

MARINE BENTHOS – A FUTURE PERSPECTIVE

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INTRODUCTION

The term benthos is widely referred to flora and fauna which are intimately associated with sediments in an aquatic environment. They support a rich variety of floral and faunal assemblage of marine bottom communities, viz., bacteria to vertebrates. Their distribution in the marine environment starts from intertidal zone to deep sea. Depending on the ecological niche they are classified as interstitial, eulittoral, sublittoral and abyssal benthic communities. Their distribution is inversely proportional to depth on the horizontal and vertical realm. The littoral zone supports rich benthic communities than deep sea. Development of morphological adaptations such as calcareous shells, elongated, stalked and branched body, appendages with cilia and bristles and strong body musculature are characteristics of benthos.

Benthic organisms are reported from different kinds of substrate like hard bottom, soft bottom, coarse bottom and also from organic matter and other macrodebris. Benthos are, in general, sessile and slow moving in nature. 75% of benthic animals live on firm substrates (rocks, corals etc), 20% on sandy/muddy bottoms and only 5% of the total are planktonic. Many benthic animals within the sediment perform periodic vertical migration. Benthos are mostly either filter feeder or browsers or deposit feeders. Their feeding depends on particle size, quantity abundance and choice preference. Their species diversity and abundance vary widely with geographical area, climate, spatial and temporal difference, physico-chemical factors and other biological interactions.

The size of benthos varied from microscopic to several orders of magnitude. Benthos are classified on the basis of their size and their position in the sediment. The organisms that live within the sediment are called as 'in fauna' and they move within the interstitial spaces or they build burrows or tubes. 'Epifauna' which are either attached or move at or on the surface sediment. Organisms that like amphipods, shrimps and scallops make extensive movements by swimming at the bottom. Based on the size, benthos are classified into three categories viz., microfauna which vary from 1 to 50 μm (bacteria, protozoans, protophytes etc) meiofauna which vary from 50 to 500 μm (foraminiferans, copepods, nematodes, turbellarians, several larval forms etc) and

macrofauna which are more than 500 μm in size (all macroinvertebrates, macrophytes and selected vertebrates like fishes).

The community structure of benthos is mainly decided by the following environmental factors:

- (i) Physico-chemical factors such as region, climate, temperature, salinity, water currents and circulation, tidal exposure, depth, substratum, sediment grain size, oxidation- reduction state, dissolved oxygen, organic content, nutrients and light.
- (ii) Biological factors like (a) food availability and feeding activities, (b) prey-predator relationship and species removal, (c) reproductive effects on breeding, spawning dispersal and settlement, (d) behavioural effects which induce movement and aggregation and (e) growth and mortality.

TYPES OF BENTHOS

Benthic flora

The benthic flora widely represents from phytobenthos to macrophytes. In general, the flora is highly diversified and heterogenous in size with dominance in selected habitats like creeks, estuaries, intertidal salt marshes, rock pools, shallow lagoons and coral reefs etc. Major components of phytobenthos are (a) cyanophyceans, (b) cryptomonads, (c) euglenoids, (d) dinoflagellates, (e) diatoms, (f) fungi and (g) photosynthetic bacteria. While major components of macrophytes are seaweeds and grasses, mangroves, and salt marsh vegetations.

Macro and microalgae and photosynthetic bacteria sustain extensive populations in and on the sediments and solid substrates depending on the availability of light and oxidation – reduction condition. High algal production is observed in salt marshes, intertidal sediments ($80\text{-}200\text{ g C m}^{-2}\text{y}^{-1}$) and in the eulittoral areas upto 20 to 30 m ($<80\text{ g C m}^{-2}\text{y}^{-1}$) depth depending on the light penetration. In sediment, photosynthetic activity is restricted to the upper 6-8 mm from the surface depending on the type of sediment and the wave length of light. Chlorophyll a of the order of 100 mg/m^2 is common in intertidal sediments. In most of the cases about 2 to 4 mm from the surface sediment accounts for the compensation depth.

MICRO-BENTHOS

Microfauna is mainly consisted of bacteria, ciliates and micro-flagellates. Bacteria are the most numerous and ubiquitous organisms present in sediments and their metabolic activities largely control the chemical nature of sedimentary environment. Bacteria in sediments are generally similar to those in water in reference to antibiotic sensitivity, degradative, and fermentative capability and cation requirements. Common aquatic bacteria like *Flavo bacterium* and *Achromobacter* are often present in sediments. Both gram+ve and gram-ve cell types are present with larger cell size than bacteria isolated from water. Aerobic heterotrophs which oxidize organic compounds usually occur in surface sediments to depth determined by the penetration of dissolved oxygen. In anoxic conditions at deeper layer anaerobic bacteria use various organic and reduced inorganic compounds as hydrogen acceptors. Bacteria capable of anaerobic respiration (fermentation) and chemosynthesis characterize these sediment layers. The bacterial biomass in the top 10 cm sediment vary from 5.5 gm² – 26.5 gm² depending on the sediment particle size. Bacteria accounts for more than 50% of the metabolism of benthic communities. In general, micro organisms are responsible for over 95% of community respiration.

MEIO-BENTHOS

Meiofauna includes a wide assortment of metazoans with small elongate bodies adapted to an interstitial mode of life. They include ciliates, tardigrades, turbellarians, gastrotrichs, oligochaetes, archiannelids, harpacticoids, ostracods, nematodes, foraminiferans, rotifers, and gnathostomulids. The meiofaunal community shows complex ecological properties, with predictable patterns of species composition and abundance in time and space and with recognizable patterns of resource partitioning. Micro flora and fauna form major source of food for the meiofaunal communities although they use selectively the dissolve organic compounds to synthesize carbon. About 16-20% of the meiofaunal production (av 20 g C m⁻²y⁻¹) is utilized by macrofauna, while the rest is available for the mobile carnivores like fishes, birds and crabs, as well as used for within meiofaunal communities.

MACRO-BENTHOS

The larger metazoans over 500 µm in size representing all the phyla form this group. Macrofauna mainly constitute three mode of feeding such as filter feeders (bivalves, sponges, ascidians, worms, barnacles etc), browsers (amphipods, isopods, gastropods etc) and deposit feeders (annelids, bivalves, gastropods, holothurians, crustaceans etc). The preference of macrofauna to hard bottom and silty sand rather than muddy bottom is well recognized. Enumeration of population and com-

munity structure, biomass, and species diversity of macrobenthos is much easier as compared to meiofauna and microfauna. Macrofauna serve as a major source of food for the demersal fishes. It is possible that the macrobenthos get about half of the sedimented carbon and that many species are able to transform it to macrobenthos production with an efficiency around 40%. In that case an overall benthic transformation efficiency of 20% may be realizable and yield to demersal fish of 5 g C m⁻²y⁻¹ be well within the capacity of most benthic communities.

ROLE OF BENTHOS

Benthos play a vital role in the marine food chain and in the recycling of essential life sustaining elements like, C, N and P in the marine ecosystem. The sedimented organic matter from the water column is effectively consumed and converted into invertebrate benthic biomass, dissolved organic matter and inorganic nutrients by benthic organisms. The nutrients released from the sediments due to bacterial degradation of organic matter, diffuse and disperse fairly rapidly into the overlying water and influence the primary production which in turn triggers the zooplankton production in the marine environment. There is certain amount of evidence that significant amounts of nitrogen and phosphorus are released from sediments in organic form which is directly utilized by selected microfauna and meiofauna for the organic synthesis.

Bacteria play a vital role in the process of decomposition of organic matter, nutrient recycling, in the energy cycle of benthic ecosystem and as a source of food for benthic animals. Bacteria are responsible for more than 50% of the metabolism of benthic communities. In short, they are responsible for a healthy marine food chain.

Bacteria are major source of food for meiobenthos and meiobenthos are food for macrobenthos which in turn serve as an important source of food for demersal fishes. Since, the demersal fishery contributes about 30 to 50% of the total fishery potential of an area, the benthic production plays a major role in deciding the demersal fishery potential.

Macrobenthos create bioturbation during their movements and feeding activities which conditions the sediments for meiofauna and microfauna and as a stimulant of nutrient regeneration. Many deposit feeders ingest anaerobic sediments and transfer them to surface layer where they become oxidized. This also helps transfer of bacteria and organic matter from deeper reduced layer to surface oxidized zone. Simultaneously, this also aids the transport of well oxygenated water from the surface to deeper zones.

Benthos due to their differential tolerance have been considered as the best indicator organism of environmental stress or aquatic pollution. Benthic macroinvertebrates are widely used in 'biomonitoring' programmes both as surveillance and compliance in order to assess the health of the environment.

In the aquaculture industries, benthos play a significant role in the assessment and monitoring of culture ponds. If the benthic ecosystem of the culture pond is properly maintained, the benthos form an additional source of natural food for the culture species like shrimps which invariably feed on benthic organisms.

The benthic ecosystem of coral reef, mangroves and intertidal beach and mudflats serves as a good feeding, breeding, spawning and nursery grounds for many marine organisms of economical importance, variety of migratory and resident birds, fishes, sea mammals and reptiles.

FUTURE RESEARCH

- Integrated approach on benthic ecology viz. studies on micro, meio and macrobenthos with required physico-chemical parameters will enable better understanding of benthic marine environment and its role on the overall marine food chain.

- Biodiversity of the benthic ecosystem is essentially to be established for formulating adequate marine conservation and protection measures.
- The role of mangroves, salt marshes and coral reefs on the fertility of the nearshore coastal ecosystem is to be understood in detail. Public awareness on this subject is to be created.
- The importance of bioturbation on the benthic ecology is to be investigated.
- Clear understanding of the energy flux within the benthic ecosystem as well as between the overlying water column and benthic ecosystem is needed for developing reliable predictive ecosystem models.
- Benthos in environmental monitoring studies should be persuaded in depth.
- More information on deep sea benthos needs to be established for a better understanding of deep sea benthic ecosystem.
- The relationship between demersal fishery potential and benthos is to be understood in detail.
- Study to understand relationship between benthos and fossil fuel is needed.