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Impact of suspended culture of the edible oyster *Crassostrea madrasensis* (Preston) on the sediment texture and organic carbon content at the farm site

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Abstract

The impact of farming of the edible oyster *Crassostrea madrasensis* on the sediment characteristics in Ashtamudi Lake was studied. The meat weight in the 25 m^2 trestle (rack) farm with approximately 30,000 oysters was found to increase from 27 kg in March to 228 kg in September with a corresponding total shell-on weight of 188 kg and 1431 kg respectively. The effect of farming on the top 1-5 cm and 5-10 cm column of the farm substrate was studied separately. Sediment in both the columns beneath the farm and the reference site (non-farm) in the estuary was predominated by fine sand (about 70%) followed by silt, clay and coarse sand. The average organic carbon content in the two sediment columns during the crop period were 0.87 (1-5 cm) and 0.73 (5-10 cm). Though there were variations in the sediment texture and organic carbon content between the farm and the reference sites the impact due to short term oyster farming on these parameters was not significant.

Keywords : Oyster biomass, impact, sediment texture, silt, clay, coarse sand, organic carbon

Introduction

Oyster farming is basically eco-friendly since additional inputs like supplementary feed are not introduced into the system. However, there is concern that bivalves may alter the nutritive value, stability and textural composition of the sediments by removing large amounts of suspended material through their feeding activities and alter the sedimentation rate through biodeposits directly beneath the aquaculture sites (Tenore *et al.*, 1982; Hargrave, 1994; Kaiser *et al.*, 1998; Christensen *et al.*, 2003).

Influences of natural and cultivated populations of suspension feeding bivalve molluscs have been reviewed by Newell (2004). Suspension feeding bivalves serve to couple pelagic and benthic processes because they filter suspended particles from the water column and the undigested remains ejected as mucus-bound feces and pseudofeces sink to the sediment surface. Benthic environmental impacts may arise from the deposition of solid wastes from the mollusks growing on the structures which comprise organic faeces and pseudofaeces, shells and other detritus discarded or dislodged from the farm. The wastes that are deposited fall through the water column and settle on the sediment beneath or near to the grow-out structures. These wastes can potentially alter the physical character of the sediment; alter nutrient cycling in the sediment or cause biological changes to the macro benthic community.

Edible oyster farming by private entrepreneurs started in the Ashtamudi Lake Kerala, India during 1996. Farming commences during November- December by suspending rens made of oyster shell clutches from wooden structures. Spat fall starts by end of November and by June-July the crop is ready for harvest. However, due to southwest monsoon rains during June to August and due to fluctuations in the meat percentage of farmed oyster, farmers may postpone the harvest of the crop to September –October. In the present study an attempt is made to study the variations which occur in the sediment characteristics of the estuarine substrate beneath an oyster farm during the oyster farming period of eight months.

Materials and methods

Experiments were carried out in the Ashtamudi Lake, which is the second largest estuarine system in Kerala (latitude 8^0 53' N and 9^0 02' N and longitude 76^0 31' E and 76^0 41' E). An oyster farm of 5m x 5m trestle (rack) (F-1) was constructed using bamboo poles and stocked with 500 rens. Each ren consisted of five shells strung on a 3mm dia nylon rope at 10 to 15 cm interval. A similar, but smaller farm was constructed near the experimental farm and stocked with same type of rens so as to facilitate substitution of rens taken for monthly biomass estimation from the experimental farm. The reference site (R-1) (non-farm) was located at approximately 100 m from the experimental farm site in the same estuary. The farm size and stocking density are identical to the commercial oyster farms in Kerala.

Estimation of farmed oyster biomass. For estimating the oyster biomass, three rens were taken at random from the farm site in each month of sampling. They were washed and brought to the lab where all the oysters attached on each cultch (3 rens x 5 cultch) were carefully separated. The number of dead and live oysters in each cultch was noted. The length (dorso-ventral measurement, DVM), width (antereo-posterior measurement, APM), total weight and meat weight of each live oyster were measured. Shell dimensions were measured using a digital vernier caliper (Mikito™) up to the nearest 0.01 mm and weight to the nearest 0.1 mg using a digital balance. The individual measurements were pooled and from these values average biomass per ren was calculated. Based on this, the average biomass in the farm for each month was estimated. To maintain uniform stocking density throughout the experimental period, three rens from a similar farm constructed near the experimental farm and having the same age and size group of oysters were replaced after taking the monthly sampling. Care was taken not to remove these rens in the subsequent sampling.

Analysis of sediment characteristics. Replicate sediment samples from the farm and reference sites were collected using a cylindrical PVC corer (80 mm dia x 100 mm high) during every second week of a month starting from January to September 2002. The core sample was unloaded on to a clean plastic tray without disturbing the sediment column. The sediment column was then divided into two portions of 5 cm each starting from the top sediment surface and labeled as 1- 5cm and 5 -10 cm respectively. The portioned samples were packed separately in heavy duty polythene bags and transported immediately to the laboratory where they were kept in a deep freezer till the analysis was carried out.

Frozen sediment samples were thawed and transferred to a small plastic tray and oven dried at 60° C for 24 – 48 hours till a constant weight was achieved. The dried sediment sample was then gently racked up and pulverized by breaking the clods using a pestle and mortar, sieved through a 0.5 mm mesh sieve and a representative sample was packed into a self sealing plastic sachet. Such sachets were stored in a desiccator having silica gel as dehydrant. Organic carbon was analysed by the method described by El Wakeel and Riley (1957). For analysis of particle size, replicate sediment samples from each site were collected as described above. Instead of freezing the samples, they were air dried under shade, then pulverized and packed in self sealing heavy duty polythene bags for later analysis. These were analysed by mechanical analysis by the International pipette method.

Results

The rens were placed in December 2001 and spat settlement was observed during January and February. The crop were harvested by the end of September 2002. The average number of oysters per shell (cultch) was 12 and the estimated number of oysters in the farm was 30,000. There was no mortality of farmed oysters. The length of the oysters ranged between 35.3mm and 62.3 mm, width between 25.2 mm and 50.6 mm and depth 13.2mm and 25.3 mm. The average meat weight of the oysters in the farm increased from 27 kg in March to 228 kg in September and the corresponding total shell-on weight was 188 kg and 1431 kg respectively (Fig. 1.).

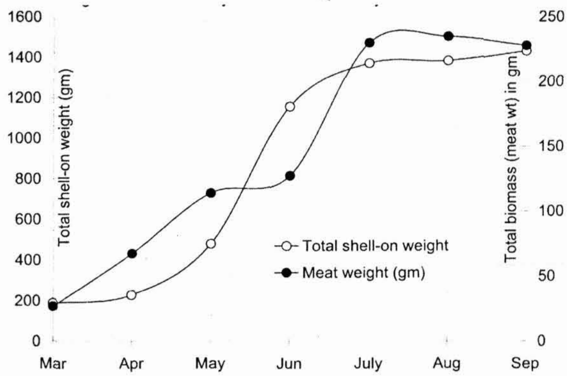

Fig.1. Growth of the oysters in the 25 m² oyster farm

The sediment beneath the trestle and at the reference site had wide seasonal variation in the percentage composition of coarse sand (2 to 0.2mm dia), fine sand (0.2 to 0.02mm dia), silt (0.02 to 0.002mm dia) and clay (< 0.002mm dia). However, throughout the period of study the soil texture at both the sites and in the 1-5cm and 5-10 cm column was predominated by fine sand followed by silt, clay and coarse sand (Fig.2).

The average percentage of coarse sand in the 1-5 cm layer at the farm site was 1.7 ± 0.86 while at the reference site it was slightly higher, 6.75 ± 8.98. In the 5-10cm layer also almost similar variation between F-1 (1.8± 1.49) and R-1 (7.2 ± 11.44) sites was observed. Though the variations were similar, one important observation was the considerably high percentage of coarse sand at the reference site of both the column samples during April and June (Fig.3). Even with these variations the overall difference due to farming at the end of crop period was not statistically significant (P >0.05).

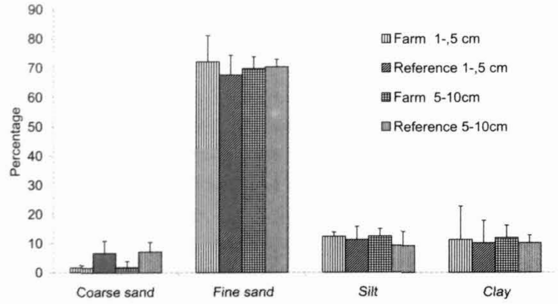

Fig. 2. Composition of the sediment components in the oyster farm and reference site

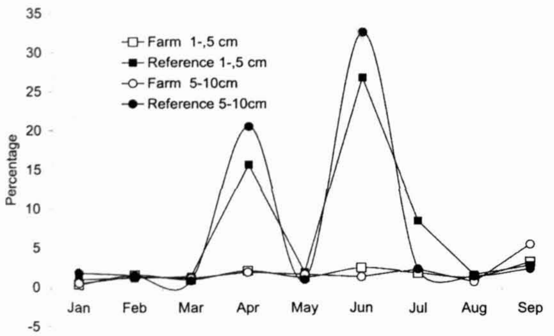

Fig. 3. Monthly variation in the percentage of coarse sand in the sediment beneath oyster farm and reference site

The average percentage of fine sand in the 1-5 column was slightly higher (72.1± 4.1) than that at R-1 (67.6 ± 6.7) while in 5-10 cm column the average percentage of fine sand was higher in the reference site (70.3 ± 7.71) than the F-1 (69.8± 4.54). Though there were seasonal variations, the percentage of fine sand decreased considerably during June (Fig. 4). However, these variations were not significant (P >0.05). The percentage of silt ranged between 12.3 ± 2.10 and 11.2 ± 4.03 at 1-5 cm column of F-1 and R-1 respectively. In the 5-10 column, the percentage of silt was lower, 9.2 ± 4.21 at R-1 while that at the farm site F-1 (12.4 ± 2.56) it was much higher. The percentage of silt decreased during June but again increased in July. In the subsequent two months, there was a fall in the percentage of silt in all the samples except in the 5-10 cm column of the farm site (Fig.5). The average percentages of clay in both the columns and at both the sites were almost similar. However, the trend in variation was not similar except during April-May (Fig.6). The percentage of clay increased during June in the farm which was followed by a decrease in July. Though the

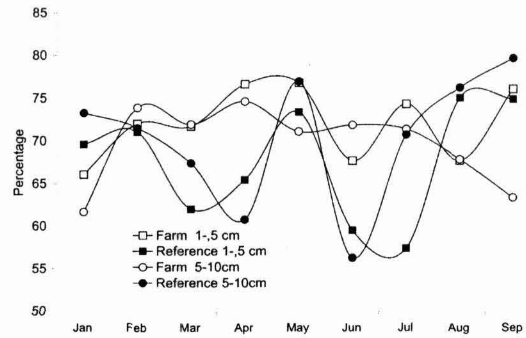

Fig. 4. Monthly variation in the percentage of fine sand in the sediment beneath oyster farm and reference site

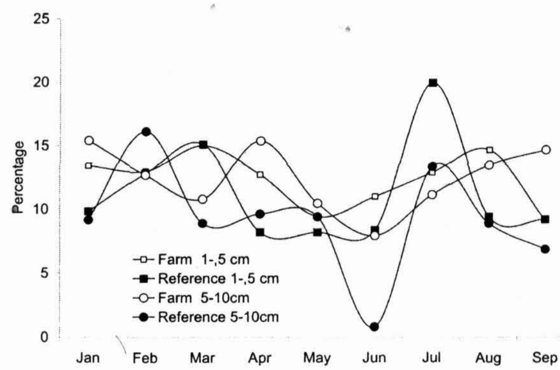

Fig. 5. Monthly variation in the percentage of silt in the sediment beneath oyster farm and reference site

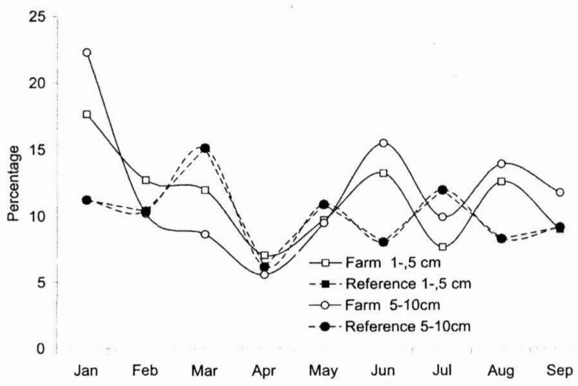

Fig. 6. Monthly variation in the percentage of clay in the sediment beneath oyster farm and reference site

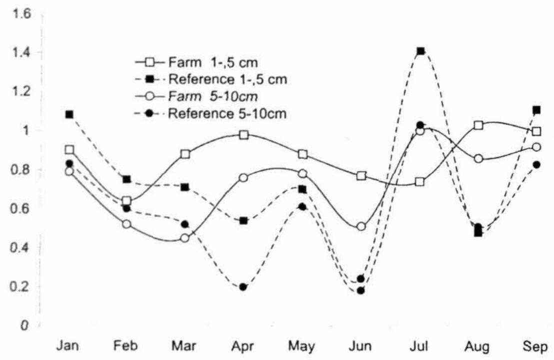

Fig. 7. Monthly variation in the organic content in the sediment beneath oyster farm and reference site

fluctuations were different in the reference site, the variations were not statistically significant ($P > 0.05$) and became similar at the end of crop period.

The organic carbon in the sediment also showed wide seasonal variations. The organic carbon content was slightly higher at the farm site but during July the values were higher at the reference site. During August at the reference site it decreased but in the following month increased again. ANOVA was carried out to test the seasonal effects in the farm and reference sites and it indicated that the differences were not significant ($P > 0.05$).

Discussion

In the present study it was observed that short-term oyster farming does not alter the sediment characteristics of the farm. Variations were found in the sediment texture of the reference site also indicating the natural seasonal changes in estuarine substrata. Land runoff during seasonal rains influences the sediment texture as observed by the increase in coarse sand during June at the farm and reference sites. The comparatively high tidal exchange at the farm site have helped dispersal of the feaces and other biodeposits from the farm site. Moreover the biomass of the farm was low when compared to farms in the temperate countries where each oyster string is about 6m long. In areas with high densities and low tidal flushing, heavy biodeposition has led to accumulation (or concentration) of organic matter in the sediments and enhancement of benthic fluxes of nutrients (Souchu *et al.*, 2001). Several studies have also indicated the influence of intensive biodeposition of faeces and pseudo-faeces that modify the physical and chemical characteristics of the benthic environment as they accumulate in the bottom sediments (Kasper *et al.*, 1985; Gilbert *et al.*, 1997; Mirto *et al.*, 1999). This enrichment has been reported to change the characteristics of the sediment (Dahlback and Gunnarsson, 1981; Kasper *et al.*, 1985). Mattson and Linden (1983) also found sediments under mussel farms to be slightly finer and in addition noted that they had a higher organic content and a negative redox potential when compared to reference sites. Kirby (1994) reported that sedimentation beneath the farms will not only be due to organic enrichment but also due to the presence of artificial structures within the water body which provides an impediment to the flow. Any structure which slows the flow of water will increase sedimentation. The farm structures and oyster strings in the present investigation might have obstructed the free flow of water currents through the farm site thereby aiding sedimentation and organic enrichment but during the short-term farming period the impacts were not significant.

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