Studies on Ecology of Soft-Bottom Meiobenthic Community from Sundarban Estuarine System, West Bengal, India

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By

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Estuaries are the most hydrodynamically active and pervasive transitional zone, where indispensable biogeochemical processes take place. They are regarded as vital conduits for the transport of sediments and organic materials from rivers to oceans making them an essential carbon sink. The amenities estuaries offer, render them as the most precious national treasures; which may impinge on the health and vibrancy of human society and economy. Presently, SES is subjected to multiple anthropogenic environmental changes, which rapidly transforming the community structure and functioning of estuarine benthic ecosystem. In addition, acceleration of various climate change events increases the vulnerability of estuarine biodiversity and causes local extinction of many species. Hence, a complete database about the meiobenthic diversity is essential before many species might get extinct due to global biodiversity loss and climate change. Contrarily, abrupt losses of biodiversity may represent a significant threat to human well-being, since being a maritime country like India, a large percentage of people relies on their coastal environment for their food security and livelihood. As meiobenthos occupy important trophic position in aquatic food web, therefore, enhancement of biodiversity knowledge is indispensable to understand the ecosystem functioning. Benthic environment is the most valuable habitat on earth that support high faunal biodiversity and perform key ecosystem services. Any aquatic system will no longer remain functional without a healthy benthic community. Within benthic organisms, meiobenthos are the most amenable and suitable groups as indicators of ecosystem monitoring. Present thesis provides a comprehensive synthesis of the ecological status of SES based on evidence from meiobenthic diversity.

SES consists of the world's largest mangrove ecosystem. There is only a handful of reliable information available on the status of benthic population from SES in terms of distribution and ecology due to a dearth of proper taxonomic literature from tropical water as well as lack of trained taxonomists. In the present research, we explore for the first time community structure, function and diversity of meiobenthic and nematode assemblages inhabiting the bottom of Sundarbans. Free-living nematodes are the most numerically dominant and species-rich meiofaunal component of aquatic sediments with ubiquitous distribution residing all climatic conditions. They represent several advantages for considering ideal model organisms as elegant indicators of ecosystem health. Nevertheless, little is known on how functional characteristics depend on their species composition and

diversity. Although a copious amount of research papers have dealt with quantitative aspects of meiofauna, however, systematic databases on aquatic nematodes are insufficient and inadequate.

Chapter summaries and future perspectives

Chapter I represents a brief introduction on meiobenthos, emphasizing the ecological significance, particularly free-living nematodes and their application in benthic science. This chapter also includes a review of literature where past and present status of meiobenthic research in Indian water as well as around the globe is discussed. A concise description of study area is delineated in later part of the chapter as well.

Chapter II-Part A reveals intra-monsoonal variability among meiobenthic organisms and how they adapt to the environmental changes. In 2013, SES encountered an excessive monsoonal rainfall compared to last few years. Moreover, a cloud burst event occurred in the same year at upper Himalayan regime, which might have increased the precipitation load in manifolds at SES. This pioneering study indicates significant differences in total meiobenthic densities during early and later phases of monsoon. Average meiobenthic abundance decline noticeably in the study area from early phase of monsoon to later one probably due to unusual monsoonal washoff which completely flushed the estuary. The survey recorded a total of six major taxa from both phases, namely free-living nematodes, harpacticoid copepods, benthic foraminifera, ostracods, kinorhynchs and polychaete juveniles. Free-living nematodes are recorded as the most abundant taxonomic group in both the phases. A total of 72 species of nematodes are identified for the first time from this ecoregion. A strong dominance of deposit feeder nematodes (both 1A and 1B) reveals a wide range of environmental perturbations due to heavy monsoonal runoff. Thus, this chapter helps to understand the natural variations among meiobenthic communities along with its changes caused by climate change induced unusual monsoonal precipitation in tropical estuaries like SES.

Chapter II-Part B describes seasonal succession of meiobenthic structures across Matla river of SES with reference to functional diversity of nematode communities. This chapter also establishes ecological relationship with different environmental parameters seasonally. Total meiobenthic abundance differs significantly among seasons with highest in spring and lowest in monsoon. PCA depicts a distinct separation of seasons with reference to environmental variables. Nematodes constitute the major component among meiobenthos both in numerical abundance and species composition. Among 79 species documented during study period, the most widespread ones are *Sabatieria preadatrix*, *Sphaerolaimus bulticus*, *Desmodora communis*, *Dorylaimopsis punctata*, *Daptonema hirsutum & D. procerum*, *Monoposthia costata* and *Terschellingia longicaudata*. Most of the nematodes encountered throughout the study are non-selective deposit feeders (1B), which generally prevail in silty sediment due to food availability (bacterial growth and organic detritus deposition). A significant abundance of slender body and clavate tail shape in each season are observed as an adaption to higher content of silt and clay of the sediment. Life strategy characterization exhibits a dominance of colonizers and intermediate (c-p 2, 3 and 4), suggesting a high stress level with an increase of opportunistic species. Seasonal patterns in the functional structure of nematode assemblages are primarily related to differences in sedimentary conditions. Therefore, this part of the chapter provides diverse morpho-functional and ecological traits characterized by notable micro-habitat and niche heterogeneity. The dataset will be valuable for designing and implementation of ecosystem based approaches to sustainable management for this ecologically fragile ecosystem.

Chapter III has given a clear picture on how distribution pattern of meiobenthic organisms differ vertically and interacts with prevailing environmental factors. This is a first time documentation of vertical stratification of meiofaunal community and nematode species composition from the sediments of five dominating mangrove vegetation from the world's largest mangrove ecosystem. The vertical profile of faunal composition reveals upper 3-4 cm harbor 90% of total meiofauna, while they are present up to 15 cm depth. A good quality of food proxies such as Chl a, phaeopigments and organic carbon provide the best condition for them to achieve the highest density. Their population structure pinpoints a strong distinction among various mangrove species they inhabit, driven by local sediment conditions at microscale. Overall, present investigation supports the notion that local sedimentary environment determines the distribution patterns of meiofauna throughout the sediment depth. Moreover, marine nematode species compositions are used to test Maturity Index (MI), life strategy or ecological traits (i.e. c-p classes) and Index of Trophic Diversity (ITD) for assessing ecological health, which indicate a stable habitat. In the current context of habitat destruction and anthropogenic perturbations, investigation of mangroves-meiofauna ecological interactions would be imperative for risk assessment and different management targets in future.

Chapter IV clarifies the issue regarding meiobenthic structural changes undergone by anthropogenic stressors. Meiobenthic components have been considered as suitable indicators in a variety of monitoring programs to assess estuarine health. Global climate change has tremendous impacts on benthic ecosystem and it is conjectured that along with future climatic scenario anthropogenic stressor like oil pollution may cause serious environmental disasters, which may jeopardize benthic habitat. Presently, very limited information is available about the synergistic effect of elevated temperature and oil pollution on meiobenthic community and tolerance potential from tropical intertidal environment. The present research highlights combined impact these two stressors by selecting three sets of temperature (25°, 30° and 35°C) and two sets of diesel oil (low and high) combinations through a 60 days mesocosm experiment. The investigation shows deleterious effects of these stressors on meiobenthic species composition and abundance. Diversity profiles for the nematodes are less affected and copepods show a graded response of decreasing density with increasing dose of both the stressors. However, other taxa such as turbellaria, halacarid mites and polycheate juveniles are adversely affected and eliminated from the treatments. In regards to free-living nematodes, both the anthropogenic drivers synchronously lead to an elimination of k-selected species like Halalaimus gracilis, H. longicaudatus, Oxystomina aesetosa and Pomponema sp. with a significant decrease in abundance of H. capitulatus and Oncholaimus sp. The rselected species Daptonema invagiferoum, Sabatieria praedatrix, Theristus acer, Monhystera sp. and Thalassomonhystera sp. have endured even at high doses of diesel treatment in three different temperatures set up. Global warming induced elevated temperature together with diesel oil contamination, as a whole, are found to alter species dynamics within shallow intertidal meiobenthic as well as nematode communities, which might have significant Armageddon on benthic ecosystem functioning. In milieu of climate change scenario our observation would be a pioneering footstep to understand the effect of human-induced changes upon meiobenthos.

Taken together (Chapter II Part A & B and Chapter III), these results indeed provide a first order approximation of meiobenthic community structure from SES. This documentation presents a reliable dataset on meiobenthic diversity and ecology, which will act as a building block for the future researchers working on SES meiobenthic community. To make an effective Marine Protected Areas, knowledge of biodiversity is a primary necessity. The missing biological information regarding composition, distribution, structural and functional diversity of meiobenthic species have been revealed. The datasets of this thesis can also be

helpful to construct ecological modeling in near future. With increasing pressures of habitat destruction, overexploitation marine resources, anthropogenic disturbances including global climate change and introduction of exotic species, the present documentation may contribute towards better understanding of ecosystem functioning, which, in turn, might help to implement different ecosystem based management approaches to the aforesaid environmental issues. As human lives are inextricably linked to estuaries due to the ecological services they provide, a wise management practice is likely to be crucial for this superior environ in forthcoming days. Future research, thus, should be devoted to enhance our gap of knowledge on the status of ecosystems of SES from other parts of it.

Additionally, by performing mesocosm experiment new insights were attained in meiobenthic composition impacted by anthropogenic stressors. Howbeit, there are some caveats remain in our knowledge. For instance, the duration of experiment should be enhanced considering multiple communities as well as multiple stressors to investigate the underlying mechanisms of species-specific resilience. It would be interesting to unmask the knowledge on the interaction between meiobenthos and other biota to additive responses of environmental drivers. In addition, by including more benthic taxa to provide a better holistic approach, we would be able to understand profoundly regarding estuarine food web dynamics.