stations where observations were made]. (B) Diagrammatic representation of the cross-section of mud bank

ferred to plastic buckets from which sub-samples were taken and kept in polythene jars.

Freshly collected mud is slimy with a bluish tint. When dried, it becomes dark grey and hard. Small fragments of molluscan shells and foraminiferans are also found in the mud. When examined as a thin film under a microscope, shiny quartz and silt particles are also seen in addition to organic aggregates of different shapes and sizes, similar to those observed in detritus[2]. At station 2, a few samples were found to contain beach sand. These on drying became loose with whitish grey in colour.

For the determination of particle size, a small quantity of dried mud was taken. It was soaked and resuspended in petri dishes containing distilled water. Small quantities of the suspended material were then taken with a dropper and smeared thinly on a glass slide. The sizes of the particles were measured with a micrometer eye piece and the total numbers of particles present under each size group were counted.

For the determination of chlorophyll (chl.) *a*, acetone extracts were prepared from 50 mg of fresh mud and both chl. *a* and phaeophytin were measured at 665 nm on a spectrophotometer using standard procedures[3]. Organic carbon in the mud was determined according to the method given by Wakeel and Riley[4] and from the carbon values, caloric content of the mud was estimated using a factor, 1 mg C = 7·9 cal. This factor was determined after measuring the caloric content of a number of mud samples by the method of Karzinkin and Tarkovskaya[5]. The observed factor was found to be very close to the theoretical caloric value for amorphous carbon, which is 1 mg C ≡ 8 cal.[6]. Total phosphorus, nitrogen and carbohydrate were determined according to the procedure of Strickland and Parsons[7].

Results

Particle size — In all, 82 samples were analysed and particles of size range <1-300 μm were found in all the 82 samples. The bigger size range occurred in about 26% samples and the largest size groups were present only in a few samples (Table 1). Dora *et al.*[8] found the sediment of the mud bank at Narrakal (Cochin) to be rich in fine clay with some silt and practically no sand. In their samples, nearly 11-60% of the fine clay particles were less than 1 μm in diam. Nair and Murty[9] in their report on the clay minerology of the mud bank of Cochin have indicated that 60-65% of the minerals in the mud are kaolinites.

The analysis of the particle size at different stations throughout the period of observation is shown in Fig. 2. During July-September, the range in the particle size at stations 1 and 2 was almost similar. At stations 3 and 4, in these months, the size range of particles was relatively larger. From October onwards, there was no regular pattern of distribution in the size of particles at different stations. Large and small particles were distributed randomly and from December-March, the range in the particle size became somewhat limited. Another significant feature in the distribution of particle size was that during 1971, the particle distribution at various stations in July and September was very different from that of the corresponding months in 1972. This indicates that the characteristics of the suspended material do not remain constant, although it is the same mud which keeps circulating within the calm waters of the mud bank or up and down depending on whether the mud bank was active or passive.

Phosphorus content — Phosphorus values varied considerably from time to time and fell within a range of 0·23-3·15 mg P/g dry weight (Table 2).

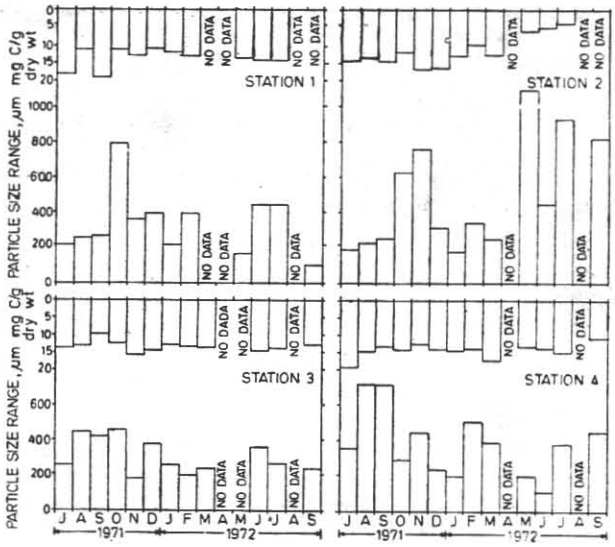

Fig. 2 — Seasonal variation in the particle size and organic carbon of mud taken from 4 stations of the Alleppey mud bank

Table 1 — Percentage Occurrence of Particles of Different Size Range in Dried Mud of the Alleppey Mud Bank

Range μm	Occurrence in total samples	Occurrence %
<1-300	82	100
301-600	22	26
601-900	10	12
901-1350	2	3

Table 2 — Total Phosphorus Content in Dried Mud of the Alleppey Mud Bank

Station	Date of collection 1971	Total phosphorus mg P/g dry wt
4	30 July	2·45
3	6 Oct.	0·23
2	6 Dec.	0·31
	1972	
1	13 Jan.	2·18
2	do	3·15
4	30 May	0·30
1	27 June	0·49
3	do	1·77
4	do	0·31
3	8 July	0·79
4	do	0·28
4	12 July	0·63
1	18 July	0·86
3	do	1·67
4	do	1·98
3	26 July	2·15

Seshappa[10] has earlier reported inorganic phosphorus values from the mud bank at Calicut. Both interstitial and adsorbed values of phosphate determined by him were high as compared to the concentration of phosphorus found in sea water. Present values of total phosphorus are much higher than those of the interstitial phosphorus or adsorbed phosphorus given by Seshappa[10] and confirm that the fine mud of the mud bank is rich in phosphorus.

Organic carbon — At station 1, throughout the observation, the values ranged between 1 and 2% (Table3). At station 2, the range in the carbon value was larger and during June and July 1972, very low values were recorded. At stations 3 and 4, the carbon content of the mud was of a similar order of magnitude as that of station 1.

TABLE 3 — SEASONAL VARIATION IN TOTAL ORGANIC CARBON OF MUD TAKEN FROM FOUR DIFFERENT STATIONS OF THE ALLEPPEY MUD BANK

Month	Organic carbon (% dry wt)			
	Station 1	Station 2	Station 3	Station 4
		1971		
July	1·83	1·44	1·34	1·89
Aug.	1·44	1·26	1·29	1·44
Sept.	1·98	1·47	0·96	1·29
Oct.	1·17	1·14	1·23	1·35
Nov.	1·32	1·64	1·55	1·22
Dec.	1·11	1·62	1·47	1·35
		1972		
Jan.	1·23	1·26	1·26	1·41
Feb.	1·32	0·96	1·29	1·35
March	—	1·26	1·38	1·71
April		No collection		
May	1·38	0·57	—	1·29
June	1·40	0·48	1·41	1·32
July	1·41	0·33	1·35	1·46
Aug.		No collection		
Sept.	—	—	1·26	1·05

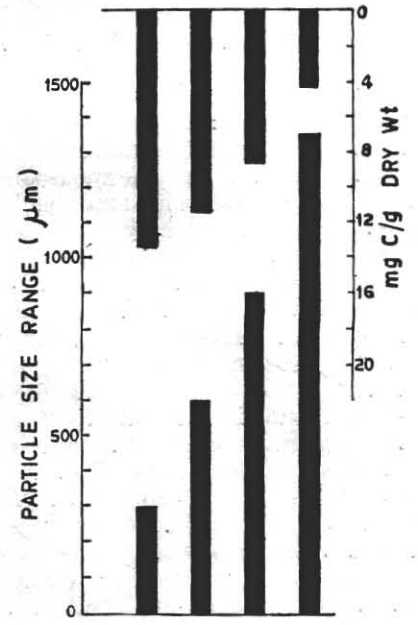

Fig. 3 — Relation between four groups of particle size and organic carbon of mud taken from the Alleppey mud bank [Data from all stations and all seasons are pooled]

The relationship between particle size and carbon content of the mud at different stations, throughout the period of observation, is shown in Fig. 2. Carbon content of the mud was closely related to the particle size. When the range in particle size was small, i.e. when the mud was composed of fine particles, the carbon values were high. Similarly, coarser mud had a lower carbon content. This is clearly evident from the pooled data of particle size and organic carbon of the mud (Fig. 3). Finer particles were always richer in organic matter than the coarser particles. The carbon values of the particulate matter present in the overlying water were lower than those of the mud (Table 4), indicating that organic matter is largely associated with the mud.

Chlorophyll and phaeophytin contents — Chlorophyll content was extremely low and the values were either nil or small (Table 5). Phaeophytin values, on the other hand, were somewhat higher and fell between 0·0004 and 0·01% dry wt of mud. This indicates that the pigment content of the mud is largely composed of degraded chlorophyll.

Carbohydrate content — Table 6 gives the carbohydrate values of the mud. The range in values

TABLE 4 — ORGANIC CARBON IN THE PARTICULATE MATTER OF OVERLYING WATER OF THE ALLEPPEY MUD BANK ON DIFFERENT DATES

30-7-1971		26-8-1971	
Station	Organic carbon % per litre	Station	Organic carbon % per litre
1	0·62	1	0·79
2	0·48	2	0·38
3	0·53	3	0·45
4	0·44	—	—

TABLE 5 — CHLOROPHYLL *a* AND PHAEOPHYTIN CONTENTS OF MUD OF THE ALLEPPEY MUD BANK TOGETHER WITH DATES OF COLLECTIONS AND STATIONS

Station	Date of collection	Chlorophyll (% dry wt)	Phaeophytin (% dry wt)
		1971	
1	17 Sept.	0·0003	0·005
2	do	0·0001	0·004
3	do	0·0002	0·005
4	do	0·0010	0·006
1	6 Oct.	nil	0·007
2	do	nil	0·010
3	do	nil	0·006
4	do	nil	0·010
1	3 Nov.	nil	0·006
2	do	nil	0·010
3	do	nil	0·004
4	do	nil	0·004
1	19 Nov.	0·0010	—
2	do	0·0005	0·001
3	do	nil	0·002
4	do	nil	0·006
1	6 Dec.	nil	0·005
2	do	0·0020	0·007
3	do	nil	0·006
4	do	nil	0·005
		1972	
1	13 Jan.	0·0009	0·007
2	do	0·0020	0·004
3	do	0·0006	0·005
4	do	0·0020	0·004

TABLE 6 — CARBOHYDRATE CONTENT OF MUD OF THE ALLEPPEY MUD BANK ON DIFFERENT DATES

6-12-1971		13-1-1972	
Station	Carbohydrate mg/g dry wt	Station	Carbohydrate mg/g dry wt
2	1·20	1	3·10
3	2·07	2	2·80
4	2·70	3	3·50
		4	3·91

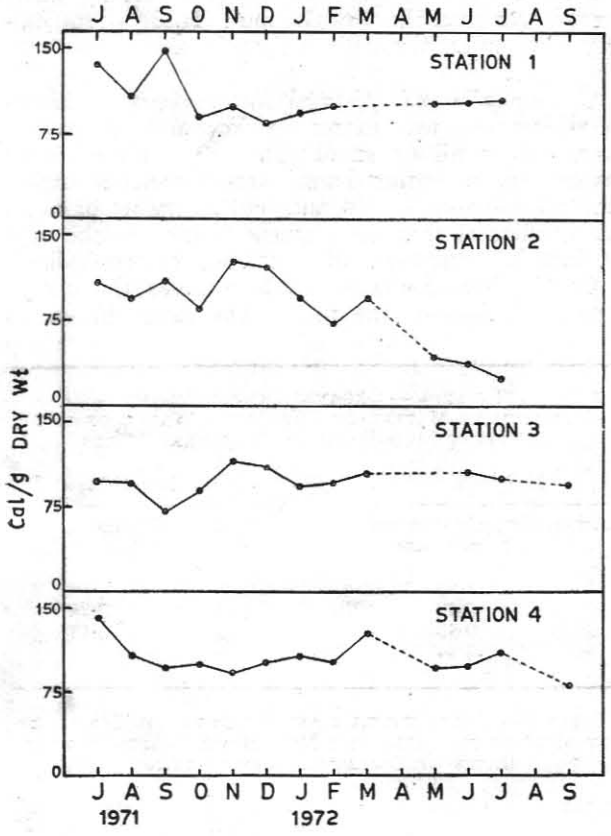

Fig. 4 — Seasonal variation in caloric content of mud from the Alleppey mud bank [Dotted lines between points indicate no data]

indicates that the carbohydrate content of the mud is low.

Caloric value — Caloric value of the mud was directly related to its carbon content. Mud rich in organic matter gave a higher caloric value (Fig. 4). The range in caloric value at different stations was almost similar except at station 2 during June and July 1972, when very low values were recorded. From the range in caloric value, it is clear that the mud is largely composed of inorganic material (fine silt particles, etc.) and is of poor nutritional value.

Discussion

From the size analysis of the mud carried out for over 13 months, it is evident that there is no marked qualitative difference in the mud with seasons. In other words, whether the mud is consolidated at the bottom, when the mud bank is passive, or when it is in suspension during the

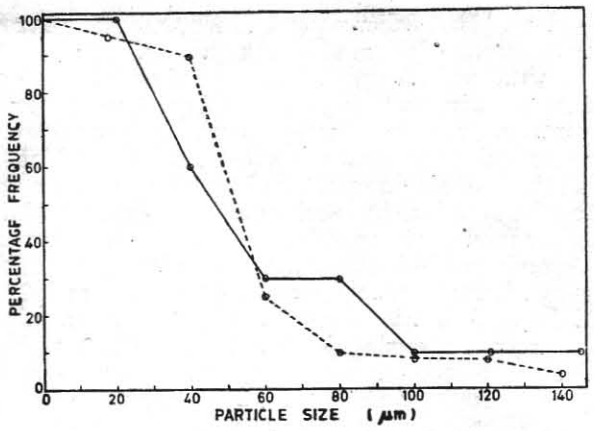

Fig. 5 — Size frequency distribution of mud particles obtained from the guts of fish and prawns [O- - -O, *Sardinella longiceps*. O—O, *Metapenaeus dobsoni*]

active phase of the mud bank, qualitatively the mud is similar.

The high phosphorus content found in the mud is of considerable significance. The consolidated mud present at the bottom during the passive phase of the mud bank probably acts as a storehouse of phosphorus. When, because of strong wave action, the mud gets into suspension, the adsorbed phosphorus is probably released into the interstitial water. Highly fluctuating values of total phosphorus found in dry silt of the mud bank and given in Table 2 probably indicate that the release of phosphorus into the overlying water is an intermittent process and can occur at any time if proper conditions are available. It does not seem to be confined to SW monsoon alone when the mud banks become active. Evidently, the presence of mud banks increases the fertility of coastal waters of this region. The high phosphorus contents reported from the inshore waters of the Malabar coast during the SW monsoon[11], is probably because of the release of phosphorus from the mud bank into the overlying water. Highly turbulent conditions during the SW monsoon probably induce the release of adsorbed phosphorus more readily; but the process can occur in other months also.

As reported earlier[12], fairly dense concentrations of fish and prawns occur in the vicinity of the mud banks which are fished during the monsoon months by the indigenous crafts. The mud banks, when active, act as temporary fishing harbours during a period when the sea is highly turbulent elsewhere. It has often been thought that the migration of fish and prawns towards the mud bank is for feeding purposes as the mud banks provide a richer source of food than the adjoining sea.

The available evidence shows that the mud is extremely poor in nutritional value. It is neither rich in plant pigments nor in total organic matter. An examination of 50 guts of the oil sardine and 10 guts of prawns from the specimens caught in the mud bank area showed that their guts largely contained mud and in most cases they were nearly half full with mud. Fig. 5 shows the particle size of the mud taken from the guts of oil sardines and prawns. The guts largely contained fine particles similar to those found in the mud bank which are relatively rich in organic matter. Odum[13], while

studying the ecological significance of particles ingested by the striped mullets, reported that the guts of mullets largely contained fine particles. According to him the fine particles have significantly higher organic value than the coarser particles which the fish rejects. Feeding, therefore, on fine silt would undoubtedly provide some nutrition to fish and prawns and would probably serve as food when other food materials are not readily available. However, migration of fish and prawns towards the mud bank is probably as a result of physical processes operating in the sea when the mud bank becomes active.

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