Coastal Environment of Midnapore, West Bengal: Potential Threats and Management

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Abstract

The paper deals with the Integrated Coastal Zone Management (ICZM) of the Midnapore Coast, West Bengal. It is suggested that management studies should include baseline information related to rainfall, runoff, tidal rhythm, currents and waves with their related aspects. This information is important to develop proper coastal protection measures.

Beaches and shoreline should not be considered simply as an object of beauty for recreation only and holiday-making. These are assets of great economical value and need measures to be devised for their protection. It is necessary to make a study of flora and fauna with their distribution in relation to prevailing economic conditions so that conservation measures could be devised. Existing mangroves and associated coastal vegetation should be fully protected by adopting suitable means.

Tourism should be encouraged according to the nature of the environment.

To enforce coastal regulatory laws in relation to the various activities related to coastal management. These laws have been formulated in relation to coastal protection.

Introduction

Among all the 9 maritime states of India which have an impressive coastline, the total of them amounts to 7500 km (approximately). The state of West Bengal (W. B.) commands a significant geographical location harbouring the mighty Ganga estuary (Hoogly-Matlah estuarine complex), shared with the neighbouring country Bangladesh. Historically and geographically the coastal Midnapore is a contiguous part of deltaic Sundarbans of global importance, limiting the Hoogli estuary on the western front. The coastal area of W.B. extends over

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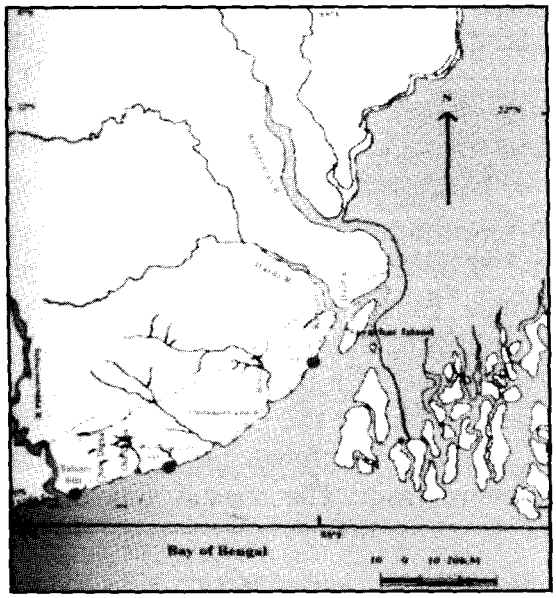
0.82 million hactre and extends along 220 km of coastal line. Of the two coastal districts of W.B., the undivided Midnapore district is characterised by sand dunes, long shore currents, high salinity, low turbidity and low vegetative coverage in comparison to its counterpart, (the South 24 Parganas District) supported by Sundarban Mangrove Ecosystem (Annon, 2005, Paul, 2002). The Midnapore coast (60 km) covers 27% of the W.B. coastal tract extending along the west bank of Hoogli Estuary from New Digha at the extreme south west point of the Midnapore district and then curving around Junput, Dadanpatrabarh, Khejuri and Haldia on the east to further northeast up to Tamluk (erstwhile Tamralipta) or even Kolaghat on the bank of Rupnarayan (Fig. 1). Biodiversity of this coastal environment, i.e. floral and faunal diversities are in tune with habitat diversity in this short stretch coastal zone and represents striking features with the regard to ecosystem functioning, commercial bioresource production, coastal zone management and promotion of ecotourism. Biodiversity is dynamic at all three levels, the genes, species and habitats and changes over time in response to natural and human- induced selection pressures. Diversity of habitats in terms of changing physical,

Fig. 1



Map of Coast Midnapore, West Bengal

chemical and geomorphological parameters imparts impact on genetic composition which leads to the changes of biotic assemblages spatially ad temporally.

Habitat diversity of Midnapore coast:

The Midnapore coastal tract (longitudinal extension 87°20'E to 88°5'E and latitudinal extension 21°30'N to 22°2'N) in between Hoogli and Subarnarekha estuarine confluence with the Bay of Bengal, although very short in length, it displays unique habitat diversities in respect to vegetation composition, occurrence of dunes, mudflats, sandflats and other ecological parameters like variation of salinity, temperature, texture of sediments etc. Besides, this coastal tract can be divided into two distinct zones based on the continuous erosion and accretion processes. Different habitats having contrasting ecological features are as follows:

S-I. Talsari: This site is located at the confluence of Subarnarekha estuary with the sea. The Subarnarekha estuarine delta is the westernmost unit of the topographic expression in the present coastal plain. A degraded tract of mangrove swamp is still in existence around the estuarine link of Talsari tidal and intertidal flats.

S-II. Digha (Old and New): The history of modern Digha is not very old. In 18th century, the Digha village under Birkul Parganas under the British Rule was a health resort for the British in India and was considered as the most popular weekend beach resort in West Bengal. In the present day, over 40 lakhs tourists visit Digha every Year.

S-III. Shankarpur: Shankarpur, a small village located 180 km. away from Kolkata and 16 Km West from Digha in the coast of Bay of Bengal. Shankarpur is a well known fishing harbour and also a tourist spot of West Bengal. This fishing harbour has a capacity of providing facilities for to and fro movement of more than 150 mechanised boats per day. The total employment generation capacity of this area is more than 10.000 people per day.

S-IV. Dadanpatrabarh: This important fish-landing and processing centre is situated around 10 km away from Kontai subdivisional town by the side of sea. A total of 85 migrant fishers and around 200 local

fisher families are engaged in fishing. Small patches of degraded mangroves have been thriving for their survival in the area.

S-V. Junput: Junput, a small coastal village and an important fish-landing centre on Hoogli estuary is located 15 km east of Kontai. People belonging to below poverty line are engaged in fishing, especially for fish drying. A good patch of mangroves comprising namely of *Rhizophora mucronata* and *Avicennia* spp has come up in the intertidal zone.

S-VI. Khejuri: Khejuri, a small coastal block with historical importance is situated near the Haldi river mouth. This was followed by a mangrove afforestation programme for 4 consecutive years viz. 1999 (10 hectors area), 2000 (10 hectors area), 2001 (10 hectors) and 2002 (15 hectors area) covering a total area of 48 hectors. This has resulted in the development of a healthy green patch of mangroves in this coastal tract. Besides others, grazing is the main problem to protect these plants. Small numbers of fishermen are engaged in fishing in the area.

S-VII. Haldia: Haldia, a newly grown up industrial town in the district of Midnapore, West Bengal possesses a good number of industries like petroleum refineries, fertilisers, pesticides, battery, detergent etc. A large number of industries are located in close proximity of the confluence of the two estuaries, *viz.* Hooghli and Haldi, which are subjected to severe impact of pollutants discharge.

S-VIII. Nayachar Island: The 46-sq. km Nayachar is a newly emerged island located (2154'41"- 2201'30"N & 88 03'00" 88 08'52"E) at the middle part of the macro- tidal estuary of Hugli River within the complex environmental setting of Bengal Delta system. After being raised considerably through continuous accretion of sediments, the surface of Nayachar Islands becomes colonised by salt marshes, the species association of which underwent through various series of succession with the changing bio-tidal environment associated with geomorphological dynamism (Paul, *et.al.*, 2003-04). This island, formed out of sediment deposition during the past several decades, started accretion from 1945. Between 1967 and 1997, the island progressively enlarged, yielding an average accretion rate of 0.88 sq. km per year (Hazra and Sanyal, 1996). The island exhibits very rich

biodiversity in terms of the salt marsh grass and swampy mangrove plant species along with various species of birds, fishes, plankton organisms, soil micro-arthropods and benthos (Dey, *et. al.*, 2008; Khalua, 2003).'

S-IX. Kolaghat: The river Rupnarayan, one of the most important tributaries of the Hoogli, has been showing signs of rapid deterioration because of siltation resulting in navigation difficulties. In addition to the navigation difficulties, present trends of eco-degradation is likely to hamper the drainage of freshwater brought down by several freshwater rivers of South West Bengal, resulting in salinity invasion to all the estuarine networks of Midnapore coast. Kolaghat Thermal Power Plants which has been functioning since mid- eighties produce large amount of fly ash. This fly ash constituting very fine size of suspended particles has posed major ecological threats to adjoining water and soil ecosystem (Mishra, *et. al.*, 2002).

Geological and climatic factors of Midnapore coast:

***Beach profile*:** The beaches form linear coastal features, usually developed along the shoreline buffer to absorb or diminish and to reflect or transform the wave energy which is generated over the large areas of the Bay, both driven by winds and tides. Larger and flatter beach profiles of Midnapore coast are associated with beach berm, beach face, ridge and runnel, rip channels, low tide terrace, long shore trough, long shore bar and significant back wash ripples within the limits of back shore, foreshore, inshore and adjacent shallow water area of offshore zones. The beach face is marked by various sedimentological structures and active bioturbatious. The fine sand beaches of Midnapore coast have gentle foreshore slopes and provide a firmly packed hard sand surface for safe walking, playing, bathing and car driving. The beach provided with spits, are usually developed on drift alignment of long shore sediment. The amount of silt and clay fractions has increased in the extensive tidal flats of the lower foreshore region. Reduction of beach volume by attrition in Digha resulted in lowering of the beach planes (Chakraborty 1996). All motions on the sea surface are generated and controlled by a range of forces, viz. tides, waves and currents. Ripples and waves are generated by the wind and controlled by surface tension alone or in conjunction

with storm. The waves in turn may generate coastal currents which are responsible for the sediment drifts along the beaches, i.e. long shore or littoral drift. Based on the nature of the tidal range, this coast is designated as Macrotidal to Mesotidal coast (Paul, 2002).

Dunes: Coastal sand dunes are common geomorphological units in different parts of India. Dunes act as natural barrier to protect the coast from the damaging actions of wind, tide and wave, thus assuming a significant role in environmental protection. Recently, the long-term movement of shoreline obtained from the study of old survey report and new satellite data indicates that there is continued erosion at Digha proper but accretion at its western boundaries of Midnapore coast. Between 1877 and 1965, the beach-front-dune complex retreated landward by about 970 m at the rate of 11 m per year due to frequent marine transgression (Bhandari and Das, 1998).

Sea level rise and erosion: Local sea level change and storm surge on seasonal effects or generation of waves of large height contribute to erosion over a time scale of hours to months. Comprising the annual sea level variation, it is observed that the annual mean sea level has risen steadily. In the Ganga-Brahmaputra delta, the suspended sediment load is high. If the sea level rise is being considered due to sedimentation load at the rate of 0.1 mm per year, the net rate of sea level rise would be 3.14 mm per year (Hazra, *et. al.*, 2002). The causative factors of coastal erosion at Midnapore coast are identified as- (i) Strong littoral drift on a fine grained and flat beach bordered by dune in the landward side, (ii) loss of sandy materials inland by wind action, (iii) strong tides during cyclonic storm, (iv) possibility of faulting in the Digha shore- face in recent past and (v) bathymetry of the inner continental shelf and orientation of the ' Western Brace' with respect to Digha at its shore- face (Mukherjee and Chatterjee, 1997).

With regard to the coastal erosion along the Digha-Dadanpatrabarh stretch, a general observation is that while the entire coastal stretch from Digha-Dadanpatrabarh to west Dadanpatrabarh is presently under severe coastal erosion, the eastern segment of Digha-Dadanpatrabarh coast near a small tidal estuary is under stable conditions leading to accreting condition. An acceleration of erosion is also noticed from the year 1994. In the Digha coast, several mouzas,

which are still shown on the land use and land holding maps, have been engulfed by the sea during the last 30 years. The seawall was able to arrest the beach retreat but the beach lowering could not be protected. It was also noticed that the beach was steepened considerably after the construction of seawall, as compared to the pre-construction period (Hazra, *et. al.*, 2001, Mukherjee and Chatterjee, 1997).

***Erosion and accretion*:** Historical records show that during the period 1877 and 1965, Digha shoreline of Midnapore coast moved inland by 970 m with an average retreat of 11 m per year. However, the rate of shoreline retreat has been increased sufficiently within the short-term period between 1965 and 1995 by 525 m with an average retreat of 17.5 m per year. To prevent such increasing erosion rate, the West Bengal Government constructed 4.7 km long sea wall with laterite stones in between 1972 and 1988 in the east west part of Digha. The sloping face of the sea wall touched the upper part of the beach plain and protected the bank line behind the long sea wall from open wave attack (Paul, 2002). Kolkata Port Trust also constructed a 2.8 km long guard wall on the northern end of Nayachar Island in Hugli estuary for improvement of the navigation channel of the Hugli river by diverting the eastern bank current to move along the Haldia bank during the ebb tide flow and down flowing river current. Several cross spurs have also been constructed along the northwestern bank of Nayachar Island in the same scheme of river training works (Dey, *et. al.*, 2008).

***Natural causes of erosion*:** It is observed that the normal wave attack produces net loss of sediments by erosion in the lower part of the sandy beach during the southwest monsoon period. During this time, a spring tide level touches the base of beach-fringed dune and produces micro-cliff by erosion or by shoreward transport of unconsolidated dune sands. Even the stratified, grass covered large blocks or chunks of unconsolidated sediments have been observed to roll down after erosion by undercutting of sand bank in Hugli estuary within a short term period of tidal energy variation and wave activities. However, the enormous discharge of freshwater, carried by Hugli-Rupnarayan-Kasai-Subarnarekha system, amplifies the tide and surge situations along with the seasonal high seas in the southwest monsoon brace.

Beaches of Digha coast, Talsari, Junput and Shankarpur shoreline generally return to steeper reflective profile after the high energy wave event is over. Beach and dune erosion are the major thrust of this region due anthropogenic activity, recreational exploitation and unplanned urbanisation (Mukherjee and Chatterjee, 1997).

Tides: The daily water level fluctuations of high tide and low tide and their cycle cause the changing water content of the beach and deposition tends to take place at the top of the beach at high tide and erosion as the tide falls. The mean range of the tide during springs at Haldia and Digha is 4.90 m, 4.20 m respectively.

Meteorological data: Seasonal monsoon winds and maritime actions in the Bay of Bengal influence the tropical dry and wet climate of the region. The rainy season is largely confined to the months of June to October after a long dry spell of hot humid summer (Chandra *et. al.*, 2008).

Floral and faunal diversity

Floral diversity of Midnapore coastal belt: Fifty seven species of mangroves and their associated plants from the intertidal, supra-littoral and backshore zones under 32 families, 28 species of benthic algae under 4 families and 8 phytoplankton species under 3 families from the intertidal zone, supra-littoral brackish zone from the sub-tidal open estuarine marine zones of different habitats of contrasting ecological features have been recorded (*Annon*, 2005): *Avicennia officinalis, A. alba, Exococaria agallocha, Acanthus ilicifolius Sueda maritima, Salicornia brachiata, Rizophora mucronata* and *Ipomea pes-caprae*, represent the major mangrove species.

Dune growing plants such as *Ipomea, Spinifix, Pandanus*, etc. play a major role to stabilise dunes like the mobile dunes or the fore dunes, stabilised or back dunes. These species once established stabilise the shoreline and act as a buffer against erosion. It is observable that the gradual and orderly sequence of plant development from seaward to landward side is: (1) *Spinifex littoreus* formation on the beachfront seashore, (2) *Ipomoea pes-caprae* development on the mobile dunes, and (3) *Casuarina-Ipomoea-Pandanus* association on the fixed (stabilised) dunes. In highly unstable conditions, only low growing

Spinifex littoreus with deeply penetrating root system survives (Bhakat, 2000; Bhakat, 2001).

Faunal diversity of Midnapore coastal belt: Midnapore coastal belt in its extension of 60 Km encompasses a diversified habitats and niche which accommodate a galaxy of faunal components in the form of pelagic and benthic forms. Seventeen species of zooplankton mainly comprising of Copepoda, Chaetognatha, Rotifera and some considerable number of nauplii larvae have been recorded (Manna, *et. al.*, 2008). A total number of 48 molluscan species belonging to 3 classes, 15 orders and 36 families have been reported from the intertidal habitats (Khalua, *et. al.*, 2003).A total number of 22 polychaete species belonging to 10 families have been identified (Chandra, *et. al.*. 2008). A total number of 12 actinarian species belonging to 2 classes, 3 orders and 6 families have been recorded from different study sites. Besides, sea cucumber (Holothuroida), sea pen (Cnidaria), *Lingula* sp. (Brachyopoda), were found in the mudflats of Talsari, Shankarpur, Junput, and Nayachar Islands. Of the 68 arthropod species recorded from this coast,13 brachyuran crabs, 13 species of prawns and shrimps (21), 21 insects belonging to 33 families represent the major groups of fauna (Annon, 2005; Chatterjee, *et. al.*, 2008). A total number of 51 soil microarthropods belonging to insect orders, viz. Collembola, Hymenoptera, Diptera and Isoptera, have been recorded from the different parts of this coast and they were found to play considerable role in estuarine-mangrove nutrient cycling (Dey, *et. al.*, 2008 and Dey, *et. al.*, 2009). Both the species of horse-shoe crabs, *viz. Carcinocorpius rotundicauda* and *Taphypleus gigas*, are also recorded from the Digha-Talsary intertidal flats (Annon, 2005). A total of 51 fish species under 2 classes, 9 orders and 25 families have been documented from different fish markets and landing centre (Annon, 2005).

Fish landings at Midnapore Coast: Huge amount of eroded sediments, fly ash along with several other industrial discharges have made this vast sheet of water bodies almost unsuitable for living species. This is reflected by the steady decline of the abundance of fin fish and shell fish seeds, smaller fishes and other nektonic forms. It has been reported that an annual fish landing for 2003-2004 was 14,700.8-kg/yr.

The data collected during the last ten years from the Department of Fishery, Government of West Bengal, relating to fish landings at Digha-Shankarpur Mohana, reveals a drastic reduction of total landings of different fishery resources. Operation of increased number fishing trawlers with nylon thread gears may be considered a major factor for such condition. Same trend was observed from the Junput fish landing centre and Dadanpatrabarh. The overall species wise analysis of the average catch for the three years showed that the highest contribution was from non-penaeid prawns (15.13%) followed by catfish (14.06%), pomfrets (10.33%), bombayduck (8.86%), croakers (8.2%), other clupeids (7.53%), anchovies (5.36%), hilsa (4.26%), ribbonfishes (6.2%), penaeid prawn (5.4%), seer fishes (2.33%), marine crabs (1.7%) and miscellaneous group of fin and shell fishes (10.56 %) (Annon, 2005).

Status of coastal Pollution: source and nature of wastes

Because of increasing urbanisation and industrialisation, throughout the Indian Ocean region, the load of sewage and industrial waste is constantly on the increase. Fertiliser, pesticides and insecticides are freely used in most developing countries for agriculture and pest and vector control. The quantities of pesticides and insecticides used every year vary from 45,000 tonnes in India to 3.5 tonnes in Bangladesh. In many countries, however, organochlorine pesticides are either prohibited or are gradually being replaced by organophosphorus and carbamate pesticides (Qasim, *et. al.*, 1988). The water quality has deteriorated considerably in this coast because of discharges of untreated or partially treated sewage from the industries, municipalities, coastal towns. Natural habitats of the wetland swamps have also been affected seriously, as they have been used for industrial aquaculture. In many areas, saltmarshes and tidal floodplains of estuarine banks and tidal creeks have been used to develop fish farm in the protective flood banks for sustaining aquaculture. Increased soil salinity, viral infection among the fishes and contribution of pollutants to the sea waters are the adverse consequences of the present rapid growth of fish farming which has been developed without paying heed to coastal zone regulation acts (Chakraborty, 1998).

It is well known that oil and other related organic products after being discharged from different fishing trawlers, barges, tankers, dredgers,

ships and other marine vessels pollute considerably both pelagic and benthic environment. Domestic sewage in small quantities is known to fertilise the sea which leads to an increase in marine productivity (Qasim, *et. al.*, 1988) because of eutrophication. Kolaghat Thermal Power Plant (KTPP) on the bank of Rupnarayan releases hot effluents and coal-burnt ash into this estuarine system (Mishra, *et. al.*, 2002). Waste disposal from the tourist centers of Digha and nearby fishing harbours of Shankarpur contributes pollutants into the nearby estuaries and salt marshes. (Annon, 2005)

Environmental impact of fly-ash disposal in estuary around Kolaghat thermal power plant

In any thermal power station, fossil fuel such as coal is burnt and chemical energy contained therein is released in the form of heat by oxidation reaction. The outcome of such an operation is the contamination of the adjoining environment. Spatial and temporal variations of environmental factors over a year are considered to be important in generating information and in analysing the changes taking place within a stipulated span due to mixing of effluents with water. The ecological monitoring (bioresource availability and physiochemical parameters of the River Rupnarayan located adjacent to Kolaghat thermal power plant have been made by Mishra, *et. al.*. (2002).

Impact of tourism

Digha coast is the second highest revenue-earning tourist spot of West Bengal-only next to Darjeeling hill resort. Picnicking under the shades of Casuarina trees on the dune surface, walking and bird watching on the sand dunes, bathing in the beaches covered by sea water, car driving and horse riding on the beaches are the major features of recreational exploitation of the coast along this seaside tourist place. As a center of tourist attraction, Digha has gradually developed and the area witnessed an unprecedented construction boom just within the range of few hundred metres behind the sea wall. Many multistoried hotels have come up within a short distance of the sea wall especially in Old Digha. The indiscriminate installation of heavy tube wells into the dune bank has led to the collapse of subsoil layers and the resultant seepage of saline water into the drinking water. Another important feature is that the sea wall does not cover the most erosion prone areas to the east of Gobindabasan village, a stretch of 2-km up to Digha estuary.

Around 40 lakh people visit this coastal spot annually. Temporary fishing villages are being constructed on the dune slope which destroys the dune continuously in different study sites like Dandanpatrabar, Junput, Digha mohona fish landing center. Huge extraction of fluids from the near surface water table may often cause subsidence and saltwater percolation into the aquifer and thus increase the ground water salinity. This is observed in most of the study sites like Digha, Contai, Junput, Sankarpur and Haldia. Another threat to the coastal environment in general and biodiversity in particular is the development of Mandarmani tourist complex in the Dandonpatrabar, Purusottampur stretch of Midnapore coast violating the Coastal Zone Regulation Act.

VIII. Trend of exploitation of ecologically and economically important finfish and shellfish species: Fishing with small meshed nylon nets reduces considerably the stock of juveniles, which are present in the fishing zone. It has been a regular feature especially around spring tide that local people in the process of collection of seeds of *Paeneus monodon* in saline stretch and *Macrobrachium* sp in fresh water dominated zone destroy a large amount of juveniles of other fishes like Mugil sp., *Rhinomugil corsula, Gudusia* sp., *Liza* sp., *Tenualossa ilisha, Polynemus paradiseus, Lates calcarifer* etc. along this coast. Besides, construction of fishing harbour and non- scientific fishing activities contribute to biodiversity loss (Annon, 2005).

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References

Annon. 2005. *Studies on bio-resource assessment and management of degraded mangrove ecosystem of Midnapore Coast, West Bengal,* Research project report, Ministry of Environment and Forests. Govt. of India. [Sanction No. 3/6/2001-CSC (M) Dated. 5th Nov. 2001] pp. 1-99.

Bhakat, R.K., 2000. An ecological study on dune stabilising plants of Digha for appropriate coastal afforestation. *Indian Journal of Geography and Environment.* **5**, pp. 87-89.

Bhakat, R.K., 2001. Coastal dunes of Digha, India- A plea for continued protection. *Indian Journal of Geography and Environment.* **6**: pp. 54-60

Bhandari, G.N. and Das, S.C. 1998. A study of beach erosion for appropriate protection of Digha Coast. In : Mukherjee, Ananda Dev; Datta, Kalyan Kumar; and Sanyal, Pranabes. (eds.), *Coastal Zone Problems*, Proceedings of National Workshop (March 20-22, 1998. Jadavpur University). pp. 51-60.

Chakraborty, P. 1996. '*Map-info*' in coastal zone management. *In: Integrated Coastal Zone Management — A Manual.* (Ed.) A.K. Ghosh and Pranabes Sanyal, Published by Department of Environment. Government of West Bengal. pp. 44-49

Chakraborty, S.K., 1998. Coastal Aquaculture and Environment in the context of West Bengal, India. *Journal of Bio Sciences*. **4**. Vidyasagar University.

Chanda, A and Chakraborty, S. K. 2008. Distribution, population and community ecology of Macrobenthic intertidal Polychaetes in the Coastal tract of Midnapore, West Bengal, India. *Journal of Marine Biological Association*. **50(1)**, pp. 7-16.

Chatterjee, S.; Bhunia, G.; and. Chakraborty. S. K. 2008. Bioturbation of Brachyuran crabs and its impact on coastal ecosystem of Midnapore district, West Bengal, India. In: *Proceedings of Fourth International Conference on Environmental Science and Technology* 2008(II) *at Houston, Texas U.S.A.* pp. 133-148.

Dey, M.K., Hazra, A.K. and Chakraborty, S.K., 2008. Diversity of Macroarthropods and their role in the plant litter decomposition in the coastal tract of east Midnapore District, West Bengal, India. *Zoological Research in Human Welfare*, **20**. pp. 207-226.

Dey, M. K.; Hazra, A. K. and Chakraborty, S. K. 2009. Functional Role of Microarthropods in Nutrient Cycling of Mangrove-Estuarine Ecosystem of Midnapore Coast of West Bengal, India. *International Journal of Environmental Technology and Management*, **10 (10)**, pp. 1-18.

Hazra and Sanyal, A. 1996. Ecology of collembolan in a periodically inundated newly emerged alluvial island in the river Hoogly, West Bengal. *Proceedings Zoology Society*, Calcutta, **49(2)**. pp. 157-169.

Hazra, S., Ghosh, T., Dasgupta, R. and Sen, G. 2002. Sea level and associated changes in the Sundarbans, *Science and Culture.* **68.** pp. 309-321.

Khalua, R.K., Chakravarty, G. and Chakraborty, S.K. 2003. Annotated list of molluscs from the coastal tract of Midnapore District, West Bengal, India. *J. Marine Biological Association,* **45(2).** pp. 245-249

Manna, B., Banerjee, S., Aditya, G. and Chattopadhyay, J., 2008. Study of marine planktonic diversity in Digha coast, Bay of Bengal. *Zoological Research in Human Welfare.* **3.** pp. 49-54.

Mishra, S.S., Pradhan, P., Giri, S. and Chakraborty, S.K., 2002. Environmental Perturbation with regards to water quality and fishery resources of river Rupnarayan: a potential threat from a thermal power plant, West Bengal, India. In. Sustainable Development and cold water fish genetic resources. (Eds. S.R. Verma.), *Nature Conservators.* **7.** pp. 155-172

Mukherjee, A.D. and Chatterjee, S., 1997. Coastal erosion and accretion at and around Digha in Medinipur District of West Bengal. *Indian Journal of Geography and Environment.* **2.** pp. 1-11.

Paul, A.K., 2002. *Coastal Geomorphology and Environment.* ACB Publications. 575 pp.

Paul, A.K., Mukherjee, C.N., Bhattacharyya, P. and Mazumder, M. 2003-04. Environmental management and prospects of coastal tourism under the changing shoreline characters of Hugli-Subarnarekha complex. *Indian Journal of Geography and Environment.* **8 & 9.** pp. 1-27.

Qasim, S.Z., Sengupta, R. and Kureishy, T.W.1988. Pollution of the seas around India. *Proceedings of Indian Academy of Science (Anim. Sci.).* **97(2).** pp. 117-131.