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Editorial: Benthic Biodiversity of the Indian Ocean

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Editorial on the Research Topic

Benthic Biodiversity of the Indian Ocean

INTRODUCTION

Benthic organisms are an important component of the marine biodiversity. Although the benthic organisms constitute only a fraction of the total marine biomass (Bar-On and Milo, 2019), their contribution to the remineralization and biogeochemical cycling of different elements in the ocean is immense (Bourgeois et al., 2017; Aller and Cochran, 2019). Benthic biomass varies from as low as ∼1.5 mg C/m^2 in the deep abyssal regions to as high as ∼4.0 mg C/m^2 in the highly productive marginal marine regions (Wei et al., 2010). The biomass estimates are highly uncertain due to the limited information about the distribution of marine organisms in the deeper oceans (Ichino et al., 2015). A large number of studies on marine benthic biodiversity are restricted to the marginal marine regions including the continental shelves and slopes (Wei et al., 2010). The regions deeper than 3,000 m, comprising ∼75% of the total oceanic area contribute ∼50% of the total marine benthic biomass (Wei et al., 2010). Marine benthic organisms survive on the organic matter flux from the ocean surface and thus are highly vulnerable to the changes in the surface primary productivity (Yool et al., 2017). Therefore, it is important to document the benthic biodiversity of oceans and also to understand their contribution to the elemental cycling.

The Indian Ocean, the only ocean with its northern landlocked boundary in the tropics is unique in several aspects. The northern Indian Ocean has one of the world's most intense oxygen-deficient zone at the intermediate depth. The waters on its margins turn hypoxic seasonally (Naqvi, 2021). These oxygen-deficient zones support a unique biota (Sivadas et al., 2020; Suokhrie et al., 2020), with the capability to denitrify (Sokoll et al., 2012). The chemosynthetic community is abundant in the hydrothermal vents on the mid-oceanic ridges (Perez et al., 2021), as well as the submarine volcanoes in the Andaman-Nicobar region. The vast gas hydrate reserves along the margins of several Indian Ocean rim countries also house unique biodiversity (Mazumdar et al., 2019). Therefore, it is imperative to understand not only the host-substrate relationship of benthic biota inhabiting these diverse environments in the Indian Ocean, but also their unique adaptations as well as the contribution to the elemental cycling in this region. This Research Topic was proposed to include the contributions on benthic biodiversity of the Indian Ocean and its influence on the biogeochemical cycling.

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CURRENT STATUS OF THE INDIAN OCEAN BENTHIC BIODIVERSITY STUDIES

The benthic diversity of the Indian Ocean has been explored for the meiobenthic, macro-benthic, and mega-benthic organisms and the best-explored habitats are the coastal and intertidal ecotones while the sampling effort decreases as we go deeper offshore (Wafar et al., 2011). Although sparse and sporadic, the slopes have sizable benthic diversity records, primarily from the marginal regions of India, South Africa and a few gulf countries. Among the coastal habitats, rocky shores, sand flats, and the mudflats (including mangroves) have been well-studied for mostly macro-benthic community. There are several autecological studies as part of the doctoral thesis for a few important benthic organisms such as horseshoe crabs, large gastropods, polychaetes, bivalves, as well as numerous studies on toxicological experiments using benthic species as model organisms. Although the Indian Ocean harbors rich reef habitats, most of the earlier studies extensively focused on documenting the species. However, with the advent of climate induced coral bleaching and the subsequent eradication of reef habitats, the major focus has shifted to understanding the responsible factors and their varied effects on the reef community. The mega-benthic communities of the shelf region are well-inventoried as a part of the benthic fishery documentation while it also enabled the description of many new species as part of the by-catch investigation. The shallow subtidal areas and the shelf macro-faunal community have been well-investigated in the past two decades, with a large emphasis on polychaete fauna especially due to their use as "indicator species" of anthropogenic perturbation. There were several programs that aided the exploration of deep sea benthic biodiversity which were initiated with the onset of the Indian Ocean Expedition in the 60's/80's followed by the poly-metallic nodule and ridge programme for the exploration of deep-sea resources. The studies from the deep Indian Ocean are, however, limited. There are multiple constraints that govern these limiting factors such as funding, logistics, expertise, and long-term programmes.

SYNTHESIS OF SPECIAL ISSUE PUBLICATIONS

The papers published in this Research Topic include diverse groups of marine benthic organisms including, corals, sponges, foraminifera, nematode, gastropod, bivalve, fungi, bacteria, and barnacles. This Research Topic highlights the work from the Indian Ocean, which is beyond just the community structure but includes aspects of seasonality, functioning and their comprehensive distribution with respect to regions.

The 2,360 km long coast of North West India, is a heavily industrialized and urbanized zone. This coast with unique biogeographical and climatic features with two notified marine protected areas also supports rich biodiversity. Therefore, it is imperative to collate and review the base line data of marine macrobenthos of North West India mainly because the tropical ecosystems sustain higher biodiversity and face faster species extinction. Sukumaran et al., have aptly provided an overview of these macrobenthos. In order to understand the status of studies from the deeper regions, Barnes et al. have provided a detailed review of the bacterial and fungal diversity in the abyssal regions of the Indian Ocean. The authors note that as compared to other oceans, bacterial and especially fungal diversity studies are limited from the deeper Indian Ocean. The work on the meiofaunal community by Ghosh and Mandal from the Sundarbans, the largest mangrove forest on earth, located on the east coast of India, showed a marked seasonality. The study documents 11 meiobenthic taxa dominated by nematodes. The functions derived from morphological traits reveal that most of the species are opportunistic and feed on organic matter. Sautya et al. studied the distribution pattern of the benthic meiofaunal community from the western Indian continental margin, including the oxygen-deficient zones and the abyssal plain. A total of 22 taxa (groups) were found, with nematodes dominating the population. The article by Gajera et al. is an elaborate work on the coastal gastropod's radular morphology. Radula is an important anatomical feature, specific to a species as well as affecting the feeding ecology of the gastropods. They provide useful insights in to the differences within taxa and similarities in closely related clades, which were also assessed *via* the construction of a phylogenetic tree of the species. The other two articles focus on the distribution of barnacles and the influence of environmental settings on their habitat preference from the coastal habitats of the Indian subcontinent. The article by Trivedi et al. gives a comprehensive inventory of barnacles' distribution in different eco-regions of India with the validation of species occurrence. The other study by Buasakaew et al. emphasizes the role of salinity and temperature, as it deters the recruitment of barnacles in the rock pools, while the submergence time also plays a significant role in the recruitment success.

Marine sponges are sessile filter feeders. Sponges maintain a continuous water flow to obtain food and oxygen. Their structural components are species specific, affecting sponge morphology and pumping capacity. Dahihande and Thakur investigated the influence of different structural components on the pumping capacity of the marine sponges. Mote et al. report an interesting host-symbiont relationship in the corals and sponges. They report a significant difference in the abundance and diversity of Symbiodiniaceae in the encrusting sponge and coral. A highly diverse bivalve population modulated by the multitude of oceanographic parameters, has been found along the eastern margin of India, by Chattopadhyay et al. A decreasing bivalve diversity is found on both the northern and southern side of 14°N latitude, which is different from the widely accepted latitudinal biodiversity gradient.

The presence of hard parts in several marine microorganisms, like the foraminifera and diatoms, helps in the long-term preservation of the ecological signatures. Minhat et al. have studied the influence of ambient conditions, including the depth and organic matter, on the distribution of foraminifera in the Strait of Malacca. Similarly, Suokhrie et al. reported depth specific benthic foraminifera assemblages from the Bay of Bengal. A strong influence of the riverine influx, coupled with the organic

matter and dissolved oxygen, is reported on benthic foraminifera distribution and diversity. The remains of such skeleton bearing organisms are an excellent tool to reconstruct the past climate and oceanographic conditions. Verma et al. have used the temporal changes in the benthic foraminiferal assemblage to reconstruct millennial-scale changes in the monsoon induced productivity, the subsequent organic matter flux to the ocean bottom and the development of the oxygen deficient zones, in the western Bay of Bengal during the last 45 kyr. A large shift in the dissolved oxygen concentration is observed during the last glacial interval as compared to the Holocene.

THE WAY FORWARD

The contributions in this Research Topic are miniscule as compared to the expected biodiversity of the Indian Ocean. We recommend to make global efforts to explore the benthic biodiversity of the Indian Ocean. The future research efforts should be directed toward understanding the factors modulating the diversity of benthic macro-, meio- and microfauna, fungi, bacteria, and viruses, especially from the specialized habitats and deeper regions of the Indian Ocean.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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