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MANDAPAM CAMP

16-18 September 1987

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ON CONSTRUCTION AND MAINTENANCE OF MARINE FISH CULTURE PONDS ALONG SOUTHEAST COAST OF INDIA

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ABSTRACT

The most expensive input in coastal aquaculture operations is construction and maintenance of culture ponds and farms. Experience gained on construction and maintenance of culture ponds in three localities along southeast coast of India during 1972-'86 has shown that since the earth is porous and incohesive in this region, adequate precautions have to be taken. For instance in order to overcome such problems as erosion of dykes due to prevailing rains, wave action of pond water at dyke bases and deposition of sand inside the ponds, suitable steps have to be devised. Another problem encountered has been poor tidal amplitudes, particularly during premonsoon months, closure of bar mouths in the postmonsoon season and the consequent paucity of sea water supply to culture ponds. The paper gives an account of the experience gained to minimise and/or counter these problems, in the context of the varying climatic and soil conditions in the three localities. Also, the ways and means of applying such techniques for successful management of culture ponds and farms in similar problem-prone areas are discussed.

INTRODUCTION

The most expensive input for culture of marine resources in coastal areas is construction and maintenance of ponds and farms. In India traditionally "bheris" (Pillay, 1954) and prawn or fish cum paddy culture ponds are constructed in West Bengal (Pillay and Bose, 1957), Kerala (Panikkar, 1937; Gopinath, 1956; Panikkar and Menon, 1957) and Goa (Gopinathan and Dani, 1973). Construction of experimental coastal ponds was first reported in India from the forties in Krusadai Island, Tamilnadu (Pillay, 1947; Chacko and Mahadevan, 1956) and Cochin (Pillay, 1948). Pioneering work involving some amount of skills to make the ponds and the dykes durable was carried out by Central Marine Fisheries Research Institute at Mandapam in the fifties (Tampi, 1960). A pilot farm was constructed in Lower Sunderbans by Central Inland Fisheries Research Institute in the sixties (Jhingran, *et, al.*, 1972). Continuing the work of CMFRI, a few ponds were constructed at Veppalodai in early seventies (Bensam and Marichamy, 1981). A private firm, M/s Shaw Wallace & Co Ltd has constructed some prawn culture ponds at Killai (near Porto Novo) in the late seventies. During 1979-85 C M F R I developed an inexpensive technology for construction and maintenance of culture ponds at Mandapam (Bensam, 1986), and has also taken steps to minimise deposition of sand opposite the supply canal to the Fish Farm for ensuring the flow of sea water.

MATERIAL AND METHODS

Data for the present paper are based on construction and maintenence of culture ponds at Veppalodai (Long. 78° 12' E and Lat. 8° 54' N) during 1972 - '77, Killai (Long. 79° 39' E and Lat. 11° 29' N) during 1977 - '79 and Mandapam (Long. 79° 48' E and Lat. 9° 14' N) during 1979 - '85. Five ponds were constructed at Veppalodai of which four were of 0.035 ha in area each (Bensam and Marichamy, 1981) and the fifth pond of 0.28 ha was constructed north of the smaller ponds, total area being 0.42 ha. Four ponds were developed at Killai, vide Fig. 1, of 0.36, 0.37, 0.42 and 0.45 ha for culture of prawns, with a total area of 1.6 ha In Mandapam a set of experiments was carried out in eleven ponds with a total area of 0.8 ha (Bensam, 1986).

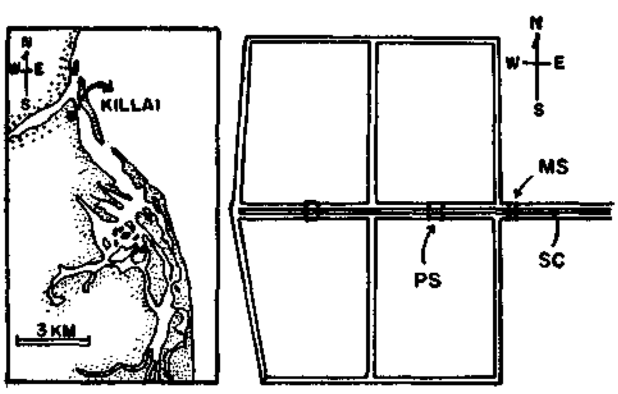

Fig. 1. Location of the prawn culture farm at Killai in the Vellar - Coleroon estuarine system and Lay - out of the ponds at Killai; M S: Main sluice; P S: Pond sluice; S C: Supply canal.

For examining the physical property of soil, sampling pits of 0.5 x 0.5 m area and 1.5 - 2 m depth were excavated, at 10 - 25 m distances. The soils were classified based on the sizes of grains, followed by Rahim (1968), Denila (1984) and Bensam (1986). The proportion of particles larger than 5.0 mm such as pebbles, molluscan shells, coral pieces and the like was dealt with separately.

Based on the quality of earth in each locality, the basal width of dykes in relation to height was determined approximately, peg markings were made and excavated earth was arranged in layers. Basal width and height of dykes were measured as per the procedure adapted by Jhingran *et al.* (1972). The methods followed for calculating erosion, deposition of sand, etc. are the same as described in a recent paper (Bansam, 1986). Since the reduction in the volume of dykes due to subsidence is only due to compaction of earth and not due to any loss, subsidence is not taken into account for calculating the quantity of earth lost. At Mandapam erosion was studied in a dyke by undertaking protective measures namely turfing and providing an inner strip of original ground (Bensam, 1986) as well as without them in another dyke, as a control. Percentages of earth lost from the dykes in each locality, including the control at Mandapam were monitored at the end of each year, for 5 to 7 years. The rainfall data for the localities were treated as the ones collected from the nearest observation centres of Indain Metereological Department, viz. Tuticorin for Veppalodai, Cuddalore for Killai and Pamban for Mandapam. The data on wind velocities for Mandapam were collected from the Pamban Centre.

For monitoring the actual tidal amplitudes at the entrances of the supply canals in relation to Mean Sea Level (M S L), a bench mark was first determined with the help of a civil engineer and scales were fixed. Since at Veppalodai water was pumped from a branch of Kallar Estuary, the scale was positioned there at the site of pumping. Daily recordings of the high and low tidal limits were made and monthly means were worked out in relation to M S L. At Mandapam the scale was also used for measuring the height of sand deposited opposite the supply canal as well as inside the breakwaters constructed. During 1985 such monitoring was made both inside and outside the breakwater, the latter as a control for comparing sand deposition and for determining their efficacy to reduce sand deposition. To assess the quantity of sand present in the waves at Mandapam, a pail was used for collecting water from the waves and the sand in the water so collected is expressed as gm/L of water by wet weight. The first experimental breakwaters constructed at Mandapam were partly curved and the second ones were linear. All of them were of the "rubble mound" type, made of granite and coral stones, without pointing.

PHYSICAL QUALITIES OF SOIL

The physical qualities of soil in the localities of pond construction may be judged from Table 1. Clay, silt and sand were predominant at Veppalodai (76%), but much lesser at Mandapam (44%). Gravel was minimum at Veppalodai (14%) and maximum at Mandapam (24%). In the latter locality, coral pieces and molluscan shells contributed to so high as 32%; but large components formed only to an extent of 10% and 7% at Veppalodai and Killai respectively. Following the types designated by Rahim (1968) and Denila (1984), the earth may be designated as "silty clay" in Veppalodai, "silty gravel" in Killai and "sandy gravel" in Mandapam. From these it is obvious that the soil at Veppalodai is the best one for construction and maintenence of culture ponds, followed by the one in Killai. But, the soil at Mandapam is the least suitable among the three localities because the predominant proportion there is composed of large particles, gravel and sand (81%).

Table 1. *Percentage composition of the types of soil in the three localities of pond construction.*

Locality	Veppalodai	Killai	Mandapam
Type of soil/ Size of Particle (mm)	Mean Percentage weight in total quantity		
"Clay" < 0.002	27	18	3
"Silt" 0.002-0.5	25	19	16
"Sand" 0.5-2.0	24	23	25
"Gravel" 2.0-5.0	14	23	24
Larger ones > 5.0	10	7	32

The profile of soil in Veppalodai was silty clay in the upper 1.2 m depth, followed by 0.8 m depth of sand. In Killai the upper 50 cm was clay, followed by 90 cm of silt and 60 cm of sand and gravel. In Mandapam there was clay and gravel in the upper 30 cm, resting on a 70 cm thick layer of coral pieces and molluscan shells, below which silt and sand were found.

STRUCTURAL WORK OF DYKES

The structural work of dykes constructed and the profile of soil in them are depicted in Fig. 2. Since the earth in Veppalodai was cohesive, it was decided to construct the dykes with the structural proportion of 4 base : 1 height, in the diamension of 4.8 m and 1.2 m (Fig. 2 A). Width of the crest was 1.2 m and the excavated slopes were at an

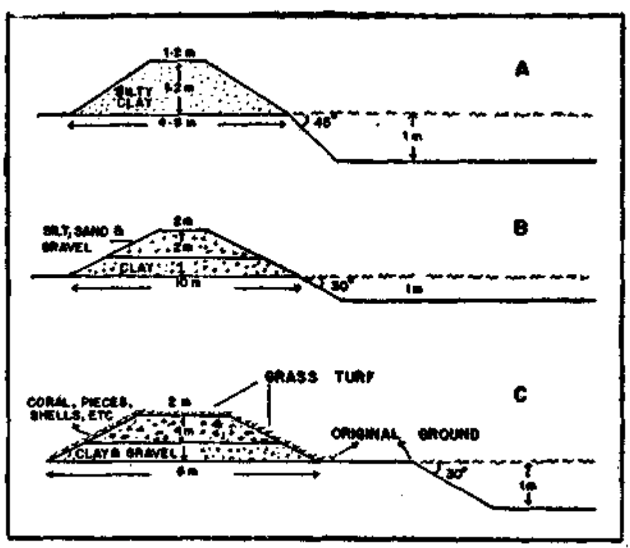

Fig. 2 Semidiagrammatic vertical sections of the dykes constructed at A: Vappalodai, B: Killai and C: Mandapam

angle of 45°. In Killai the structural work was of 10 m base and 2 m height (5 : 1), with a crest of 2 m width and excavated slopes at an angle of 30° (Fig. 2 B). In Mandapam the structural work considered for the present paper is the one with 6 m base, 1 m height, 2.5 m crest width, excavated angle of 30°, with a strip of original ground unexcavated on the inner sides and with grass turfing on crests and slopes (Bensam, 1986), vide Fig. 2 C.

SUBSIDENCE AND EROSION OF DYKES

The estimated quantities of earth lost due to subsidence and erosion in the respective years of experiments are presented in Table 2;

Table 2. *Subsidence due to compaction and erosion due to rains on dykes at the three localities, including a control at Mandapam.*

Locality	Veppalodai	Killai	Mandapam	
Description of dyke	Without turfing and inner strip of original ground (ledge)			With turfing and ledge
Year	1973	1978	1980-81	1980-81
Duration of Subsidence (Days)	60	90	68	63
Vol. of subsidence (cu m/m length)	0.24	0 36	0.73	0.75
Rainfall during subsidence (mm)	1.9	6.0	8.8	
12 monthly rainfall (mm)	952	1,788	671	
Vol. eroded from crests & slopes (cu m/ m length)	0.928	0.840	0.78	Nil
Vol. eroded from bases (cu m/m length)	0.25	0.12	0.52	Nil
Total loss (cu m/ m length)	1.418	1.32	2.03	0.75

Table 3. *Estimated loss of earth from dykes due to erosion at the end of successive years at the three localities, including a control at Mandapam.*

Locality	Veppalodai	Killai		Mandapam
Description of dyke	Without turfing and inner strip of original ground (ledge)			With turfing and ledge
End of the years	Percentage loss of earth from the original condition			
I	27	7.5	30	Nil
II	30	12	59	"
III	34	18	63	"
IV	40	25	77	"
V	45	28	82	"
VI	*	30	91	"
VII	*	32	*	*

* Not observed.

and the percentage quantities lost at the end of successive years monitored are given in Table 3. The volume of subsidence was lowest at Veppalodai, higher at Killai and highest at Mandapam. This appears to be related to the type of soil which is silty clay at Veppalodai and hence most compact, with least subsidence. But, the soil at Mandapam being sandy gravel has undergone the highest subsidence. From Tables 2 and 3 it may also be seen that the quantity of earth eroded from the dykes was the highest in the one without turfing, etc. at Mandapam, followed by the one at Veppalodai. Such a trend was also observed in the long run, with highest erosion in the dyke without turfing, etc. at Mandapam by the end of the 5th year, followed by the ones at Veppalodai and Killai. But, the dyke constructed with turfing, etc. at Mandapam has not undergone any erosion, even after a passage of six years.

The quantity of sand and silt deposited inside the ponds during 1973 at Veppalodai, with 951 mm annual rains was estimated to be 460m³/ha/12 months. At Killai the quantity was 320 m³/ha/12 m during 1978 with 1,788mm rains. At Mandapam, with turfing and the structural work provided, the quantity was only 160 m³/ha/12 months, with 671 mm rains. The source of this sand was neither from crests nor slopes, but from the edges of the inner strips unexcavated and which were subjected to wave action of pond water.

TIDAL AMPLITUDES

The monthly mean values of low and high tides in relation to M S L at the three localities are shown in Fig. 3. From the month of about April or May, the amplitudes became weaker in all localities, resulting in poor water supply to ponds. Higher tidal amplitudes were observed to resume only with the onset of the north-east monsoon winds, from about the month of October until April or May.

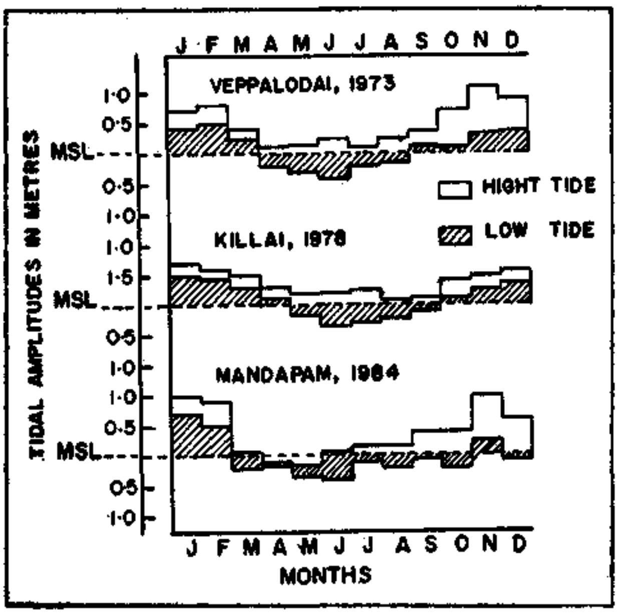

Fig. 3 Mean monthly tidal amplitudes in the three localities in relation to Mean Sea Level, during 1973, 1978 and 1984.

SAND DEPOSITION OPPOSITE SUPPLY CANAL AT MANDAPAM

The data collected on the quantity of sand present in the waves of the Palk Bay opposite the supply canal during 1984 are presented in Fig. 4. Sand was present in the waves only during north east monsoon and post monsoon months, in quantities varying from 1.5 to 43 gm/L. During May to September, coinciding with south-west monsoon winds the wind direction in relation to the physiography of the locality is such that the winds neutralise the waves, push sea water away from the coast and deposit only negligible quantities of sand ranging from only 2.5 to 15 cm height in the course of 1 to 30 days. But, during north east monsoon months the wind direction is reversed, waves become strong and deposition of sand reached so high as 50 cm height on a single day. Some observations made in this connection along with the wind velocities prevailing in Mandapam are presented in Table 4.

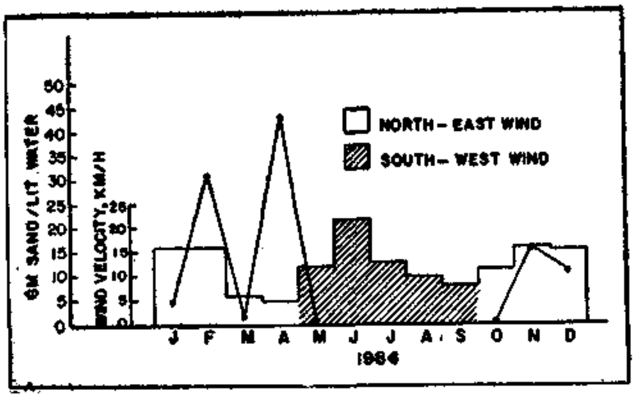

Fig. 4 Monthly mean weight of sand present in the waves at Mandapam and monthly mean value of wind velocity.

Table 4. *Intensities of sand deposition on the Palk Bay side of Mandapam during certain periods of south-west and north-east winds.*

Duration (From-To)	Wind Velocity (Km/h)	Height before deposition (cm)	Hight after deposition (cm)	Net height deposited (cm)
(A) South-west winds				
11 to 30-9-'83	7-21	55	60	5.0
1 to 31-5-'84	1-22	62.5	65	2.5
(B) North-east winds				
28 to 30-11-'83	21.6	140	185	45.0
26 to 27-12-'84	27	100	140	40.0
31-12-'84 to 1-1-'85	37	90	140	50.0

EXPERIMENTS ON MINIMISING SAND DEPOSITION AT MANDAPAM

To begin with, two partly curved breakwaters with a mean height of 0.65 m above M S L were constructed during July-August, 1984 (Fig. 5 A). The western breakwater had two arms terminally, partly covering the terminal part of the eastern one, for flowing water in between. A reduction in sand deposition upto 31, 51 and 33% was recorded during October, November and December of 1984 due to construction of the breakwaters, when compared to the corresponding months of the previous year. But, from the end of October '84, waves overtopped the breakwaters and deposited sand inside, revealing that the height provided was inadequate. As may be seen from Fig. 5 B, the length, breadth and height of the space inside the breakwaters got filled up by 31-1-1985, blocking the flow of water. Hence, the structural work had to be modified.

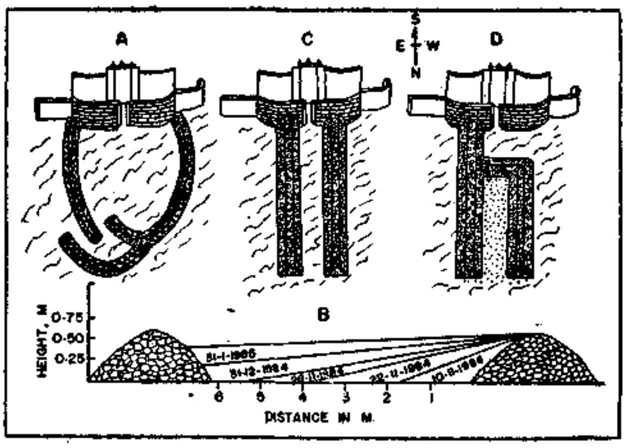

Fig. 5. Semidiagrammatic sketches of experimental breakwaters constructed at Mandapam. A: the curved breakwaters; B: The extent of sand deposition inside the curved breakwaters on days of overtopping; C: The linear breakwaters; D: The linear breakwaters with passage made at the southern end of the western breakwater.

In the second experiment the breakwaters were linear (Fig. 5 C), the eastern one of 23.4 m length and the western of 27.4 m length, the mean height being 1.4 m above M S L. The mean height of sand deposited inside in this experiment is compared with that in the previous experiment as well as with that in a control outside the breakwaters, (Table 5.) From the Table it may be seen that in the new

Table 5. *Height of sand deposited inside experimental breakwaters (B W) at Mandapam during North-East monsoon months of 1984 and 1985 and comparative reduction in height.*

Mean height deposited above (+) / below (—) Mean Sea Level (cm)				Reduction inside linear B W during '85 (precentage)	
Year	1984		1985		
B W type/ Experiment Months	Curved	Control	Linear	From '84	From Control, '85
September	+ 6.5	+ 12	— 5	11.5 (20)	17 (92.5)
October	+ 19	+ 23	— 3.6	21.6 (31)	26.6 (95.3)
November	+ 96.5	+ 78.2	+21.9	74.6 (51)	56.3 (44)
December	+117	+102	+62.4	54.6 (33)	39.6 (26)

structural work the reduction in sand deposition was 51% lesser in November, 1985 when compared to 1984 and was 95.3% during October, 1985 as compared to the control in the same month. But, due to overtopping of the breakwater after October the interspace gradually got filled up by February, '86. And, to flow water in the subsequent months, at the southern end of the western breakwater, a passage of 5 m was made by removing the stones there (Fig. 5 D) and using the same stones to make a bar in between the breakwaters. In this manner, water was flowed into the supply canal during 1986-'87. However, periodical removal of the sand deposited in this passage was found essential, in order to ensure continuous flow.

DISCUSSION

Since the strength, stability and durability of marine fish culture ponds depend solely upon the quality of the soil, it is essential to acquire a sound knowledge of the quality of the soil, before taking up construction. Ideal soil for pond construction is clayey, available along the southwest and certain other parts of India. This is firm, cohesive, water - retentive and slow to erosion by rains and wave action of pond water. For instance, in Kerala the soil quality is so good that elaborate precautionary measures are not needed for construction and maintenance of ponds (Panikkar, 1937; Gopinath, 1956; Panikkar and Menon, 1957). The soil along south-east coast of India is not so good, as may be seen from the present studies. Along this coast three kinds of soil were encountered in the three localities studied, viz, silty clay, silty gravel and sandy gravel, depending upon the proportions of the components. Thus it is obvious that the soil from one locality is different from the soil from another locality. In all the three localities, the soil is loose, incohesive, with poor water retention and susceptible to erosion. Again, based on the qualities of the soil, the degrees of erosion were observed to vary from one place to another. Therefore, in order to make the dykes durable, different proportions of structural work had to be developed, as a research and development effort. Thus, in the locality of silty clay the least basal width was provided; in the place of silty gravel a little wider base was given; and, in the area of sandy gravel the greatest width was afforded. But, inspite of the adequate structural work provided in the last locality, only the degree of erosion could be reduced. And, for ensuring absolute protection for the dykes, turfing and provision of a ledge had to be made. A comparison of the long term durability of the dykes in the three centres reported in the present paper has revealed that even though the soil in a locality is not quite suitable for construction, it is possible to maintain durable dykes by undertaking suitable protective measures. In the course of the present studies, certain unidentified grasses and creepers were found to grow on and around the dykes at Veppalodai and Killai. If only these were transplanted on the dykes there, as was done at Mandapam subsequently, the dykes would not have undergone so much erosion as was recorded.

Experience papers published on pond constuction in India are rather few so far. The dykes described by Tampi (1960) had coral stone pitchings resting on a toe wall. The provision of a puddle core wall is the salient feature of the dykes developed by Jhingran *et al.* (1972). The structural work designed at Mandapam recently (Bensam, 1986) has a ledge all along the inner sides. Certain methods have been suggested by some authors for protecting dykes against erosion. However, for a developing country like India, with availability of inexpensive labour at present, grass turfing is found to be cheaper than granite pitching or lining with asbestoes, bricks and the like, suggested by Bardach *et al.* (1972) and Chen (1976). A perusal of literature shows that nothing tangible is known of the durability of the dykes constructed at various centers. At Mandapam, the dykes constructed during 1980-'81 (Bensam, 1986) have remained durable even beyond six years, without any damage. The measures taken at Mandapam have also resulted in considerable reduction in the deposition of sand inside the ponds.

Another crucial factor for economical and successful marine fish culture projects is the availability of sea water supply to culture ponds through tidal amplitude. Jhingran (1982) has drawn attention to poor tidal amplitudes along southeast coast of India during summer and premonsoon months, along with closure of bar months due to sand deposition and the resulting death and decay of organisms in embanked estuaries and backwaters. In this connection' the steps taken to minimise deposition of sand opposite the supply canal at Mandapam by constructing breakwaters are perhaps the first of their kind in India. From the experience gained with the two experiments carried out, it appears that for achieving much more success under the prevailing conditions of the sea at Mandapam, it is essential to increase the height of the breakwaters to atleast about 2.5 m above M S L. Also, the length of the structural work appears to need much more enhancement upto a suitable distance away from the waves breaking region. More experiments involving engineering skills seem to be essential in order to arrive at much more success in this regard.

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