Deployment of Artificial Reef Modules
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Introduction

As a result of increasing human population along the coastal area, anthropogenic impacts on the coastal zone have become severe over the past few decades. Majority of the damages to coastal ecosystem have been due to direct anthropogenic stress. According to Bryant et al. (1998), 57% of the world's coral reefs are potentially threatened by human activity such as coastal development, destructive fishing, over exploitation, marine pollution, runoff from deforestation and toxic discharge from industrial and agricultural chemicals. The Gulf of Mannar region of southeast coast of India, having 21 islands is unique with wide diversity of corals and associated flora and fauna. Fishery is the primary economic activity of the people living along this coast. For the past 30 years, the fishermen of the Tuticorin coast of Gulf of Mannar have involved themselves in illegal coral quarrying activities and as a result, one of the islands (Vilanguchalli) present in the Gulf of Mannar was already submerged. Reef associated fishery resources are in the threat of depletion due to unregulated and over fishing activities. The deployment of artificial reef modules in Tuticoin coast would help in the enhancement of biological resources and protection and restoration of habitats.

Artificial Reef Modules

The creation of artificial reef modules on flat, featureless, sandy sea beds has been a form of enhancement for subsistence, commercial and sport
fishing practiced in certain countries for centuries. It is only in more recent years that advanced engineering and design principles have been incorporated into this field, along with quantitative ecological and socio-economic assessment of habitat structure and function (Seaman, 1995). Most of the large-scale units for fish are designed to provide substantial open space, permit good circulation within the unit, promote current deflections, and project high enough in the water column to attract both reef and mid-water species. Stable, durable and non-polluting materials were used for construction of artificial reef modules for the present work. The criteria are based upon the requirements for the use of non-hazardous material of sufficient stability and durability to ensure that the materials remain in the deployed area to last long enough for providing the intended habitat enhancement. Two types of materials were used in the present study, 1. Triangular shape Ferro cement modules (FC) and 2. Cube shaped fly ash (FA) modules. These modules were deployed in Tuticorin coast at four sites.

Site Selection

The artificial reef site selection is one of the most critical decisions in the entire process. There are a range of factors that should be taken into account when selecting a site for artificial reef modules such as the physical environment, the biological environment and local users of the area (Heaps et al., 1997). For the present study social, economic and environmental factors are considered for site selection. Four study sites were selected for the present study, three sites at the outside area of Vaan and Koswari islands and one at the outer Tuticorin Harbour patch reef area (Fig. 1).
Fig 1. Map showing the study area
Also two control sites were selected, one at outside the island and another at the Harbour patch reef area. The data on the physico-chemical parameters, plankton diversity and benthic fauna, assemblages of fin and shellfishes and catch per unit effort were collected in the artificial reef and control sites. The samples were collected from the 3 Ferro Cement (FC) artificial reef and control-1 sites for a period of 17 months from June 2002 to October 2003. The sampling was carried out in Fly ash (FA) artificial reef and control-2 sites for a period of 12 months from February 2004 to January 2005.

**Different types of modules**

**Ferro cement triangular modules**

For the construction of these modules, slabs were made with Ferro cement. Each slab is 137 cm in length and 90cm in width. In each slab twelve holes were made, in which eight holes with a diameter of 18 cm and four holes with a diameter of 11 cm for the movement of the water and fishes. These slabs were transported to the study sites with the help of raft (Fig 2 & 3).

![Fig 2. Photograph showing slabs on the temporary raft](image)

![Fig 3. Photograph showing raft towed by boat](image)
Once the selected deployment site was reached, three slabs were joined and tied with iron wires to make into triangular modules (Fig 4). Each module was deployed manually into the water (Fig. 5 and 6) with the help of SCUBA divers. A total of 105 Ferro cement modules were deployed in three different depths (FC site-1, 5.6m, FC site-2, 6.2m and FC site-3, 6 m). The sites were mentioned as FC sites 1, 2 and 3 and marked as such in Fig.1. The control site near FC artificial reef areas is named as control -1.

Fig 4. The Ferro cement triangular module in the FC site 1, 2 and 3.

Holes – 18 cm and 11 cm diameter

Fig 5. Photograph showing the assembling of the slabs

Fig 6. Photograph showing deployment of module
Fly-ash modules

The feasibility of artificial reefs using fly-ash waste products were tried to determine the use of fly-ash waste products constructively in the marine environment and to investigate the effects of habitat structural complexity on recruitment of fin and shellfishes diversity in the fly-ash artificial reefs in Tuticorin coast. Cube shaped artificial reefs, each with 2'2" length and 2'2" height (Fig 7) were constructed using fly-ash bricks, which were made of 55-60% raw fly-ash, 20% gypsum and the remaining part with sand and cement. Total 55 cubes were made and they were transported to study site (FA site - 4) with the help of raft.

![Fig 7. The Cube shaped Fly-ash module.](image)

The fly-ash modules were deployed outside the mainland patch reef area of Tuticorin Coast at 8.3 meter depth (Fig.1). In developing countries, economy is one of the major important factors and so low cost materials favour the
construction of artificial reef modules. Concrete is one of the most widely used materials for the construction of artificial reef throughout the world. An earlier report clearly indicates that fly ash modules are safe for organisms, favourable for attachment by sessile life and can induce excellent aggregation of fish (Suzuki, 1995). Use of fly-ash bricks for making artificial reef modules has no adverse effect on the marine environment and so it can be used to make the substrate for marine communities.