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## Macrobenthic Molluscan Diversity in the Major Intertidal Zones of the Maritime States of India

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## ABSTRACT

The macro-benthic molluscan diversity in the estuaries of east coast of Indian sub-continent was studied during May 2014 to April 2015. The intertidal mudflats in four maritime states of India namely West Bengal (Shankarpur coast), Odisha (Bahuda estuary), Andhra Pradesh (East Godavari estuary) and Puducherry (Kalapet coast) were selected for the present work. A total of 17 dominant species were observed under the molluscan community encompassing two major classes namely Bivalvia and Gastropoda. Shannon-Weiner species diversity index was enumerated in all the sites to evaluate the magnitude of environmental stress. The mean value varied between 2.210 (Shankarpur coast in West Bengal) to 2.730 (Bahuda estuary in Odisha) which reflects different degree of stress operating on the estuarine/coastal ecosystem.

## 1. Introduction

Estuaries are the unique spots of the planet Earth, which are situated and sandwiched between the land and the sea. The estuarine water represents the zone of intersection between the river and sea water and are flushed by the recurring tides once or twice in every 24 hrs. The hard substrata in the estuaries/coastal zones act as the dwelling place of a large variety of molluscan species, which include objects like trunks of mangrove trees, sluice gates, lighthouses, stony boulders used for beach reclamation, jetties, groins, cross-spurs, guide wall etc. Review of literature exhibit that a large bulk of published documents are available on the biodiversity of estuary [1-7], but very little information is available on the spatial variation of macro-benthic molluscan diversity considering the entire panorama of the east coast of Indian sub-continent. The present work is an attempt to observe the spatial variation of macro-benthic molluscan community structure in the intertidal zone selected along the east coast of the Indian sub-continent.

## 2. Experimental Methods

## 2.1 Sampling

The present study was carried out during May 2014 to April 2015 in the intertidal mudflats selected in four maritime states of India namely West Bengal (Shankarpur coast), Odisha (Bahuda estuary), Andhra Pradesh (East Godavari estuary) and Puducherry (Kalapet coast). The population of molluscan species was estimated in fifty quadrates (of dimension 1 m × 1 m); ten from each of the five coordinates per station. The molluscs were handpicked, collected and brought to the laboratory. The molluscan specimens were cleaned, photographed and finally preserved in 4% formalin. The standard literature of Zoological Survey of India (ZSI) was used for identification of the molluscan species [22].

## 2.2 Statistical Analysis

Data from ten quadrates (selected at random) were collected from each coordinates in each station (n = 50) to ensure quality to the population

data and the mean values of these data sets were finally used to enumerate the community structure of macro-benthic molluscs in the study area through computation of Shannon - Weiner species diversity index [8], as per the standard expression.

$$\text{Species diversity index } (\bar{H}) = - \sum_{i=1}^s P_i \log_e P_i$$

$$\text{or, } (\bar{H}) = - \sum_{i=1}^s n_i/N \log_e n_i/N$$

where,  $P_i$  = Importance probability for each species. $n_i$  = Importance value for each species.

N = Total of importance values.

## 3. Results and Discussion

The macro-benthic molluscan community inhabiting the intertidal zone of four major estuaries/coasts in the eastern part of India showed the presence of 17 dominant species. In the Shankarpur coast of West Bengal, 6 bivalve species and 4 gastropod species were recorded during the study period. In the Bahuda estuary of Odisha, the number of bivalve species was 9 and the number of gastropod species was 8. In the East Godavari mudflats in the state of Andhra Pradesh, we documented 8 bivalve species and 8 gastropod species. In the Kalapet coast of Puducherry, the number of bivalve and gastropod species was 9 and 7 respectively (Fig. 1-8).

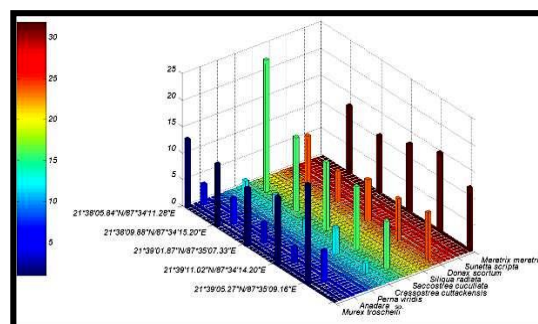


Fig. 1 Population density of bivalve species in the Shankarpur coast of West Bengal; value for each coordinate represents the mean value of 10 quadrates

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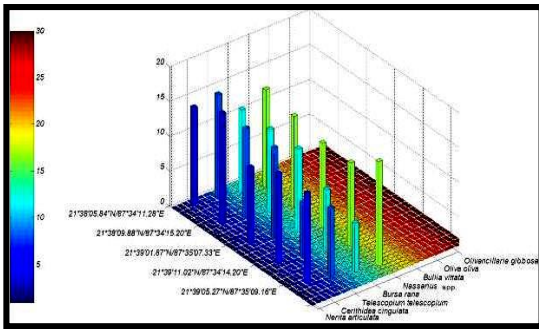


Fig. 2 Population density of gastropod species in the Shankarpur coast of West Bengal; value for each coordinate represents the mean value of 10 quadrates

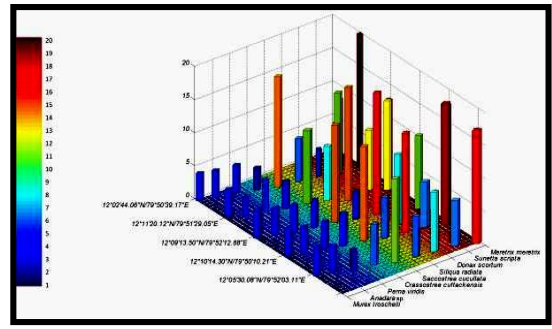


Fig. 7 Population density of bivalve species in the Kalapet coast of Puducherry; value for each coordinate represents the mean value of 10 quadrates

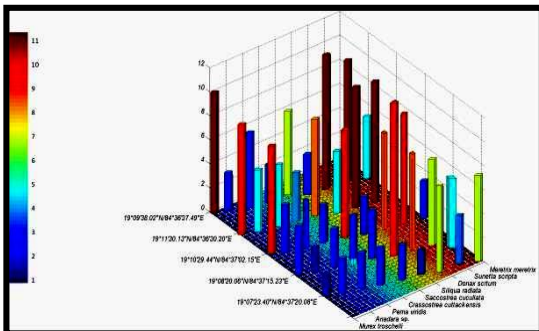


Fig. 3 Population density of bivalve species in the Bahuda estuary of Odisha; value for each coordinate represents the mean value of 10 quadrates

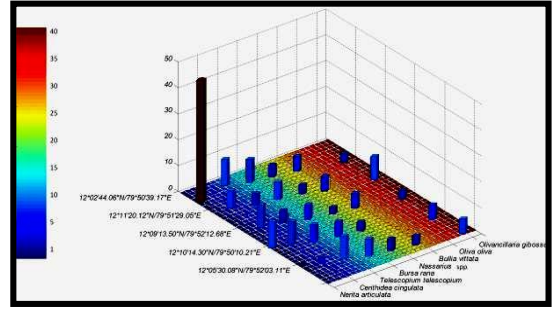


Fig. 8 Population density of gastropod species in the Kalapet coast of Puducherry; value for each coordinate represents the mean value of 10 quadrates

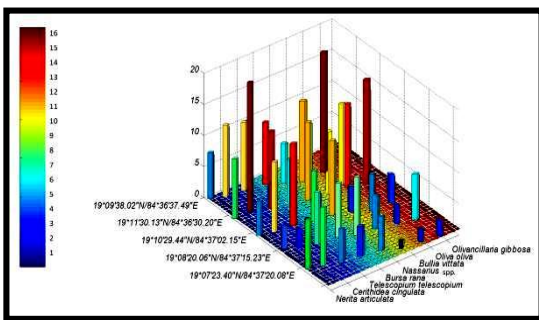


Fig. 4 Population density of gastropod species in the Bahuda estuary of Odisha; value for each coordinate represents the mean value of 10 quadrates

The Shannon-Weiner species diversity index ranged from 2.180 to 2.226 (in Shankarpur coast of West Bengal), 2.693 to 2.765 (in Bahuda estuary of Odisha), 2.176 to 2.474 in (East Godavari estuary of Andhra Pradesh) and 2.138 to 2.578 (in Kalapet coast of Puducherry). Considering the mean values of Shannon-Weiner species diversity index, it is observed that the value is highest in Bahuda estuary (2.787), followed by East Godavari estuary (2.638), Kalapet coast (2.599) and Shankarpur coast (2.278). The mean population density is also highest in Bahuda estuary (115.60 m<sup>-2</sup>), followed by Kalapet coast (110.4 m<sup>-2</sup>), Shankarpur coast (107.6 m<sup>-2</sup>) and East Godavari estuary (74.2 m<sup>-2</sup>). The picture of lowest diversity index of macro-benthic molluscs in Shankarpur coast despite of considerable population density is the outcome of uneven distribution of population amongst the species, which is an indication of high degree of environmental stress in and around the selected sampling station (Fig. 9-16).

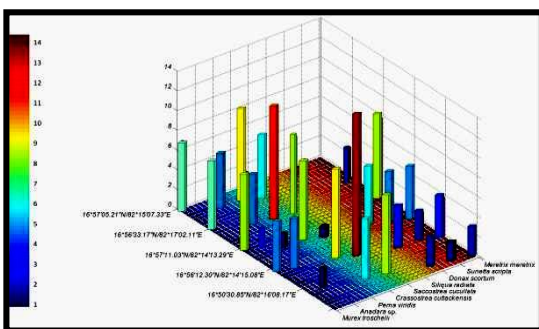


Fig. 5 Population density of bivalve species in the East Godavari estuary of Andhra Pradesh I; value for each coordinate represents the mean value of 10 quadrates

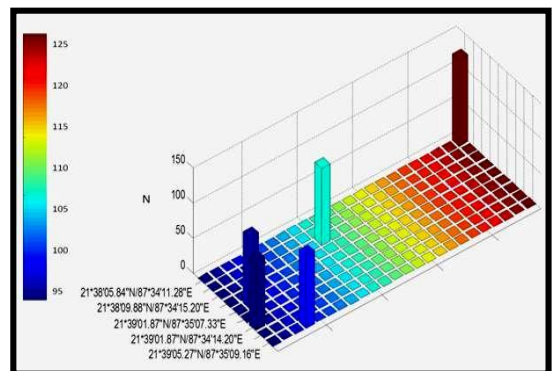


Fig. 9 Total population (N) in the Shankarpur coast of West Bengal

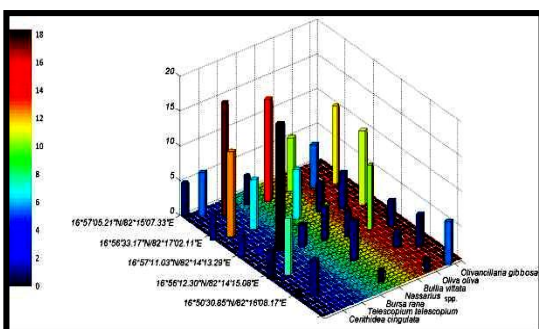


Fig. 6 Population density of gastropod species in the East Godavari estuary of Andhra Pradesh; value for each coordinate represents the mean value of 10 quadrates

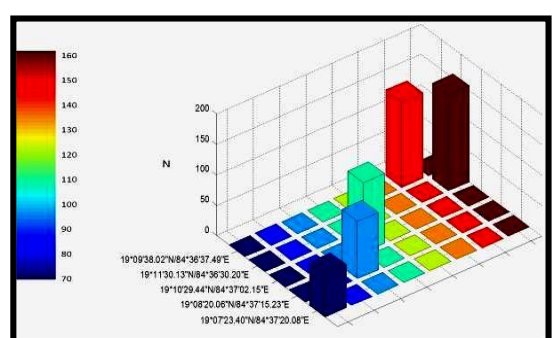


Fig. 10 Total population (N) in the Bahuda estuary of Odisha

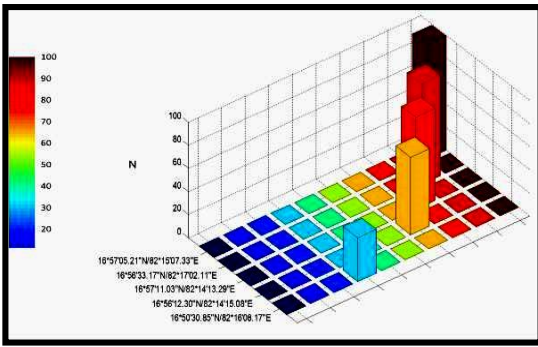


Fig. 11 Total population (N) in the East Godavari estuary of Andhra Pradesh

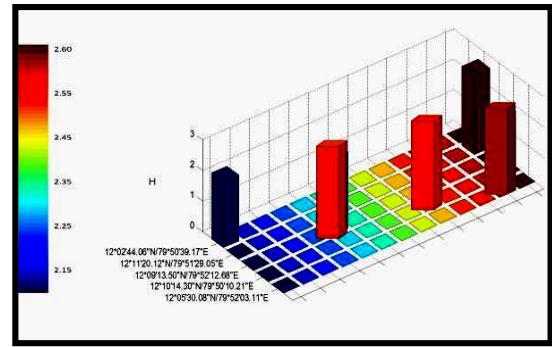


Fig. 16 Shannon-Weiner species diversity index (H) in the Kalapet coast of Puducherry

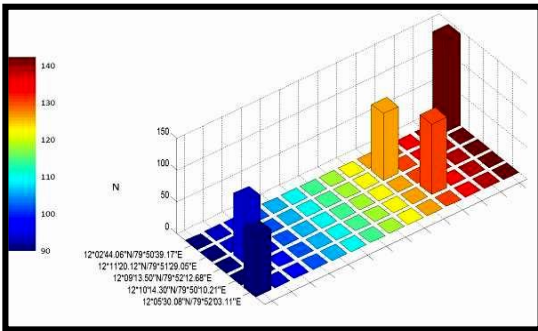


Fig. 12 Total population (N) in the Kalapet coast of Puducherry

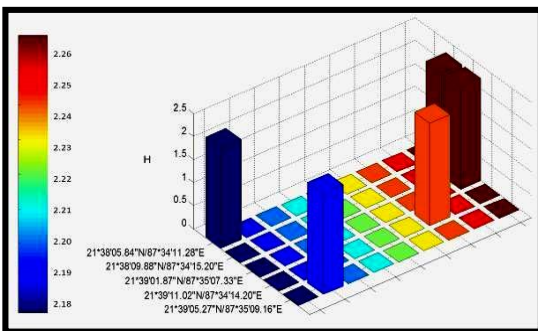


Fig. 13 Shannon-Weiner species diversity index (H) in the Shankarpur coast of West Bengal

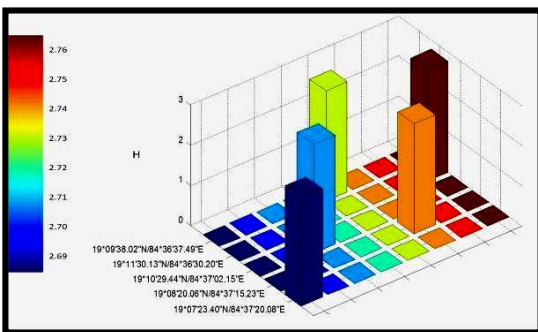


Fig. 14 Shannon-Weiner species diversity index (H) in the Bahuda estuary of Odisha

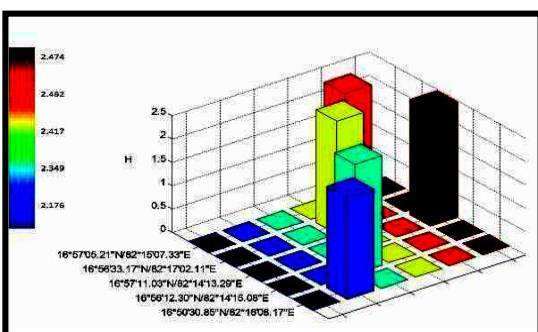


Fig. 15 Shannon-Weiner species diversity index (H) in the East Godavari estuary of Andhra Pradesh

The macro-benthic molluscan community is noted for its high ecosystem services mainly in the verticals of bioremediation [9-11], biomonitoring (as indicator species) [6, 12], carbon storage [6, 7, 13], livelihood [3, 14] etc. Considering the significance of this community, the present study was undertaken not only to prepare a check-list of the most common bivalves and gastropods in the major estuaries/coasts of east coast of India, but also to evaluate the health of the community in context to environmental stress. For this we used the Shannon–Wiener species diversity index as proxy and observed maximum value of the index in the Bahuda estuary of Odisha. This coast is relatively free of any type of human interference/anthropogenic pressure. The East Godavari estuary in the state of Andhra Pradesh and Kalapet coast in Puducherry experience considerable anthropogenic stress particularly due to intense fishing activities and tourism related pressure. Shrimp culture and salt pan also fall within the domain of anthropogenic activities in these two sites. The moderate value of Shannon –Wiener index in East Godavari estuary and Kalapet coast is an indicator of such human induced stress in these areas. In the state of West Bengal, the Shankarpur coast exhibited lowest value of Shannon-Weiner index, which may be attributed to high pollution load in the environment due to presence of shrimp farms, tourism units and a major fish landing station [7, 11, 15, 16]. Several boat and trawler repairing units are also concentrated along the coast of Shankarpur due to which the area experiences stress of high degree.

The value of Shannon–Wiener index has several ecological explanations. As Margalef, (1968) stated that, ‘the ecologists find in any measure of diversity an expression of the possibilities of constructing feedback system’ [17]. Higher diversity then signifies longer food chains and more cases of symbiosis (mutualism, commensalisms etc.) and greater probabilities for negative feedback control, which reduces the drastic oscillation and hence increases stability. The value of Shannon–Wiener index is also a unique indicator of environmental stress. As the sensitive species gradually shift or get eliminated from the habitat with the increase of magnitude of environmental stress, therefore the species diversity index has been claimed as an effective statistics for predicting the change in environment [18-19]. A scale of pollution in terms of species diversity (3.0-4.5 slight, 2.0-3.0 light, 1.0-2.0 moderate and 0.0-1.0 heavy pollution) has been described by Staub et al. [20]. In a Shannon-Weiner legislation the aquatic environment of soil and water is divided as good when  $H > 4$ , good quality is 4-3, moderate quality 3-2, poor quality 2-1 and very poor quality  $< 1$ . The Shannon-Weiner index in the present study is within the range of (2.114-2.863) which indicates less environmental stress on the macro-benthic molluscan species inhabiting the east coast of India. The distribution of species (in terms of population density) becomes more dissimilar as the environmental stress increases and accordingly species diversity decrease with poor water quality (as observed for Shankarpur coast in West Bengal in the present study). A community dominated by relatively few species indicates that the environment is under stress [21]. Considering the two primary variables namely (i) number of species and (ii) distribution amongst the population of different species in the present macro-benthic molluscan community, we observed that the selected estuaries/coasts in the eastern part of Indian sub-continent experience moderate environmental stress, the magnitude of environmental stress being in the order Shankarpur coast (in West Bengal) > East Godavari estuary (in Andhra Pradesh) > Kalapet coast (in Puducherry) > Bahuda estuary (in Odisha). A 3-class stress scale (2.000 - 2.300, 2.300 - 2.600, 2.600 - 2.900) constructed on the basis of mean values of Shannon-Weiner index thus reflects the most congenial environment for the growth and survival of molluscan biodiversity in the Bahuda estuary of Odisha. On the contrary, in the Shankarpur coast of West Bengal, the situation is worst as per the range and classification of our constructed stress scale (Fig. 17).

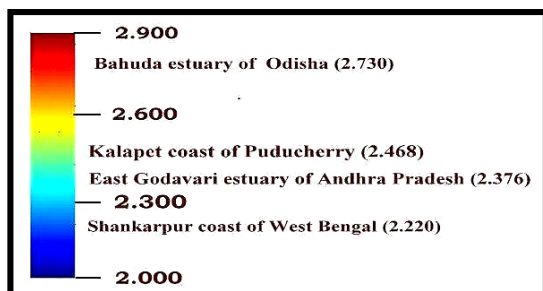


Fig. 17 A 3-class stress scale to indicate the health of estuary/coastal zone

#### 4. Conclusion

This multi-institutional joint research highlights the urgency of strict monitoring and control of anthropogenic activities for the Shankarpur coast of West Bengal. Establishment of any polluting industry or port in this region is not advisable considering the health of the ecosystem. Mangrove afforestation programme in this region may upgrade the quality of the ecosystem by way of bioremediation and providing matrix for attachment of oyster spat and gastropods.

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