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Biotic assemblage on coastal defense structures: a contributor to biodiversity

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Original Article

Abstract

This study explores the nature of faunal assemblage on coastal erosion protection structures. The biotic community structural studies of macro faunal assemblage on geotube deployed at kovalam coast reveals around 13 species of epibiota dominated by brown mussel recruitment. The traditional coastal defense structures like rock, boulders, tetrapod and caissons located along Chennai coast recorded 12 species broadly categorized as macro-algae, bivalves and gastropods. The diversity pattern of epibiota population density has been studied using β diversity. The gastropod and bivalve population recorded high β diversity indicating the low similarity among the species with high population diversity along the various coastal defense structures studied. Whereas, the macro algae recorded low β diversity indicating the high similarity of species in the population with low diversity. Thus, epibiota population recruitment on coastal defense structures ultimately contributes to coastal biodiversity, the magnitude of contribution being in the order of Gastropod > Bivalve > Macro algae.

Key words: *Epibiota, assemblage, geo textiles, diversity index.*

Introduction

The industrialization and urbanization along the coastline are historically wide spread and considered to be the major cause of habitat as well as species loss along coastal zones (Airoldi and Beck, 2007). Amidst the 7500 km long Indian coast, 23% are affected by erosion and the requirement of coastal defense structures is inevitable (Biju Kumar and Ravinesh 2011). Coastal defense structures have been reported to transform the existing habitat of soft substrata to hard substrata which create additional habitat for nearby intertidal organisms (Fabio and Chapman, 2010). The urban shoreline protection structures like sea wall were considered as surrogate for natural rocky shores and studies on biotic assemblage is required to understand the ecological impact (Connell, 1999,2000; Glasby 1999; Biju Kumar and Ravinesh, 2011). Those structures were colonized by organisms such as algae and sessile marine invertebrates that are native to natural rocky habitats as well as providing refuges and nursery grounds for fish and crustaceans. But the biotic assemblages that developed on a submerged hard substrate (breakwater) and on nearby coastal natural rocky substrate was different from the sand-filled geo-textile containers as a consequence of the physical properties of the substratum affecting organism recruitment. Through literature, it has been found that little attention has been paid to the harboring of epibiota on man-made coastal defense structures until the last decade. Predictively, the process of biotic assemblages expected to be hosted by these coastal defense structure has to be the design criteria for any coastal armoring. However, the current scenario of constructing these structures has not considered about the marine communities that could colonize them. In India, studies on faunal recruitment pattern on existing structures needs to be assessed to understand the impact on coastal biodiversity. The paucity of literature availability about the faunal assemblage in coastal protection structures necessitates the requirement of understanding the current scenario of the novel habitat created by these coastal defense structures (Chetan *et.al.*, 2010; Ravinesh and Biju kumar, 2013). Hence, a baseline study was carried out to understand the diversity pattern at different coastal defense structures and its contribution to coastal biodiversity.

Material and methods

Site description

The Kovalam beach is located near Thiruvananthapuram, Kerala on the west coast of India within a bay of 450 to 500m wide. In March 2008, the Department of Tourism, Government of Kerala commissioned ASR Ltd. of New Zealand through the Department of Harbor Engineering to design and construct an offshore multi-purpose reef at Kovalam (Johannesson and Warmoes, 1990). The goal was to protect Howha beach from erosion, while improving the ecology and enhancing tourism through the introduction of sports such as surfing. Investigations made in the Kerala coastal zone indicates that out of the 560 km coastline, 320 km is facing severe erosion particularly during the south - west monsoon (Kuriakose and Nair,1976; Moore, 1939). In order to combat the coastal erosion, different types of protective measures have been adopted along the Kerala coast (Moschella *et.al.*, 2005, Nair *et.al.*, 1998). These protective measures have partially succeeded. Along the Kovalam beach, the Kerala Department of Tourism has considered sustainable soft solution to the erosion problem by deploying sand filled geosynthetic tubes between the lighthouse and the Edakkal rocks off the beach (Fig.1 and 2) instead of traditional management options such as seawall construction. ASR Ltd. has installed 28 geobags of various sizes on the southern side of the bay with a volume of fill of 4331m^3 (Johannesson, and Warmoes, 1990). The installation process started in October 2009 and was completed in February 2010. These reefs are expected to protect the beach by mimicking natural reef structures. Since its existence from February 2010, it has been observed that these geosynthetic tubes harbor epibiota. Chennai coast is located on the east coast of India. It is the industrial and commercial center of South India and a major cultural, economic and educational center. Chennai is known as the

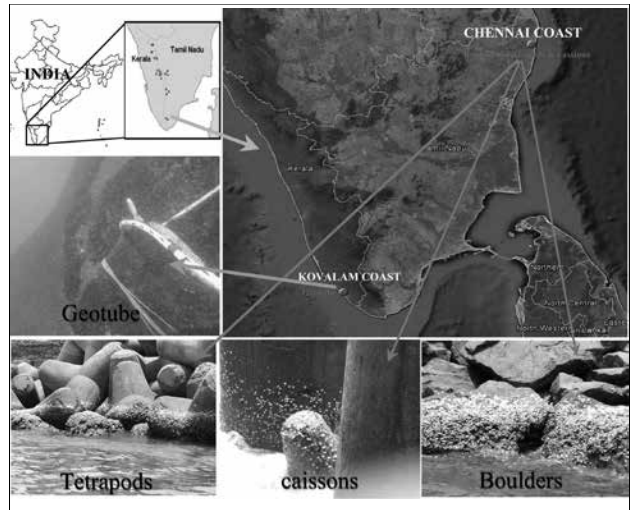
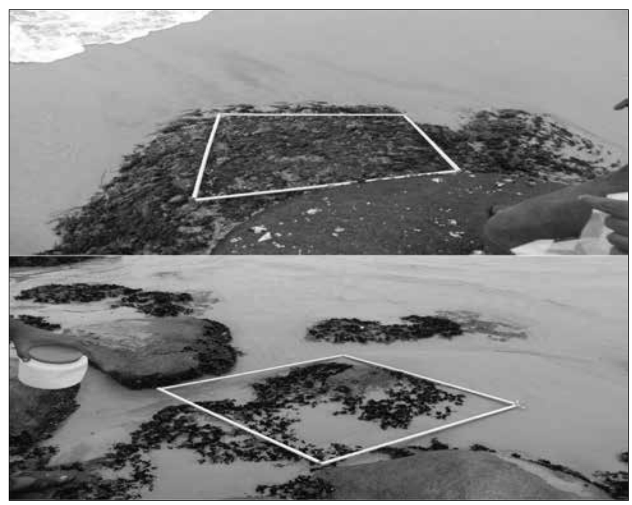


Fig. 1. Location of sampling stations and different coastal protection structures



Fig,2. Rocky shore Faunal estimation at Kovalam coast

"Detroit of India" for its automobile industry. Along the Chennai coast, the stretch of about 15km from Ennore towards its south upto Royapuram fishing harbor comprise of a number of fishing hamlets. Most of the beaches have been protected by a seawall (piled boulders & caissons) and a combination of seawall and groins (Sundar and Sundaravadivelu, 2005). These structures are designed specifically to protect the shores for a considerable duration which also act as a shelter for flora and fauna of localized community.

Four different structures like caissons, geotube, breakwater with piled boulders and tetrapods were studied during January to December 2014 on seasonal basis. (Fig.1). The epibiota diversity of a natural rocky shore and geotube at the Kovalam coast of Kerala state was assessed (Fig.1and 2). Along the boulders piled breakwaters of the Chennai fishing harbor (13° 08.001'N, 080° 18.031' E) and on caissons (13°10.384' N, 80°18.754'E) were randomly sampled by fifteen 0.25m2 quadrates during the low tide period as well as line transect at ~1m below *in situ* by SCUBA diving. The quantification of epibiota abundance on rocky substrate has been estimated by 1 m x 1 m quadrate studies at six locations with 5 random quadrants in each location and expressed as the percentage cover of macro algae and sessile fauna. The estimation of organism on the geotube at 8°23.056' N lat.; 76°58.722' E long.,was carried out by taking underwater photographs at technically difficult areas of subtidal conditions and line transect method by SCUBA diving. To understand the two distance (East & west coast of India) dependent community pattern, spatially explicit measure of β diversity was utilized (Bacaro and Ricotta, 2007).

Results and discussion

The consequence of shoreline armouring in the marine environment includes destruction of the existing shoreline habitat and the introduction of novel habitat; the effects of which have only recently received attention (Duffy-Anderson, 2003). In general, artificial structures are often constructed from materials such as concrete, plastic, metal, etc. (Ravinesh and Biju kumar, 2013) which may affect or favor epibiota colonization (Reynolds, 1965, Russell, 2000). Around 36 species were identified from different coastal structures studied. The change in faunal assemblages found on caissons, boulders, tetrapod, geotube and rocky shore opined that change in physical properties of the substratum was likely to affect the organism recruitment (Shaw Mead, 2009). Among these, rocky shores and boulders of break water has recorded high diversity of 19 species followed by tetrapod with 18 species (Fig.3, 5 and 6). The caissons recorded very low diversity represented by four species might be interpreted as the cylindrical structure discourages biota settlement due to more surface area exposed to intertidal wave forces (Fig.3 to 7). Comparison of various species richness scores of discrete

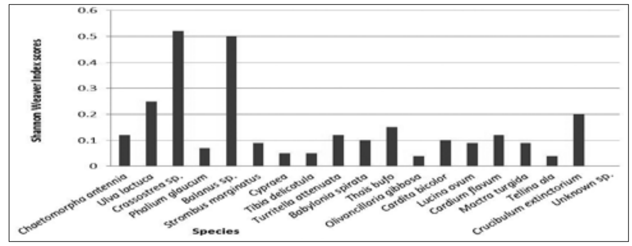


Fig. 5. Species diversity pattern along the boulders piled in the break-waters

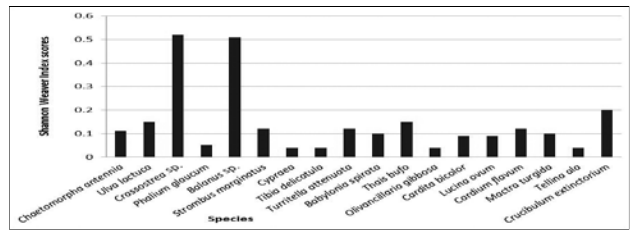


Fig. 6. Species diversity pattern along theTetrapods

structures were presented in Fig.8. It is evident that physical properties of substrate nature affect the organism recruitment has been justified as the caissons supported considerably minor quantity of biota than other substrates studied.

Among the various organisms studied from four different coastal defense structures, organisms belong to three major groups like bivalves, gastropods and seaweeds were examined for their contribution to biodiversity (Table1). The β diversity index has been adopted as it defines the variation in the identities of species among sites (Whittaker 1960, 1972).The β diversity recorded the highest score of 0.85 for gastropod population followed by molluscs and macro algae (Fig.9). The species richness for individual groups also reflected the same pattern as macro algae was represented by 4 species followed by molluscs and gastropods (Table 1). Hence the higher scores of β diversity indicate the high species diversity with low similarity among the populations. It has been

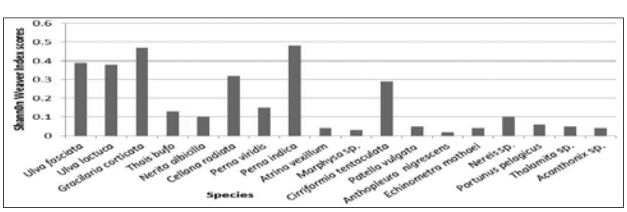


Fig. 3. Species diversity pattern along Kovalam rocky shore

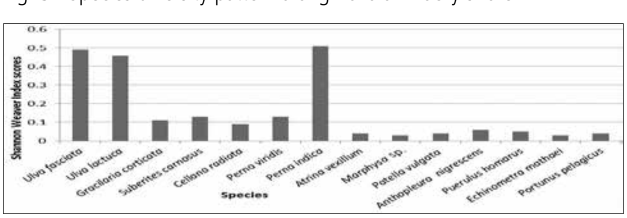


Fig.4. Species diversity pattern along Kovalam geotube

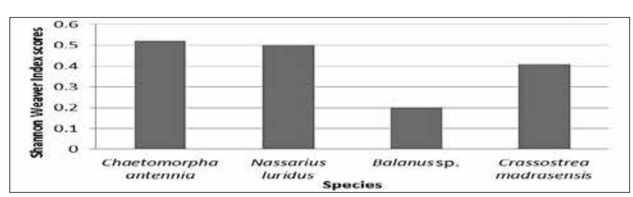


Fig. 7. Species diversity pattern along the caissons

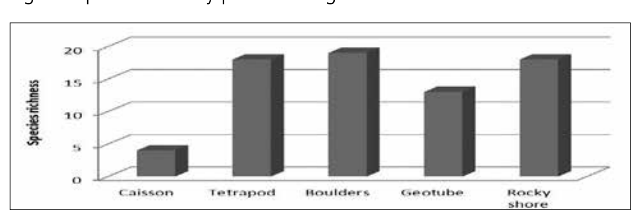


Fig. 8. Species richness of epibiota on different substrates

Table 1. Epibiotic diversity at various substrates at selected locations along east and west coast of India

Species	Rock shore	Geotube	Tetrapod	Boulders	Caisson
Macro algae					
Ulva fasciata	+	+	-	-	-
Ulva lacticulata	+	+	+	+	-
Gracilaria corticata	+	+	-	-	-
Gracillaria edulis	-	-	+	+	+
Annelida					
Marphysa sp.	+	+	-	-	-
Cirriformia tentaculata	+	-	-	-	-
Nereis sp.	+	+	-	-	-
Gastropods					
Nassarius luridus	-	-	-	-	+
Phalium glaucum	-	-	+	+	-
Srtombus marginatus	-	-	+	-	-
Cypraea sp.	-	-	+	+	-
Tibia delicatuala	-	-	+	+	-
Turritella attenuate	-	-	+	+	-
Babylonia spirata	-	-	+	+	-
Olivancillaria gibbosa	-	-	+	+	-
Thais bufo	+	+	+	+	-
Nerita albicilla	+	-	-	-	-
Cellana radiata	+	-	-	-	-
Tellina ala	-	-	+	+	-
Crucibulum extintorium	-	-	+	+	-
Srtombus marginatus	-	-	-	+	-
Patella vulgata	+	-	-	-	-
Unknown sp.	-	-	-	+	-
Crustaceans					
Portunus pelagicus	+	+	-	-	-
Thalamitta sp.	+	-	-	-	-
Acanthonix sp.	+	+	-	-	-
Balanus sp.	-	-	+	+	+
Bivalves					
Cardita bicolor	-	-	+	+	-
Lucina ovum	-	-	+	+	-
Cardium flavum	-	-	+	+	-
Mactra turgida	-	-	+	+	-
Perna viridis	+	+	-	-	-
Perna indica	+	+	-	-	-
Atrina vexillum	+	+	-	-	-
Crassostrea madrsesis	-	-	+	+	+
Echinodermata and Cnidaria					
Anthopleura nigrecens	+	+	-	-	-
Echinometra mathaei	+	+	-	-	-

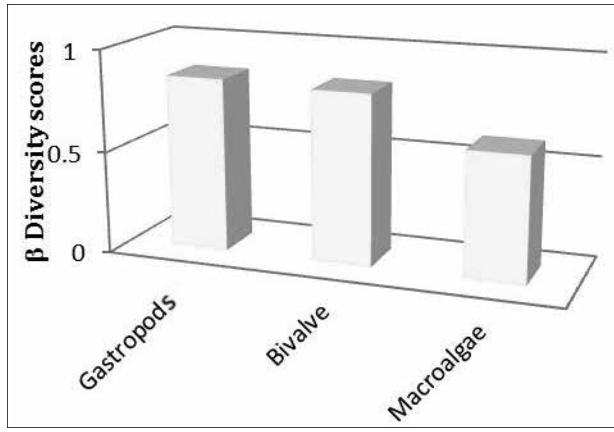


Fig. 9. diversity scores of epibiotic assemblage on various coastal structures

concluded that the gastropod population contributes more to biodiversity followed by bivalves and macro algae. It is also evident that the structure and complexity of macro algae determining the abundance patterns of epibiota as reported by many studies (Gee and Warwick, 1994; Attril *et al*., 2000; Chemello and Milazzo, 2002). Current study also recorded same pattern as Caissons recorded single species of algae with very low faunal diversity (Table 1).

Colonization of epibiota on artificial substrates leaves a positive impact on nature and their recruitment pattern alters the species succession. However, some nonnative species were segregated. A worm like gastropod native to Caribbean coast was identified through molecular taxonomy. Hence this study warranted periodical monitoring of invasive species in such artificial coastal defense structures. However, epibiota recruitment on these structures can be considered as a contributor to coastal biodiversity.

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