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Impact of unusual monsoonal rainfall in structuring meiobenthic assemblages at Sundarban estuarine system, India

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ABSTRACT

The present study investigates the impact of monsoon on meiofaunal and free-living nematode communities of the Sundarban estuarine system (SES) both from taxonomic and functional point of view. In 2013, SES experienced an unusual rainfall event followed by cloud burst event at upper Himalayan regime. Average meiobenthic abundance declined considerably in the study area from early phase of monsoon (EM) (699 ± 1569.4 ind. 10 cm^{-2}) to later one (LM) (437 ± 949.9 ind. 10 cm^{-2}) probably due to high annual rainfall which completely flushed the estuary. Free-living marine nematodes were the dominant group among all other meiobenthic taxa in both phases of monsoon. Nematode community was made up of 49 genera in 22 families. Comesomatidae, Chromadoridae, Linhomoeidae and Xylidae were the richest and most abundant families. During both phases of monsoon, stations, which were represented by fine sediments and high amount of organic carbon, harbored higher meiofaunal densities and nematode diversity with a strong dominance of 1B and 2B trophic guilds of nematodes. Different feeding guilds of nematode would be able to reveal anthropogenic-induced stress, which could be useful in assessing ecological quality of estuarine ecosystems. The present study indicates that climate change mediated unusual monsoonal precipitation may notoriously affect the meiobenthic assemblages in tropical estuaries like SES. Thus, this study could be an important first stepping stone for monitoring the future environmental impact on meiobenthic community in the largest mangrove region of the world.

1. Introduction

Estuaries are considered as one of the most productive ecotone on earth (Prandle, 2009). It support invaluable ecological function and services in the context of its role in biogeochemical cycle, transport of nutrients, water purification, flux regulation of water, particles and pollutants, shoreline protection (Kennish, 2002; Alves et al., 2015). Due to its high biological productivity, estuaries forms the most important spawning zones and nursery ground for a wide variety of commercial fish and shell fish communities. Being a specialized dynamic environment, estuaries are usually well-marked by rapid variations in temperature, salinity, turbidity, dissolved oxygen and nutrient concentrations (Frontalini et al., 2014; Semprucci et al., 2014). These physico-chemical variables are characterized by riverine run-off during monsoon.

Benthic communities have been conventionally used as indicators of natural and man-made environmental perturbations (Borja et al., 2000; Vanaverbeke et al., 2011; Semprucci et al., 2015a). They are considered as sensitive to any kind of natural disturbances (tide, wave, currents etc.) because they could reflect an integrated response over time. In benthic realm, meiofauna contributes a considerable amount (10^5–10^6 individuals m^{-2}) in terms of total benthic biomass (Giere, 2009). They have been used as suitable yardstick of environmental health owing to their small size, high abundance and diversity, ubiquitous distribution, rapid generation times, fast metabolic rates, direct benthic development and sessile habitat (Kennedy and Jacoby, 1999; Schratzberger et al., 2000; Balsamo et al., 2012). They are important food source for large benthic organisms (McIntyre, 1977; Gerlach, 1978; Zeppilli et al., 2015) and help in recirculation of nutrients. It has been suggested that the production of meiofauna in estuaries and shallow water bodies is much higher than those of macrofauna (Balsamo et al., 2010). Among meiofauna, free-living nematodes and harpacticoid copepods are the richest animal groups (Boucher and Lambshead, 1995; Lambshead, 2004). On account of their dominance, ubiquitousness and robust bodies make these groups of organisms promising components to study natural and anthropogenic disturbances in marine ecosystem (Sanduli and De Nicola, 1991; Bongers and Ferris, 1999; Semprucci et al., 2015b). Thorough analyses of community structure can therefore provide a

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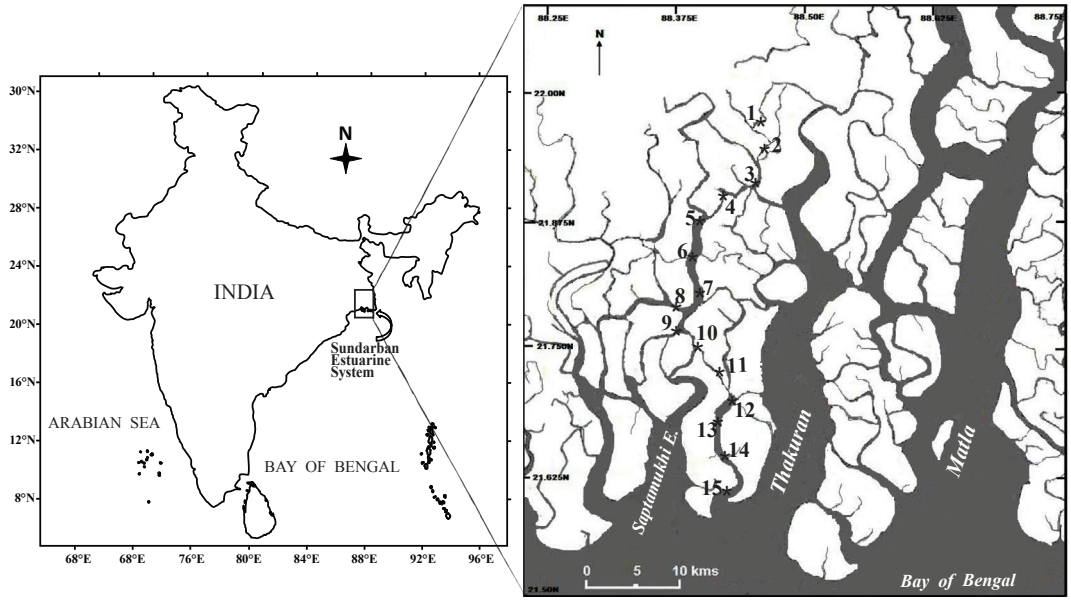

Fig. 1. Geographic location of the stations sampled in Sundarban estuarine system. All sampling stations are spread on Saptamukhi East Gulley and marked with asterisk. From S-N these are: Stations 15-11: R. Jagaddal; 10: Chaltabunia Khaal; 9-8: Curzon Creek; 7-4: R. Kaalchara; 3: Kuemari Khaal and 2-1: R. Chhatua-Raidighi.

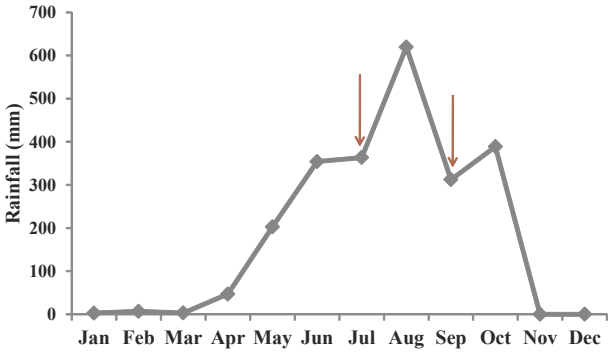

Fig. 2. Comparison of rainfall (in mm) during early (EM) and late (LM) phases of monsoon in the year 2013. Red arrows indicate sampling time. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Geographic position and name of sampling locations.

Stations	Name	Longitude	Latitude
1	Raidighi	88° 26′33.5″E	21° 59′ 23.3″N
2	Mollar Mukh	88° 27′13.9″E	21°56′38.8″N
3	Jaganath Chowk	88° 26′51.4″E	21° 54′44.61″N
4	Nandakumarpur	88° 25′1.1″E	21° 54′3.4″N
5	Nukchara Crossing	88° 24′39.2″E	21° 53′2.5″N
6	Kumarpur Junction	88° 23′31.5″E	21° 50′24.6″N
7	Birat River Crossing	88° 24′0.4″E	21° 47′58.7″N
8	Ramganga	88° 22′36.5″E	21° 47′18.3″N
9	Shibgunj	88° 23′25.2″E	21° 45′23.9″N
10	Chaltabunia Khal starting	88 °23′32.6″E	21° 44′4.3″N
11	Chapramari Ghat	88° 25′11.6″E	21° 43′15.2″N
12	Dhonchi	88° 25′50.0″E	21° 42′9.6″N
13	Between Dhonchi and Indrapur	88° 25′04″E	21°40′59″N
14	Indrapur	88° 25′13″E	21° 39′14″N
15	Bay of Bengal	88 °25′45.3″E	21° 38′14.5″N

wealth of information on the state of benthic ecosystems from intertidal to abyssal depths.

Sundarban, the largest monsoonal deltaic mangrove ecosystems of the world, is situated at the estuarine phase of the river Ganga, Bhramaputra and Meghna across India and Bangladesh (Papa et al., 2010). The complex estuarine networks are interconnecting by numerous west-east flowing channels, canals and creeks. The climate of this mangrove region is dominated by south-west (SW) monsoon (June–September) with an annual rainfall of about 1500 and 2500 mm year^{-1} (Attri and Tyagi, 2010). The monsoon period accounts for about 80 percent of the annual precipitation. Tropical mangroves forests, in general, show seasonality in precipitation. Moreover, the hydrology and physico-chemical environment are mostly governed by riverine discharge resulting from increased precipitation during monsoon (Bhattacharya et al., 2015; Venkataramana et al., 2017). On the other hand, hydrographical features play a crucial role in sedimentation pattern (Semprucci et al., 2011). Accordingly, in tropics, monsoon induced variations in hydro-climatic regimes, sedimentary environment, topography and their interactions would affect productivity of benthic communities (Alongi, 1990). Although Sundarbans is one of the well-studied estuaries in terms of water quality parameters, phytoplankton and zooplankton communities (Biswas et al., 2004; Manna et al., 2010; Bhattacharya et al., 2015), little is known regarding the effect of monsoonal run-off on the benthic ecosystem. Climate change also affected monsoon and river discharge which in turn influence regional changes (Solomon et al., 2007). Compared to last few years, SES experienced an unusual heavy rainfall during monsoon season in 2013. Furthermore, a cloud burst event occurred at the upper reaches of river Ganges (Kotal et al., 2014) in the same year which could have increased the precipitation load in manifolds at SES.

There are very few fragmented studies on meiofaunal distribution available from Sundarban (Rao and Misra, 1983; Dey et al., 2012; Ghosh et al., 2014; Sen et al., 2016). However, any comprehensive approach towards studying the ecosystem dynamics of meiofaunal populations of Sundarbans has not been attempted so far. Most ecological studies have specifically focused on seasonal variabilities of meiofauna from different habitats of Indian coasts (Ansari et al., 2001; Ingole et al., 2006; Chinnadurai and Fernando, 2007; Sajan et al., 2010; Thilagavathi et al. 2012; Datta et al., 2015), whereas intra-seasonal shift on meio-benthic diversity have not received any attention.

Against this milieu, in the present study we would like to investigate the following objectives: a) to evaluate the spatial variations in meio-benthic communities from early and later phase of monsoon, b) to