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Research Article

SPATIAL-TEMPORAL VARIATION OF BENTHIC-COMMUNITY IN GOPALPUR COASTAL SEDIMENT, EAST COAST OF INDIA

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ABSTRACT

The study on the macrobenthos of Gopalpur coast, Odisha, East coast of India was undertaken during January 2015 to December 2015. The environmental parameters, sediment characteristics and macrobenthic organisms were collected from 3 stations. The physico-chemical parameters with relation to benthic community structure were studied. The salinity and sediment texture were the most important parameter at Gopalpur coast controlled the distribution and community structure of benthos. The annual rainfall at Gopalpur varied from 001.4-230.7mm. The temperature, salinity, DO, BOD showed spatio-temporal variation. The air and water temperature of Gopalpur coast varied from 26 to 34.2^{0}C and 27.5 to 30.2^{0}C respectively. The pH of Gopalpur coast varied from 7.2 to 8.3. The percentage composition of sand, silt and clay were in a range of 81.71 to 98.83%, 1.04 to 12.22%, 0.13 to 6.07% respectively. The salinity of Gopalpur coast varied from 5.3 to 31.7 PSU. The concentration of dissolved oxygen varied from 5.4 to 7.2 ml/l. The Bio-chemical oxygen demand ranged from 1.3 to 2.3 ml/l. The diversity of macro benthos of Gopalpur coast varied from 3 to 7 groups belonging to 5 phyla and the population density varied from 550 to 1400 ind./m^2 at different stations. In total 8 groups were recorded namely nematodes, polychaetes, decapods, gastropods, bivalves, amphipods, isopods and echinoderms. 30 species were observed under 4 groups, out of which 8 species belongs to decapods, 10 species belongs to gastropods, 11 species belongs to bivalves and only 1 species belongs to echinoderms. Benthic faunal assemblages showed almost similar pattern of distribution at station-I and II (exclusive marine), dominated by nematodes. The station-III (brackish water) was quite different from the station-I and II with different environment and environmental parameters and dominated by polychaetes. In overall observation at 3 stations of Gopalpur coast nematodes dominated in abundance with 9.43-81.82% followed by polychaetes (4.55-51.79%), decapods (0-23.81%), gastropods (0-16.98%), bivalves (0-13.11%), amphipods (0-12.50%) isopods (0-11.32%), and asteroids (0-3.33%). The main objective of the research is to provide a data base and information regarding benthic community structure and to assess the pollution load as it is one of the famous tourist spot of East coast of India.

KEY WORDS: Benthic-community, Population, Environmental variables, Gopalpur Coast, East coast of India

INTRODUCTION

India is a tropical peninsular country having a coastline of about 8129km and an extensive Exclusive Economic Zone (EEZ) of about 2.02 million km^2 (CMFRI, 2006).The marine environment is divided into two regions namely pelagic and benthic region. The benthic region consists of rocks, stones, gravel, sand, mud that make up the sea floor

from the extreme high water mark of spring tides to the deepest abysses of the open ocean (McLusky and McIntire, 1988). The living resource of marine environment refers to three groups such as benthic, nektonic or planktonic. Those organisms that live in or on the sea bed during their life cycle constitute the benthos (Behera *et al.,* 2013). Based on the habitat the benthic organisms can be divided in to two major groups namely soft bottom benthos and hard bottom benthos. It is further divided into micro (less than 43µm), meio (43 to 500 µm) and macro benthos those are retained on 500µm sieve (Kundu and Mondal, 2009).

Generally, polychaeta, crustacean, mollusca and echinodermata are the four dominant groups that consists the macrobenthos in the marine environment. The distribution of macrobenthos varies in spatial and temporal scale (Ansari *et al.*, 2012) and also been attributed to climatic irregularity and pollution (Mistri, 2000). The community structures of macrobenthos are mainly decided by several phisico-chemical and biological factors. The most important physico-chemical factors which carries their distribution pattern and community structure are depth, temperature, amount of light available, turbidity, turbulence of water, circulation, tidal exposure, substratum, sediment grain size, salinity of water, oxidation reduction state, organic content, availability of elements and dissolved oxygen as well as nutrients (Defeo, 2005). Beside these the important biological factors includes food availability, feeding activities, prey-predator relationship and species removal, reproductive effects on breeding, spawning, dispersal and settlement behavioral effects which induce movement and aggregation, presence of symbiotic organisms, growth and mortality.

The intertidal region (interface between land and sea) is most dynamic region, here the action of physico-chemical factors are very high. Therefore, tidal action is the principal physical factor in intertidal region which is directly or indirectly governing all the factors. Though intertidal regions are highly productive region, the primary production available for benthos consumption is limited in intertidal region. The organism which lives in this zone solely depends on deposition of materials. The decomposing materials such as washed out land, sinking of plankton, dead and decay of biomaterials from water columns (Satpathy, 1990). The macro benthos of coastal regions is mainly deposit feeders or browsers or filter feeders (Govindan, 2002). Benthos of coastal region supports large population of demersal fish and other predators (Mclusky and Mclntyre, 1988).

Macrobenthos in marine sediments play an important role in ecosystem processes such as mineralization, promoted and mixing of sediments, flux of oxygen into sediments, nutrients cycling, dispersion and burial and secondary production (Lind, 1979; Snelgrove, 1998).It provides a key linkage between primary producers and higher tropic levels like larger consumers, fish and seabirds etc (Edger and Shaw, 1995; Moens *et al.*, 1996). The benthic production is useful to assess the fishery production of a particular area (Anbuchezhian *et al.*, 2009; Kumar *et al*, 2010). Macro benthos provides a useful tool for evaluating marine pollution (Ansari *et al.*, 1986; Gray *et al.*, 1994). Due to sensitiveness of benthos towards environmental changes the macro benthic organisms are serving as biological indicator species, which are used for monitoring marine environment (Ansari *et al.*, 1986; Austein, 2004). Odisha is one of the maritime states of India, bearing an extensive coast line of about 480km endowed with some ecologically and economically important sea beaches, estuaries, creeks, backwater, lake, lagoon and mangroves. After such a wider coastal line, very few research works has been done along Odisha coast. If we consider the secondary data base and literature especially in Gopalpur coast, a few research works has done during last decades. Gopalpur coast is one of the famous tourist spot of Odisha, East coast of India. Hence, the present study is carried out to evaluate the present status of the water quality as thousands of visitor's comes to this place very day to take pleasure. The purpose of writing this article is to provide a data base on macro benthos community and water quality parameters along Gopalpur coast after a great tourist load.

STUDY AREA

Gopalpur-on-sea is located on latitude 19.27^{o} N and longitude 84.92^{0} E of Southern Odisha which lies on a four km stretch of coastal belt of Bay of Bengal. The beach is sandy in composition dominated by sand particles. The climate here is tropical wet and dry. Three stations have been chosen along Gopalpur coast for collection of samples (Fig 1). Samples and specimens were collected regularly on seasonal basis during pre-monsoon monsoon and post-monsoon from January 2015 to December 2015. Station-I (lat 19^{0} 14' 29. 22" N and long 84^{0} 53' 28. 35" E) is fixed near Baxipolli, one of the fish landing station and fishery village along Gopalpur coast. The station-II (lat 19^{0} 15' 21. 17" N and long 84^{0} 54' 30. 70" E) is fixed on tourist beach about 1.7 Km away from station-I. The station-I and II are exclusively marine environment. The Station-III is fixed at mouth region of Haripur Creek, which is a pocket lagoon (lat 19^{0} 15' 48. 44" N and long 84^{0} 54' 56. 16" E). A small stream, namely the Nandia Nalla discharges into the lagoon.

Figure 1: Map of the Gopalpur coast showing three different stations

MATERIALS AND METHODS

Season-wise benthic and water samples were collected from Gopalpur during January 2015 to December 2015. At each station multiple samples were taken and average was calculated for higher accuracy. The intertidal samples were collected using 20cmЧ20cm quadrate from Station-I, Station-II and Station-III (used Van-Veen Grab). The Station-III is located at mouth region of Haripur Creek, Where the samples were also collected in shallow waters by using Van-Veen Grab covering an area of 0.1 m^2. After collection the benthic samples were through a sieve of 0.5 mm mesh size to collect the macro benthos poured into a wide mouth labeled plastic container and preserved with 5% formalin solution to which Rose Bengal (dye) was added (Idowu and Ugwumba, 2005). The preserved samples were sorted into their different groups and counted under light and stereo dissecting microscope. The numerical count and the percentage of composition were determined. The data were expressed in terms of number of individuals per m^2 and percentage respectively. The identification of taxa and analysis of water and sediment quality was carried out with the help of standard manuals.

RESULTS AND DISCUSSION

Seasonal and spatial variations of all the physic-chemical and biological parameters are cited in Table. 1

Temperature

Temperature is one of the most important physical parameter, which control the distribution, growth and reproduction of the marine organism in coastal region.

Seasonal air and water temperature was recorded in different stations of Gopalpur. The highest air and water temperature was observed during Pre-monsoon and the lowest was observed during Post-monsoon. The temperature scale varied from 26 to 34.2^{0}C in air and 27.5 to 30.2 ^{0}C in water throughout the year.

pH

pH is an important parameter for the distribution and diversity of benthic organisms. Seasonal and spatial variations in pH were well documented. The present study shows its highest p^H (8.3) during Monsoon at Station-III and the lowest (7.2) during Pre-monsoon at Station-I.

Sediment texture analysis

Sediment texture is the principal parameter which governs the distribution, Species composition, diversity as whole the fully community structure of benthos. The Gopalpur coast is a sandy beach always dominated by higher percentage of sand. But variation in percentage (%) of sand, silt and clay occur throughout the year are well notified and cited in the Table.1. The highest percentage of sand-98.83% was observed during Pre-monsoon at Station-I and the lowest percentage of sand-81.71% was observed during Post-monsoon at Station-III. The highest percentage of silt-12.22% was observed during Post-monsoon at Station-III and the lowest percentage of silt-1.04% was observed during Monsoon at Station-II. The highest percentage of clay-6.07% was observed during Post-monsoon at Station-III and the lowest percentage of 0.13% was observed during Pre-monsoon at Station-I. The Station I and II were showing comparatively similar of sediment

composition, but quite difference in sediment composition was encountered at station III (Haripur Creek). The sediments at station III are containing higher percentage of silt and clay and lesser percentage of sand than station I and II during 2015. The sand, silt, and clay at station I & II varied from 97.89-98.83%, 1.04-1.51% and 0.13-0.85% respectively. The sand, silt, and clay at station III varied from 81.71-87.66%, 7.43-12.22% and 4.67-6.07% respectively during study period.

Salinity (‰)

Salinity is an important factor in coastal region. The distribution, species richness and diversity of marine biota are directly correlated to different salinity gradient. Salinity variations with respect to its stations are described. The highest salinity was observed to be 31.3‰ in high tide during Pre-monsoon at Station-I and lowest salinity was observed to be 5.3‰ in mid-tide during Pre-monsoon at Station-III.

Dissolved Oxygen (DO)

DO is an important chemical parameter. The highest DO was observed to be 7.2ml/l in high tide during Monsoon 2015 at Station-I and lowest DO was observed to be 5.4ml/l in low tide during Pre-monsoon 2015 at Station-III.

Bio-chemical oxygen demand (BOD)

BOD takes its vital role for sustainability of marine organisms in coastal ocean. The highest BOD was observed to be 2.3ml/l in high tide during Pre-monsoon at Station-I and the lowest BOD was observed to be 1.3ml/l at Station-I and II during Monsoon period.

Quantitative and qualitative analysis of macrobenthos of Gopalpur Coast

The composition of macrobenthos along Gopalpur coast comprises 8 groups such as nematodes, polychaetes, amphipods, isopods, decapods, gastropods, bivalves and echinoderms. The diversity of macrobenthic groups varies from station to station along Gopalpur coast. The diversity of macrobenthic groups ranges from 3-7 groups at different stations of study area. The highest diversity was observed to be 7 groups at Station-III during Post-monsoon and the lowest diversity was observed to be 3 groups at Station-II during Pre-monsoon and Post-monsoon period of 2015. The numerical analysis data shows that the number of individuals varies from 550 to 1400 ind./m^2. The highest number of organisms were observed to be 1400 ind./m^2 at station-III during Pre-monsoon and the lowest number of organisms were observed to be 550 ind./m^2 at station-II during Monsoon period of 2015.

The station-I was highly diversified with highest number of individuals being 1225 ind./m^2 under 6 groups of macrobenthic organisms during Post-monsoon period and the lowest number of individuals being 675 ind./m^2 under 4 groups of macrobenthic organisms during Monsoon Period. The station-II was highly diversified with highest number of individuals being 750 ind/m^2 under 5 groups of macrobenthic organisms during Post-monsoon period and the lowest number of individuals being 550 ind./m^2, under 4 groups of macrobenthic organisms during Monsoon Period.

The station-III was highly diversified with highest number of individuals being 1400 ind/m^2 under 6 groups of macrobenthic organisms during Pre-monsoon period and the lowest number of individuals being 950 ind./m^2 under 4 groups of macrobenthic organisms during Monsoon Period. The station-I and II was dominated by nematodes and followed by decapods, polychaetes and the station-III was dominated by polychaetes, followed by nematodes, gastropods, bivalves during all the seasons of study period. The station-III, located at Haripur Creek comprising more diversified group of organisms (4-7groups) and number of benthic organisms (950-1400 ind./m^2), followed by station-I (4-6 groups and 675-1225 ind/m^2) and station-II (3-5 groups and 550-750 ind./m^2) during 2015.

In coastal environment the interaction between costal morphology, land, Ocean exchanges, meteorological and tidal conditions create a highly complex and finely scaled network of environmental boundaries. These boundary conditions explain why coastal waters have both higher species richness and a richer ecosystem than their Oceanic counterpart (Angel, 1994). The Bay of Bengal is dominated by an estuarine environment. A large scale dynamics prevailing in the Bay of Bengal are more or less periodic and well organized. The Physical and Chemical properties of the coastal water and sediment of Gopalpur exert considerable influence on the organisms including benthic resource present along the coastal region.

The annual rainfall is an important parameter which directly or indirectly influences most of the parameters like pH, salinity, DO of an area particularly in coastal region. Annual rainfall of an area has a positive relationship with pH and negative relationship with the salinity of that particular area. The month wise annual rainfall along Gopalpur coast varied from 0 to 230.7mm. The highest rainfall was encountered to be 662.4mm during Monsoon period followed by Pre-monsoon and Post monsoon period during 2015. The heavy rainfall caused sudden decrease in the salinity at coastal region. This situation was very acute at station-III, located at Haripur Creek. The heavy rainfall caused decrease in the salinity up to 5.3‰, this is due to discharging of huge amount of fresh water by Nandia Nala to Haripur Creek. The heavy rainfall was increased the value of pH and DO of a water body. The rain fall along Gopalpur coast is controlled by the seasonally reversing monsoonal regimes (Satapathy, 2006). The present result of annual rainfall (844.5mm) is not coinciding with the result of Satapathy (1990), which may be due to environmental changes in this region.

Among all the hydrological parameters temperature was consider as the most important critical environmental parameter influencing metabolism, growth, reproduction, distribution, and survival of organisms (Kinne, 1964). Studies on water temperature in various estuaries and coastal region in India showed that in most of the cases atmospheric temperature and the nature of the sediment underlying the water, are the two main reasons for its

fluctuation. Temperature has a positive relationship with the spawning activity of most of the benthic organisms. Spawning activity increases with increase in the water temperature (Eldred *et al.,* 1961). Some organisms have a negative relationship with temperature, their reproduction, abundance decreases with increase of temperature gradient. Temperature fluctuation in the coastal region show marked temporal and spatial variation of species groups. Due to variation of temperature some organisms are commonly found in winter months, some are restricted to summer months while others are fond throughout the year. The sea water temperature closely follows the trend exhibited by the air temperature. This may be due to the shallowness of the study stations. The sea water temperature was higher than the air temperature during the cold season from October to January. This may be due to the high heat retention capacity of water. The air and water temperature was generally high in Pre-monsoon months and low during Post-monsoon months. The spatial variation of air and water temperature among different stations was very low; this may be due to the short distance among the stations. In present study, it was observed that, the temperature to be 26^0C during post-monsoon and 34^0C during pre-monsoon. The range of water temperature at station-III (Haripur backwater) was ranged from 27.5 to 30.2^0C. Our result is supported with result of previous workers (Satapathy, 1990).

The pH of a water body is generally responsible for the growth, distribution and osmo-regulation of benthic organisms. The pH of Gopalpur coast varied from nearly neutral-7.2 to alkaline-8.3 during 2015. This was suitable for better development of most of the benthic organisms. The highest pH was observed at station-III during Monsoon period, when the salinity was very low (5‰) and water body was exclusively brackish. The lowest pH was observed at station-I during Pre-monsoon period, when the salinity was very high and water is exclusively marine. It can be concluded that the pH has a negative relationship with the salinity and positive relationship with the rainfall. The pH not showed any relationship with the temperature, DO and BOD. Satapathy (1990) has reported that the pH of Haripur Creek ranges from 6.48 to 8.78. In present study the pH varied from 7.2 to 8.3. The present result is in agreement with the result of Satapathy (1990). This may be due to similar environment, due to same place and locality.

Sediment texture is an important parameter which controls the distribution and community structure of macrobenthos of a region. The distribution of macrobenthic community is highly related to sediment type, current speed and organic content of the sediment (Gray, 1974; Crentzberg *et al.*, 1984; Buchanan, 1984; Snelgrove and Butman, 1994; Hoey *et al.*, 2004). The hard sediment was dominated by epifaunal groups and the soft sediment was dominated by infaunal groups. The station-I and II are located at Baxipalli and Tourist beach respectively exhibited nearly equal percentage of sediment content (sand, silt and clay), here the percentage of sand was very high varied from 97.89% to 98.83%, the percentage of silt and clay was very low, which varied from 1.04% to 1.51% and 0.13% to 0.85% respectively. This may be due to high tidal action, which has not given scope for settlement of the smaller sediment particles (silt and clay) into the bottom of the coastal region. Here the tidal action also washed away the finer sediment into the dipper ocean. The station-III was dominated by sand, but the percentage of sand was comparatively less than station-I and II, the percentage of sand varied from 81.71% to 87.66% during study period. The percentage of silt and clay was high at station-III. It varied from 7.43% to 12.22% and 4.67% to 6.07% respectively. This was due to location of the station-III at Haripur Creek, where the tidal action was very low and the smaller sediment particles discharged with the water of Nandia Nala were settle down into the bottom, which created comparatively soft bottom than station-I and II.

The salinity is the principal chemical parameter in marine environment, which control the distribution, abundance, diversity of macrobenthic community structure of an area. The Bay of Bengal is dominated by an estuarine environment. This estuarine property is due to the freshening of the ocean water. Freshening is in part due to the oceanic precipitation (Prasad, 1997) as well as the runoff from the peninsular rivers along east coast of India like Brahmaputra, Cauvery, Damodar, Ganges, Godavari, Irrawaddy, Krishna, Mahanadi, Pennar, and Salween drainss into the Bay of Bengal and these hinterland rivers imposing a huge amount of fresh water. The salinity values were showed the spatial and temporal variation at different stations of the Gopalpur coast.The station I and II was exhibited nearly same trend of salinity. This may be due to location of both the stations in the marine environment and situated quite distance away from fresh water influence. Salinity has a negative relationship with the rainfall. Some organisms have a positive relationship with the salinity known as holo-philic and some organisms show negative relationship with salinity known as holo-phobic. The spatial and temporal variation of salinity between station-I and II was very low. This may be due to similar type of environmental condition of these two stations.

The station III is quite different from other two stations because it is a brackish water environment. This is due to the salinity of station-III controlled by tidal ingress, fresh water drainage rate, rate of evaporation and leaching effects. The station-III was located at Haripur Creek; where influence of fresh water discharged by Nandia Nala dilute the marine water and reduced its salinity and creates a brackish water environment. At station I and II, the salinity was varied from 27.1 to 31.7(‰) But the variation of salinity at station-III was quite variable and it ranged from 5.3 to 20. 3(‰). It may be due to discharge of fresh water from various sources during different seasons of the year. Sewell (1929) has observed that the influence of northerly current which brings in warm, high saline waters from the equatorial Indian ocean into Bay of Bengal, which increases water salinity during Pre-monsoon period. Quasim and Sengupta (1981) have observed that the high discharge from river inflow during Monsoon period decreases the water salinity and low discharge of the river inflow, evaporation due to high temperature and shallowness of station during Pre-monsoon period increases the water salinity of Mandovi and Zuari eastary of Goa. Pattanaik (1990) observed that diminished runoff from rivers discharge and prevailing high atmospheric and sea temperature in pre-monsoon period increases water

salinity. In present study low salinity was prevailed during monsoon period and it showed a steady increase from Monsoon to Post-monsoon period and post-monsoon to Pre-monsoon period at all the stations. The present result is in agreement with the result of previous authors (Sewell, 1929, Quasim and Sengupta, 1981 and Pattanaik, 1990). This may be due to similar environmental condition among each study area. In present study, lowest salinity was observed during monsoon period at station I, II and III of Gopalpur coast. So the present result is in agreement with the result of Sewell (1929) and Achutankutty (1987). In present result the variation of salinity is from 5.4‰ to 31.7‰. Satapathy (1990) has observed that the water of Haripur Creek became hyper saline (36.08‰ to 39.22‰) during March and April. But in present result, the water of station-III has not become hyper saline condition during March and April. It may be due to fresh water influence by rainfall during this period. A large number of organisms response very positively to increase in salinity (George *et al.*, 2009). The salinity is the most important factor influencing the life history of macrobenthos. It also influences many functional responses such as metabolism, growth, migration, osmotic behavior, reproduction, etc. In present study the salinity of station I, II and III ranged between 5.4 to 31.7‰. So the present result is partially coinciding with the result of Das (2008) and Mahapatro (2015). This partial difference in salinity may be due environmental changes. The station I and II was exclusively marine environment; there was no fresh water influence. But at station III, the water was brackish with fresh water influence during rainy season.

The Dissolved Oxygen (DO) is an important Parameter in coastal region. It has profound influence on the distribution, general metabolism and growth of the macro benthos of an aquatic environment. The present study showed that water at all the stations of Gopalpur coast were fully saturated throughout the year and concentration ranged from 5.4 to 7.2 ml/l during study period. The average dissolved oxygen concentration was 6.1ml/l during Pre-monsoon period. It gradually increases during Monsoon period being 6.4ml/l and reaches its peak value during Post-monsoon period being 6.6ml/l. The oxygen concentration in water did not show any consistent relationship to either temperature or salinity. This may be due to climatic change. The DO of Gopalpur coast shows a stable concentration gradient with a very little temporal variation throughout the study period. The DO has a positive relationship with a large number of organisms (George, 2009). The requirement of dissolved oxygen increases as the macro-organism grows and the metabolism was related to its body weight, the heavier from showing the greater dependency on oxygen content of the water (Das, 2008). The minimum survival level of oxygen varied from 1.49ml/l & 3.80ml/l among early juvenile and sub adults respectively.

The BOD is an important environmental parameter which reflects on the health of the ecosystem. The BOD is negatively related to the DO throughout the study period. The BOD value did not show any consistent relationship with the temperature and salinity during study period (Pattanaik, 1993). The BOD values of three different stations of Gopalpur coast varied from 1.3ml/l to 2.3ml/l. The numerical analysis showed that the average BOD value 1.95ml/l during Pre-monsoon period was the highest followed by 1.8ml/l during Post-monsoon period and 1.5ml/l during Monsoon period. The BOD values of three stations of Gopalpur showed very little spatial and temporal variation, this may be due to the short distance among three different stations. BOD has a considerable influence on the distribution, metabolism and survival of organisms. The overall observation at three different stations of Gopalpur coast has indicated indicating that the Gopalpur coast is less polluted as compared to other stations of country.

The distribution and structure of the benthic communities in the coastal region were determined by the characteristics of the habitat in which they customarily inhabited. The local diversity of all the different habitats were strongly influenced by recruitment effects, species interactions or environmental perturbations including human activity in different areas (Dewarumez, *et al.*, 1992; Heip, *et al.*, 1992; Hoey, *et al.*, 2004). Physical disturbance not only affect the infaunal community but also the structure of sediment matrix itself (Dernie *et al.*, 2003).

Coastal marine benthic communities are also threatened by pollution and coastal development. Many of the pollutants that are released from domestic sewage and industrial waste outfalls end up in marine sediments and tissues of marine benthic organisms (Snelgrove, 1998). Macrofaunal organisms have a number of direct linkages with other faunal groups residing in marine sediments (Snelgrove, 1998). The various microbes that carried out critical processes such as decomposition and nutrient cycling (Giblin *et al.* 1995) are impacted by macro fauna in several ways.Macrobentic organisms are closely associated with the sediment, so all the physico-chemical parameter related with sediment has some extent of effect on the macro benthic community structure. The macobenthic groups in percentage at different stations of Gopalpur coast during different seasons of the study period are noticed. In different station the dominant groups of organisms varied. This may be due to different environmental conditions. The station-I and II were exclusively marine environment, dominated by nematodes and the station-III was brackish water environment, dominated by polychaetes throughout the study period. No changes were observed on the distribution and abundance throughout the study period. The number of ind./m^2 of macrobenthos at different stations of Goalpur varied from 550 ind/m^2 to 1400 ind/m^2 during the study period. The number of individuals of macrobenthos showed both spatial and temporal variations at different stations of the Gopalpur coast. This may be due to heterogeneity in environment and environmental factors.

In present study, it was observed that, the Gopalpur coast showed seven different groups of species at station-III during Post-monsoon period and highest ind./m^2 (1400 ind./m^2) was observed at Station-III during Pre-monsoon period. This may be due to stagnant condition of water column at station III during Pre and Post-monsoon which made less discharge of fresh water and allowed the silt, clay and organic matter settled into the bottom. So the percentage of silt, clay and organic matter was high during Pre-monsoon and Post-monsoon period and fluctuation of

salinity was very low, which contribute a stable, dense and highly diversified community structure at station III. Comparatively low diversity and low density community structure was encountered at station III during Monsoon period, this may be due to the moving of water column due to heavy discharge of fresh water into the creek, which reduced silt, clay and organic matter during Monsoon period. The dynamic fluctuation of salinity created an unstable environment during monsoon period. The lowest diversity (3) was observed at station-II during Pre-monsoon and Monsoon period and the lowest density (550 ind./m^2) was observed at station-II during Monsoon period. This may be due to low percentage of silt, clay and organic matter and interference of human beings at station II, which is an important tourist beach of the country.

It was observed the station-I and II contribute similar type of environment and environmental parameters but variation in diversity and density may be due to the influence of human beings at station-II was very acute as it is an important tourist beach but at station-I, there was no any human influence. In present study the benthic group varies from 3 to 7 and number of individuals varies from 550 to 1400 ind/m^2. In overall observation among the three stations it was showed that nematodes were dominated in abundance with 9.43-81.82% followed by polychaetes (4.55-51.79%), decapods (0-23.81%), gastropods (0-16.98%), bivalves (0-13.11%), amphipods (0-12.50%) isopods (0-11.32%), and asteroids (0-3.33%). In different station the dominant groups of organisms varied. The station I and II were dominated by Nematodes and station III was dominated by polychaetes during all the seasons of the study period. No considerable changes were observed on the distribution and abundance of macrobenthos community structure throughout the study period.

In present result about 21 species of molusca were observed, out of which10 species were gastropods and 11 species were bivalves. 8 species of decapods, 1 group of isopods and 1 group of amphipods. In this part Polychaetes, copepods, nematodes, bivalves were represented the major macrofaunal groups. The polychaetes and bivalves population contributed 24.8% to 66.7% of the total standing stock of macrobenthos. In present study the macrobenthic density varied from 550-1400 ind./m^2. So the present result is in partial agreement with the earlier workers. Behera *et al.* 2013 have reported 16 species of mollusca in Bahuda estuary, out of which 8 species were gastropods and 8 species were bivalves.10 species of crustaceans. Pati (2007) has studied on the mollusca of Rushikulya estuary. He has reported 25 species of mollusca contributing 17 species of gastropods and 8 species of bivalves. . So the present study is partially coinciding with the result of the above two workers.

Table 1: Distribution of Macro benthos at three different stations of Gopalpur Coast during 2015

ST CODE	STATION	SEASON	BEN_TYPE	SPECIES	COUNTS	PER_ COMP	TOT. POP.	TOT. GRP
	Name				nos/m^2	%	nos/m^2	no
St-I	BAXIPOLLI	PREMONSOON	MACROBENTHOS	NEMATODES	625	59.52	1050	5
				DECAPODA	250	23.81	1050	5
				POLYCHAETA	75	7.14	1050	5
				ISOPODA	50	4.76	1050	5
				AMPHIPODA	50	4.76	1050	5
St-II	TOURIST BEACH	PREMONSOON	MACROBENTHOS	NEMATODES	375	65.22	575	3
				DECAPODA	125	21.74	575	3
				POLYCHAETA	75	13.04	575	3
St-III	HARIPUR CREEK	PREMONSOON	MACROBENTHOS	NEMATODES	250	17.86	1400	6
				ISOPODA	50	3.57	1400	6
				POLYCHAETES	725	51.79	1400	6
				BIVALVES	75	5.36	1400	6
				GASTROPODES	125	8.93	1400	6
				AMPHIPODES	175	12.5	1400	6
St-I	BAXIPOLLI	MONSOON	MACROBENTHOS	NEMATODES	375	55.56	675	4
				DECAPODA	150	22.22	675	4
				BIVALVES	75	11.11	675	4
				POLYCHAETA	75	11.11	675	4
St-II	TOURIST BEACH	MONSOON	MACROBENTHOS	NEMATODES	450	81.82	550	3
				DECAPODA	75	13.64	550	3
				POLYCHAETA	25	4.55	550	3
St-III	HARIPUR CREEK	MONSOON	MACROBENTHOS	NEMATODES	325	34.21	950	4

				POLYCHAETES	450	47.37	950	4
				BIVALVES	50	5.26	950	4
				GASTROPODES	125	13.16	950	4
St-I	BAXIPOLLI	POSTMONSOON	MACROBENTHOS	NEMATODES	775	63.27	1225	6
				DECAPODA	125	10.2	1225	6
				POLYCHAETA	100	8.16	1225	6
				ASTEROIDES	25	2.04	1225	6
				AMPHIPODA	125	10.2	1225	6
				BIVALVES	75	6.12	1225	6
St-II	TOURIST BEACH	POSTMONSOON	MACROBENTHOS	NEMATODES	525	70	750	5
				DECAPODA	100	13.33	750	5
				POLYCHAETA	50	6.67	750	5
				ASTEROIDES	25	3.33	750	5
				BIVALVES	50	6.67	750	5
St-III	HARIPUR CREEK	POSTMONSOON	MACROBENTHOS	NEMATODES	125	9.43	1325	7
				ISOPODA	150	11.32	1325	7
				AMPHIPODA	125	9.43	1325	7
				POLYCHAETES	600	45.28	1325	7
				BIVALVES	75	5.66	1325	7
				GASTROPODES	225	16.98	1325	7
				ASTEROIDS	25	1.89	1325	7

CONCLUSION

The coastal region is interface between land and sea. It is the most dynamic region controlled by a large number of physicochemical parameters. The diversity in coastal region is strongly influenced by recruitment effects, species intersections or environmental perturbations including those attributable to human activity. To overcome this hazardous environmental parameters the organisms of coastal region shows various morphological and physiological adaptations, hence the coastal region is densely populated. Some coastal regions are extraordinarily fertile and act as the nursery and breeding ground for many marine macrobenthic organisms. The occurrence, distribution and abundance of coastal biota are fluctuating in a spatio-temporal scale.

Gopalpur coast situated on the extreme south coast of Odisha, exhibit the following features as far as hydrology and macrobenthos are concerned. Among all the physico-chemical parameters, temperature and sediment texture are most important parameters, which control the distribution, diversity and abundance of macrobenthic community structure in coastal region. The annual rainfall is an important parameter in coastal region. The annual rainfall at Gopalpur coast varied from 001.4mm to 230.7mm during 2015. The water temperature of Gopalpur coast closely follows the trend exhibited by the air temperature. The coastal water temperature was lower than the air temperature except during the cold season (October to January), when the reverse was the case. The air and water temperature of Gopalpur coast varied from 26 to 34.2^{0}C and 27.5 to 30.2^{0}C respectively. The pH at different stations of Gopalpur varied from nearly neutral to alkaline that is 7.2 to 8.3, which is suitable for marine organisms. It is a well-known fact that the nature of the sediment governs to a great extent the type of fauna and the density at a given place and time. Among three stations of Gopalpur, the station-III contributed larger percentage of silt and clay than station-I and II during all the seasons and highest during Post-monsoon. The bottom sediment showed sand from 81.71 to 98.83%, silt from 1.04 to 12.22% and clay from 0.13 to 6.07%.

The station I and II were exclusively marine environment exhibited nearly a stable range of salinity throughout the year, while the station III was located in a brackish water environment exhibited a dynamic variation of salinity throughout the year. The salinity of Gopalpur coast was varied from 5.3 to 31.7‰. During Monsoon the water of station III became almost fresh and during Pre-monsoon the waters of station-III became almost marine, so immigration and emigration of fresh and marine water species occured throughout the year. The water of Gopalpur coast was fully saturated throughout the year during 2015 and the concentration of DO varied from 5.4 to 7.2 ml/l. The BOD of Gopalpur coast varied from 1.3 to 2.3 ml/l. The diversity of macrobenthos of Gopalpur coast varied from 3 to 7 groups and the population density of macrobenthos varied from 550 to 1400 ind./m^2 among different stations during 2015. The major groups such as nematodes, polychaetes, decapods, bivalves, gastropods, amphipods, isopods and echinoderms were identified. However we are able to identify the species of bivalves (11), gastropods (10), decapods (8), and echinoderms (1). The macrofauna were abundant in sandy and sandy silt substratum of Gopalpur coast. In different station the diversity and dominant groups of organisms varied. No

considerable changes were observed on the distribution and abundance of macrobentic organisms throughout the study period and all the study locations were free from pollution. One year study is not sufficient to carry out the detailed study on the macrobenthic community structure of Gopalpur coast. Therefore, a detailed and long term study is required to be carried out on macrobenthic community of Gopalpur coast to relate the physico-chemical parameters with that of the abundance, distribution and community structure of macrobenthos organisms.

The physico-chemical parameters were in the permissible limit. No considerable changes were observed on the distribution and abundance of benthic organisms throughout the study period, which showed that the Gopalpur coast is not polluted, which provide suitable environment for benthic organisms.

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