

Benthic Communities Associated with Ferromanganese Nodules from the Central Indian Ocean

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Abstract

Micro- meio- and macrobenthic associations with Ferromanganese nodules collected from the Central Indian Ocean were evaluated. The area of nodules ranged from 13.58 to 21 cm². The density of abyssal macrobenthos varies from 22 – 110 no. m⁻² (mean = 58± 33 SD, n=17). Density of sediment meiobenthos ranged between 02 to 11 no. 10cm⁻² (mean=7±3 SD, n=9) and was dominated by nematodes. Significant difference was observed in meiobenthic density associated with nodules and sediment ($p<0.05$). Microbenthic abundance in association with nodules ranged between 2647 to 9680 no.10cm⁻² (4531± 11981 SD, n=9) and was mainly comprised of benthic *Coscinodiscus* sp. The nodule surface provides favorable substrate for grazers, shelter for burrowers and sessile organisms as well as protection for mobile fauna. It is concluded that benthic organisms like nematodes, polychaetes and foraminiferas may have strong influence on nodule formation and growth.

Introduction

The benthic ecosystem of the abyssal depth is a desert deprived of local primary production and is considered as a food-limited environment [1]. Therefore, the organisms living in these habitats largely depend on the supply of particulate organic matter from the surface waters. Central Indian Ocean has diverse benthic communities [2] and rich ferromanganese nodule deposits [3]. Nodules occur on 70% of the deep-sea floor, which makes the nodule associated benthic fauna geographically widespread and potentially important in community interaction. Moreover, some deep-sea biologists believe that, the formation and growth of ferromanganese nodule is either due to bacterial activity or that of the encrusting eucaryotes [4,5]. The nodule-associated fauna were found to be responsible for the exposure of nodules [6]; otherwise as they are denser than underlying sediment, they should sink down. Browsers will try to catch the prey not only on the upper surface of the nodule but also at the base [7] and in the process these nodules presumably are nudged and lifted which keeps them on the sediment surface. Some as yet unidentified mechanisms are perhaps the answer to the paradox that the nodules remain on top of the sediment for thousands of years in spite of high sedimentation rates in some areas.

To determine a mine site for ferromanganese nodules, extensive surveys were conducted by India in the CIOB [8,9]. The survey showed presence of high benthic activity associated with sediment and nodules [2]. Biogenic traces like burrows, fecal casts, pellets were also found to be associated with nodules [9]. In this paper, possible association between nodule abundance and benthic standing stock has been evaluated and discussed.

Materials and Methods

A total of 9 nodules were obtained from two stations from the CIOB area, for the study of meio- and microbenthos using a box core (50x50x50 cm size). Whereas macrofauna was collected from 17 stations using box core. The water depth of the sampling sites ranged between 5000-5500m. All the nodules were sorted and preserved individually in 10% formalin Lugols iodine solution. Each nodule was washed through 63 μ and 25 μ sieves and material retained on respective finer mesh was preserved in 10% formalin- Lugols iodine. Sub-sampling for sediment meiofauna was done by acrylic (6.7 cm diameter) core and macrofauna was sub-sampled with 15x15x10-cm size quadrant. Sediment was sieved through a mesh of 25 μ , 63 μ and 500 μ for micro-, meio-, and macrobenthos respectively. Microbenthos was preserved in lugol's iodine and macro- and meiobenthos was preserved in 10% formalin Rose Bengal solution. Data was analyzed using standard oceanographic methods and Excel statistical package.

Results and Discussion

Abundance of Manganese Nodule and Macrofauna

CIB is the richest area of nodule deposit within the Indian Ocean and is next to the Pacific Ocean [3]. Nodules are associated with practically all types of sediment and their surface density varies from traces to $\geq 15 \text{ kg m}^{-2}$ in the CIOB [8]. The density of macrofauna varied from 22 – 110 no. m^{-2} (mean = 58 ± 33 SD, $n=17$) and the value increases with increasing nodule abundance. To evaluate the possible relationship between the nodules and macrobenthos, the data on nodule abundance and macrobenthos were subjected to correlation analysis which showed positive ($y= 2.0285X + 41.666$, $r=0.3$; $n=17$, Figure 1), but weaker relationship. Among the macrobenthic organisms, polychaetes are known to extract Mn from their prey and deposit it on nodule surface [5]. Similarly, Riemann [5] proposed a mechanism for biogenic growth of nodules and noted that the stercomes agglutinated foraminifers accumulate oxidized Mn, packages it in stercomes and deposit it on the nodule. Thus, benthic foraminifers and polychaetes essentially help in the growth and development of nodule.

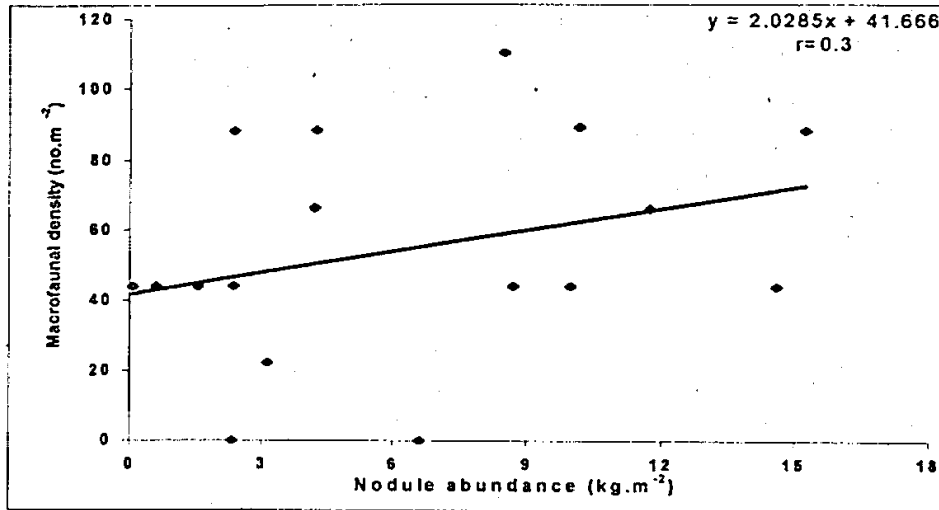


Figure 1: Regression Between Nodule Abundance and Macrofaunal Abundance

Correlation Between Nodule Size and Associated Benthic Organisms

The size of the nodules collected from two sites varied between 17.17 to 23.71 cm². Microbenthos ($\leq 25 \mu$ size) included 10 taxon groups, of which 9 were phytobenthic and only one was zoobenthic. Compare to meiobenthos, microbenthic abundance was seen to be very high with values ranging between 2647- 9680 no.10cm⁻² (4531 ± 1981 SD, n=9). *Coscinodiscus* sp. was the most dominant microbenthos. The density of nodule associated benthic organisms (meio- and microbenthos) showed very high abundance and values varied from 2658 to 9689 no.10cm⁻². It indicates that smaller sized nodule (13.58 cm²) harbor low abundance (2658 no.10cm⁻²), whereas larger nodule (21cm²) had higher abundance (9689 no.10cm⁻²) of associated fauna. It showed strong association between microbenthic communities and nodule size ($y = 613.32x - 6586.3; r = 0.687; n=9$ $p < 0.02$, Figure 2). The community was dominated by microphytobenthos such as *Coscinodiscus* sp., *Actinoptychus* sp., *Globigerina* sp. and *Navicula* sp. whereas meiobenthos was comprised of nematodes, halacarids and harpacticoids. Further, a close scrutiny of the data revealed that irregular shape and rough nature of nodule could provide more space as well as strong adherence to burrowing. Similarly, the sessile organisms prefer to settle in hollow on the nodule surface [10] whereas, foraminifers are known to grow in narrow fractures. Therefore, in addition to the size, texture of the nodule also play very important role in determining the density of the nodule-associated communities.

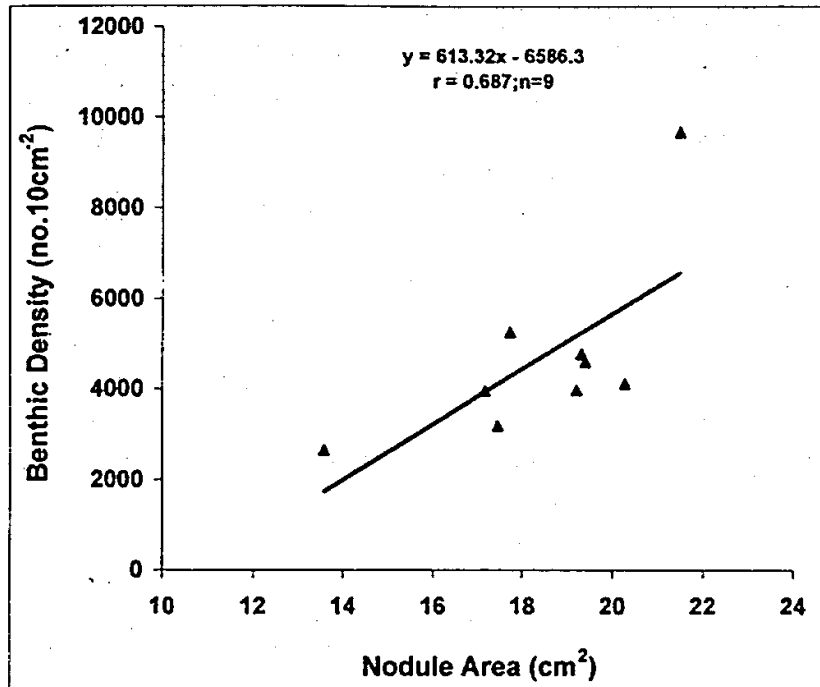


Figure 2: Regression Between Nodule Size and Benthic Abundance (Micro- and Meiobenthos)

Comparison Between Nodule and Sediment Dwelling Meiofauna

A total of 6 meiobenthic groups were isolated from 9 nodules collected from 2 stations. The nodule surface was inhabited by organisms like foraminifera, Polychaeta, Harpacticoida, Halacaroida and Nemertina (Figure 3). Nematodes, generally the most dominant metazoan in deep-sea meiobenthos, comprised 40% of faunal assemblage associated with nodules followed by foraminiferans (20%). While other groups, like, Nemertina, Harpacticoida, Polychaeta and Halacaroida showed equal percentage coverage of 10%. Nematodes had high density on nodules, probably due to the availability of quality food. Since nodules are found on top of the sediment, freshly arrived phytodetritus material could settle first on nodule surface. This particulate matter is supposed to be very rich in Labile Organic Matter [11], hence the burrowing nematodes and polychaetes may get quality food in addition to protection in association with nodules. On the other hand, possibilities of faunal exposure due to high bottom currents is very high which will not only dislodge the mobile polychaetes and nematodes from the sediment surface but will also, expose them to predators. Thus, to avoid the predatory pressure as well as to exploit better food conditions, some burrowing and mobile fauna may prefer to settle in nodule crevices.

Meiobenthic abundance showed that, in association with nodule as well as in the sediment surrounding the nodule showed that, polychaetes were totally absent in sediment sample whereas turbellarians were not observed in association with nodules (Figure 3). The data presented in figure, 2 suggested a strong binding relationship between nodule size and faunal abundance. Consequently, nodules could be the favorite substrate for some of the mobile and burrowing meio- and macrofauna and attached fauna could facilitate the nodule growth, thus the benefits could be reciprocal.

Significant difference in density between the nodule-associated fauna and surrounding sediment fauna was observed (T test; $t=0.719$; $P < 0.05$, $df=7$). Due to several reasons, the true density of hard substrate organisms remains underestimated. One of the possible reasons could be that, some mobile organisms like crustaceans attach to nodules are easily brushed off into the underlying sediment during sampling, leading to lower densities on the nodule and higher densities in sediment. As shown in Figure 3, Halacaroidea occurred with high density in sediment than on nodule whereas; turbellarians were totally absent on nodules. However, a reverse trend was observed in case of foraminifers and polychaetes, which were recovered only on nodule and not in surrounding sediment. However, as this could also be due to the limited data points, therefore it needed to be treated with caution.

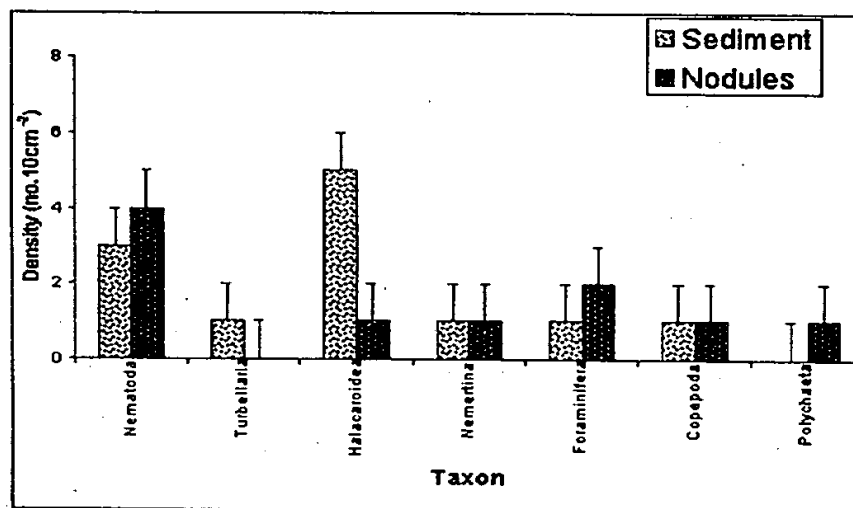


Figure 3: Meiobenthic Abundance (no.10cm²) in the CIB Area

This study indicates that nodule surface may provide favourable substrates for grazers, shelter for sessile organisms and protection for mobile fauna [9,12]. In addition to this, nodules with a covering of organic film and complex structure of spicules of sessile organisms may act as a biological trap for freshly depositing particles and could be the striking factor. Abundance of phytobenthos on nodules reflect that it could be an attractive force for other

organisms like meiobenthos which prey on microbenthos and in turn serves as a food for macrobenthos. Secondly, the presence of benthic organisms may be very significant for the growth and movement of manganese nodules [4]. Moreover, if foraminifera do take part in the process of nodule formation [5], then higher percentage of polychaetes, nematodes and foraminifera observed in association with nodule may be the deciding factor in nodule growth, as these organisms are known to extract minerals through the feeding and deposit it on nodule.

This preliminary study underlines the fact that both nodule and benthic organisms are reliant on each other. However, a more detailed sampling is required to bring out the intrinsic features of this relationship.

References

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