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# Impact of Physical Disturbance on the Community Structure of Estuarine Benthic Meiofauna

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**Abstract:** As part of the environmental impact assessment studies of brackish water aquaculture, the effect of benthic disturbance caused by manual removal of overlying sediment near to the suction snmp of an aquaculture pond was studied in the Vellar estuary. The abundance and vertical distribution of meiofauna before and after disturbance were compared. Sediment core and water samples from the pre-and post-disturbance stages were analyzed for meiofaunal abundance, TOC, texture, porosity and physicochemical parameters. Immediately after one day of the benthic disturbance, a drastic decrease in meiofaunal nnmbers was observed, indicating the deleterious effect of disturbance. On the other hand considerable increase in TOC and meiofaunal numbers from the adjacent sites was observed vouching for the positive impact of such disturbances.

**Key words:** Estuarine benthic meiofauna, abundance, vertical distribution, aquaculture pond

## INTRODUCTION

Tropical estuaries are the most fertile areas in the world and that point out the necessity of having a proper knowledge regarding their benthic productivity and the environmental parameters influencing their subsistence. Several studies have been made on the abundance, distribution and ecology of meiobenthos in temperate and sub tropical regions in India but ouly a very little attention has been paid on the experimental study of meiobenthos in relation to environmental factors due to physical disturbance and literature in regard is very less or nil. Except, a very few high-quality works on the ecological impact of physical disturbance from Central Indian Ocean Basin (Ragukumar *et al*., 2001; Sharma and Nath, 1997) and some *in vivo* experiments done in terrestrial regions and shallow waters of temperate regions by Begon *et al*. (1990). Most of the other studies are ranging from effects of large scale trawling (Tuck *et al*., 1998) and benthic storm events (Posey *et al*., 1996) to small scale disturbance caused by mobile bio turbulaiting organisms (Thrush *et al*., 1991). Much of the extensive literature concerned with how marine benthic communities respond to organic enrichment has concentrated on effects of anthropogenic inputs associated with fresh water run off (Beukema, 1991), aquaculture (Ritz *et al*., 1989) and sewage disposal (Hall *et al*., 1997).

It is well known that environmental disturbance affect the distribution of organisms in a given ecosystem. When an area occupied by a set of species is disturbed, re-colonization and succession will occur with a new set of species (Coe, 1956; Schratzberger *et al*., 2000). Meiofauna are considered as the best indicators of such environmental stress because of their small size and short generation time. Further more they are also reported to have two potential roles in marine systems: (i) as a food for higher trophic levels and (ii) as nutrient generators (Coull *et al*., 1972; Schratzberger *et al*., 2002). Marine benthic meiofaunal assemblages are subjected to a variety of physical disturbance events and their response to such events has not been studied in the estuaries of India.

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In recent years, the shrimp farming is a fast growing industry in the maritime states of India. In the global scenario there is an increasing attention on the ecological interactions and the impacts of same on benthic community structure (Bejarano *et al*., 2005). This prompted us to take up the present investigation, as a part of the enviroumental impact assessment studies of aquaculture industry. Hence this study was undertaken to find out the effect of manual disturbance caused by the removal of overlying sediment from the suction sump (15 $m^2$ approximate area) of an aquaculture farm situated at the Southern bank of the Vellar estuary, Southeast coast of India.

## MATERIALS AND METHODS

### Study Area

The study was conducted during July 2004 in the suction sump of an aquaculture farm (Blue star aqua) situated in the Southern bank of Vellar estuary at Lat. 11°29' N and Long. 79°46' (South India). The farm was defunct for several years, which caused sedimentation in the suction sump and hence the study was undertaken upon the removal of overlying sediments.

### Sampling Stations

Total three sampling stations were chosen in the Southern side of the Vellar estuary, two stations haphazardly chosen were parallel to the shore approximately 20 m in front and another behind the suction sump as well as from the suction sump. In addition a control site with almost similar sediment texture was chosen in the Northern bank (Comparatively less affected by aquaculture plants). All the four stations had almost similar depth of 1-1.5 m. After initial sampling Casuarina poles were staked at all stations to minimize the effect of anthropogenic activities like casting nets.

### Sediment Sampling

Pre-disturbance sampling was done on July 18th 2006 from all the four stations. Since initial post disturbance sampling immediately after one day at the suction sump showed only a few number of organisms, we forced to postpone 3 more days to do actual post disturbance sampling (July 23rd, 2006). Glass corers of 2.5 cm inner diameter were used for collecting sediments to a 10 cm depth manually by skin diving at 4 stations: 3 in the Southern side and 1 in the Northern side (control) of Vellar estuary. All samples were collected in duplicate and were extruded from corers and sliced 2 cm interval for vertical distribution study. Each part were placed in to jars with 5% buffered formalin and Rose Bengal (0.5 mg $L^{-1}$). Sediment samples for the analysis of Total Organic Carbon (TOC), water content, porosity, pH and temperature were collected along with core samples. Total eight core samples were collected during day time before and after 3 days of disturbance.

### Estimation of Physico-Chemical Parameters

#### Water

Physico-chemical parameters of the superlying water for water temperature, salinity, dissolved oxygen content and pH were analyzed in the site itself with the help of a degree Celsius thermometer, hand refractrometer (Atago, Japan), YSI-55 DO meter (Yellow spring, USA) and pocket pH pen (Hanna, Italy) respectively.

#### Sediment

The sediment texture was analyzed by dry sieving method and the values were plotted in a trigon plot. Sediment temperature and pH were analyzed in the site itself with the aid of a degree Celsius thermometer and soil pH meter. Total organic carbon content was measured by wet oxidation method followed by titration with ammonium ferrous sulfate (El Wakeel and Riley, 1956) and expressed as mg $g^{-1}$. Sediment Water Content (WC) was calculated by determining the difference between the wet and dry weights and was expressed as a percentage. Sediment porosity was determined with the following equation:

$$(wc/1.02)/\{[(1-wc)/2.64] + wc/1.02\}$$

Where, wc is (wet sediment weight-dry sediment weight)/wet sediment weight (Danovaro *et al*., 1999).

**Enumeration of Meiofauna**

Meiofauna were separated by a set of two sieves, the upper one with mesh size of 500 µm and the lower one with a mesh size of 42 µm. Animals retained in the lower sieve were counted and sorted group wise with the help of a binocular microscope and considered as meiofauna. The sorted samples were kept preserved for further taxonomical studies.

## RESULTS

**Pre-Disturbance**

**Meiofauna**

In the pre-disturbance samples, the range of abundance was 820-1380 animals/core sample, represented by nematodes, copepods, kinorhynchs, gastrotrichs, foraminiferans, oligochaets, polychaetes, ostracodes and others. In all the samples nematodes were the most abundant group followed by harpacticoid copepods (Fig. 1). Vertical distribution of meiofauna decreased from surface up to 10 cm. In the entire pre-disturbance sample numerical abundance was high on the top 0-4 cm section.

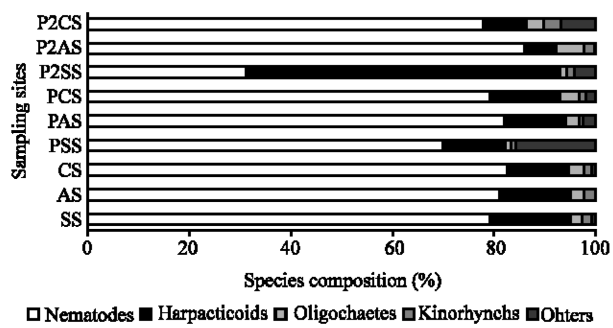


Fig. 1: Percentage composition of different meiofaunal groups in different stations

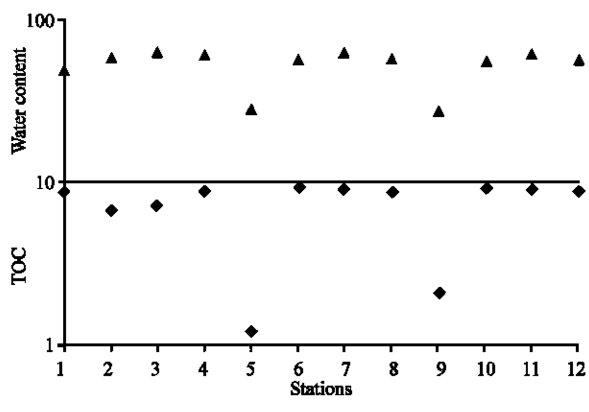


Fig. 2: Variation in TOC and water content in different stations

### TOC, Sediment Characteristics and Physicochemical Characteristics

The most noticeable feature of this study was homogeneous nature of the study area. This was evident from the homogeneity of sediment characteristics (silty clay) (Fig. 3) and TOC (6.8-8.7 mg $g^{-1}$) (Fig. 2) of the samples taken from 4 sampling sites before disturbance, as well as from the physico-chemical parameters in all the pre-and post-disturbance sites (Table 1).

### Post-Disturbance

### Meiofauna

Samples collected immediately after the disturbance (1 day) from the site P-SS showed a drastic decrease in the number of meiofauna (19/core sample). Vertical distribution was not considered because the entire site (P-SS) was heavily trampled due to the manual removal of overlying sediment. Samples from stations P-AS1, P-AS2 and P-CS did not show any significant variation in numerical abundance (Fig. 4).

### TOC Sediment Characteristics and Physico-Chemical Parameters

TOC showed a drastic reduction in P-SS and P2-SS samples (1.2 and 2.1 mg $g^{-1}$). So also before and after disturbance, sediment texture of the samples from suction sump had shown difference

Table 1: The physicochemical parameters, TOC and sediment characteristics in four different sites in three different samples

| Stations | pH | Temperature (°C) | Salinity (psu) | DO (mg $L^{-1}$) | TOC (mg $g^{-1}$) | Porosity | Water content (%) | Meio/Core |
|---|---|---|---|---|---|---|---|---|
| SS | 7.7 | 24 | 31 | 3.5 | 8.7 | 0.713199 | 49 | 820 |
| AS1 | 7.8 | 24 | 32 | 3.6 | 6.8 | 0.781384 | 58 | 973 |
| AS2 | 7.9 | 24 | 31 | 4.2 | 7.1 | 0.815054 | 63 | 1036 |
| CS | 7.8 | 25 | 32 | 3.8 | 8.6 | 0.788339 | 59 | 1118 |
| PSS | 7.5 | 25 | 32 | 3.4 | 1.2 | 0.501629 | 28 | 19 |
| PAS1 | 7.7 | 25 | 32 | 3.5 | 9.2 | 0.767123 | 56 | 1380 |
| PAS2 | 7.7 | 24 | 31 | 3.4 | 8.9 | 0.808536 | 62 | 1182 |
| PCS | 7.8 | 25 | 32 | 3.6 | 8.7 | 0.774313 | 57 | 992 |
| P2SS | 7.6 | 25 | 32 | 3.4 | 2.1 | 0.489090 | 27 | 83 |
| P2AS1 | 7.8 | 24 | 31 | 3.6 | 9.2 | 0.752375 | 54 | 1291 |
| P2AS2 | 7.7 | 24 | 32 | 3.4 | 8.9 | 0.801912 | 61 | 1071 |
| P2CS | 7.9 | 25 | 32 | 3.5 | 8.7 | 0.767123 | 56 | 1123 |

SS-Suction sump, AS1 and AS2-Adjacent site 1 and 2, CS-Control site, PSS, PAS1, PAS2 and PCS First sampling in post disturbed suction sump, adjacent site 1 and 2 and control site, P2SS, P2AS1, P2AS2 and P2CS-Second sampling in post disturbed suction sump, adjacent site 1 and 2 and control site

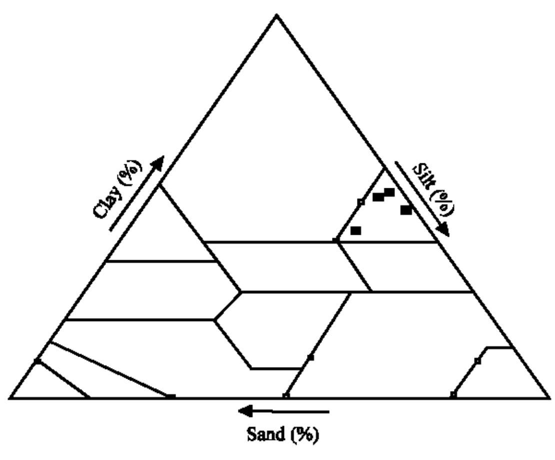


Fig. 3: Triagon plot showing the sediment texture in four different predisturbed sites

Table 2: Relationship between meiofauna numerical abundance and different physicochemical parameters and sediment characters

| Parameters | Correlation coefficient (r) | Probability (p) |
|---|---|---|
| pH | 0.71193 | >0.010 |
| Temperature | -0.33309 | <0.050 |
| Salinity | -0.26977 | <0.050 |
| DO | 0.29097 | <0.050 |
| TOC | 0.94969 | >0.001 |
| Porosity | 0.93037 | >0.001 |
| Water content | 0.91586 | >0.001 |

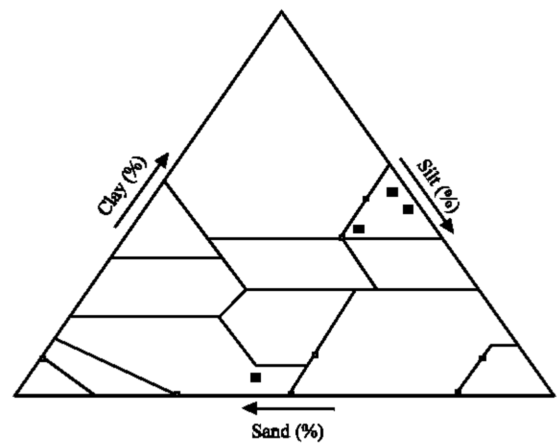


Fig. 4: Triagon plot showing the sediment texture in four different postdisturbed sites

from silty clay to sandy loam (Fig. 4), in turns water content and porosity. Assessment of correlation showed TOC, porosity and water content in the sites, before and after disturbance showed significant relation to the varied meiofaunal abundance, while, except pH none of the physicochemical parameters had relation to the meiofaunal abundance (Table 2).

## DISCUSSION

Observations showed an understandable decrease in the meiofaunal density in the suction sump (by 89%) between the pre and post-disturbance phases, this was quiet evident to understand the intensity of disturbance and its impact on meiofaunal abundance. Ragukumar *et al*. (2001) and Rodrigues *et al*. (2001) observed a similar fall in abundance of meio and macro fauna (32%) during the environmental impact assessment studies for polymetalic nodule mining. The comparatively less nnmerical abundance observed during the initial sampling (PSS) in the suction snmp to the adjacent sites and control site was perhaps because of the reduced oxygen penetration into the sediments due to high organic enrichment caused by bio-deposition (Hargrave *et al*., 1993; Mazzola *et al*., 1999; Nomaki *et al*., 2005). The slight increase in meiofaunal density, TOC and migration of nematodes towards the upper 0-2 cm section at PAS1 and PAS2 might be due to the immediate response of meiofauna to the bideposition caused by the discharged sediment plnme from the suction sump. The absence or reduced number of fecal pellets of different organisms during microscopic examination of P2AS1 and P2AS2 samples emphasis the extent of impact (20 m away from the suction sump). In a similar study on the impact of salmon's cage Duplisea and Hargrave (1996) pointed out a clear reduction of the meiofaunal biomass but not of their abundance, resulting in a general reduction in the average nematode body weight.

There was an increase in meiofaunal density (from 19 to 83 per core sample) during second post-disturbance sampling (after 3 days). The same finding was reported by Alongi (1990) in a tropical soft bottom benthic system and it was concluded that the resilient nature of meiofauna may allow them to quickly repopulate in the disturbed sediment. A significant increase in the percentage composition of harpacticoid copepods than that of nematodes was observed. The reason might be the influence of mobility of an organism (Copepod and kinorhyncha) and the regime of water current, which helped them for the easy re-colonization.

Even though the reduced TOC and the sandy sediment texture (clay silt to sandy clay) traced in the P2SS sample was very much correlated with the abundance of meiofauna. It is not utterly considerable, since these observations are from a small area, Vellar estuary and current patterns doubtlessly vary in time, space, strength and direction in all estuaries.

This study has demonstrated experimentally a relationship between physical disturbance and organic enrichment to the abundance of meiofauna in a selected site in the Vellar estuary. Based on our preliminary results it appeared that benthic disturbance caused by the removal of sediment may have harm full effect for short term. This may be a general inference for the distribution of meiofauna and subsequent re-colonization in estuarine disturbed areas. Long term monitoring is essential to derive the time-frame required for re-colonization to touches the original values.

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