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Studying the Anthropogenic Impacts on Coastal Ecosystem of Digha : A Hands-on Approach

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Abstract

The paper discusses the broad anthropogenic impacts on the seashore at Digha, a popular tourist destination in the district of East Midnapore in West Bengal, and the awareness study programme undertaken by the Digha Science Centre involving school students and teachers. The goal was to engage the young students in field studies, hands-on activities and simple analytical experimentations in order to make them understand the various aspects of Digha's coastal ecosystem and the rising problem due to human activities.

Introduction

The term 'coast' or 'coastal zone' means a spatial zone where interaction of the sea and land processes occurs. The dominant factors that influence the formation of a coast are waves, currents, tides and riverine depositions. The health of a typical coast is maintained by its sediment deposition budget which is influenced by an interplay of different geomorphic units like beach, sand dune, swash, longshore current and wave refraction. But anthropogenic activities like dams on rivers, sand mining, shoreline engineering, urbanization etc. can adversely alter the sediment budget and the overall health of the shore.

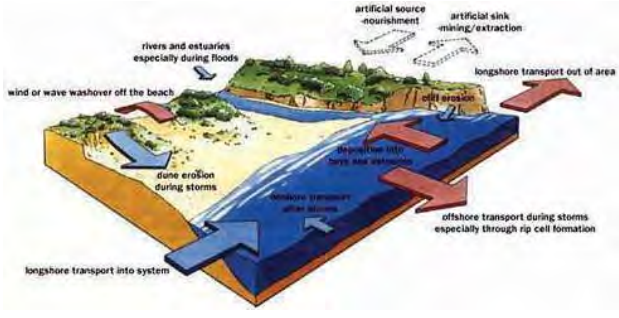

Figure 1. Sand balance of a typical seashore

The coastal environment maintains a delicate balance by the interplay of different processes like erosion, deposition, transportation and the living organisms residing in the same. The coast and its adjacent areas, on and off shore, support a rich diversity of plants, animals which are crucial to the health of the ecosystem. As every element of the food chain of an ecosystem is intertwined, their survival plays a vital role. While a high level of biodiversity has attracted humans to reside near the coasts, the various anthropogenic factors have impacted the ecosystem in a major way.

The length of India's coastline of including those of Andaman and Nicobar Islands and Lakshadweep Islands is 7517 km. These coasts support almost 30% of the total human population of India. Coasts offer economic as well as a host of recreational activities such as swimming, fishing, surfing, boating etc. As a result, a huge number of tourists are naturally attracted to these areas. This results in increasing interventions of humans on the ecosystem which lead to appreciable coast modification and environmental problems. Here we will be discussing only the broad anthropogenic impacts witnessed on the shore of Digha and the awareness programme undertaken by the Digha Science Centre.

Coast of Digha : a case study

Digha is located in the southern most part of West Bengal on the bank of Bay of Bengal. It is situated nearly mid-way along the relatively curved shoreline between the huge Ganga-Brahmaputra delta in the east and the joint Mahanadi-Brahmani-Boitaroni delta in the south west. From the geo-morphological point of view, Digha is located on the eastern fringe of the Subarnarekha basin along the south west shore line of West Bengal and on the north eastern border of Orissa.

Figure 2. Map of Digha

Impact of tourism

Digha is endowed with a nice natural flat beach and a relatively calm sea and a big fish landing station at Digha Mohna. It is well connected by rail and road to Kolkata. All these factors have played a positive role in attracting a large number of tourists throughout the year to Digha. In fact, around 35 lakhs tourists visited Digha in the FY 2012-13 alone. The ever increasing growth of tourism has resulted in a rampant growth of hotels and tourist lodges in the area. According to data published in the paper titled *'Coastal zone Management in India- An Overview'* by S Ramachandran, the percent increase of urbanization especially in the form of Hotels etc of Digha has been 1266% within a period of 10 years ie; 1988-1999. Visit of tourists on such a large scale has altered the beach characteristics considerably over the recent years. For example, the population of Olive Ridley turtles and Red Crabs that were regular visitors to Digha's coast in the past has diminished appreciably. While their absence has made the beaches less attractive, it also points to the underlying truth of ecosystem imbalance and deterioration.

Beach modification and its impacts

From a morphodynamic viewpoint, Digha's beach is erosional with a dissipative nature. Natural forces like tides with average amplitude of 4m, periodic cyclonic storms with wave height of around 7m accelerate the process. Behind the beach there are undulating sand dunes covered with halophytic vegetation. The dunes supply sand to the beach whereas the vegetation buffer protects the inland from storm surges. The rip currents and longshore currents along with the winds play a significant role in balancing the sand budget between the sand dunes and the inter-tidal zone. Unfortunately the exponential rise in construction of hotels by cutting the sand dunes has destabilized the sand supply of the beach. According to Annon (2005)[3], more than fifty five species of mangroves and eight species of phytoplankton have been recorded in this ecosystem. It is no wonder that sand binders like *Ipomea, Pandanus* and *Spinifex* and other native species like *Pandanus fascicularis, Cyperus* etc. which used to form the vegetation cover, are on their way to extinction. In addition, the construction of 5km long concrete sea wall and embankments has failed to check the erosion. Rather these structures increase the erosive strengths of waves causing beach lowering. Studies show that the average beach lowering in front of concrete wall is around 6.3 cm/year. The adjoining areas of Digha, which are not protected by sea wall experienced dune migration. Reports show that between 1877 and 1965, the beach front dune complex retreated landward by about 970 m at the rate of 11m per year due to frequent marine transgression (Bhandari and Das, 1988). Interestingly the rate of retreat has been 17.5 m per year between 1965 and 1995 after the construction of sea wall. (Paul 2002, A.K.Bhatttacharya et al, 2003)

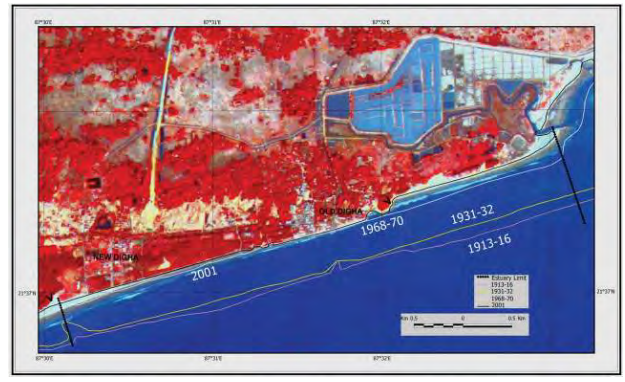

Figure 3. Evidence of coastline retreat of Digha from 1913 to 2001 (satellite imagery)

Studies have confirmed that while the total length of coast of West Bengal is around 200kms, erosion is occurring on a large stretch of 180 km of the beach (Joshi, 1995). In addition to Beach destruction, the increase in groundwater extraction by unscrupulous pumping has lead to greater sea water intrusion in the mainland leading to contamination of ground water making it saline. This was confirmed by measuring the chloride/bicarbonate ratio. According to S. Basack, A.K.Bhattacharya, & P. Maity, 2012, the specific conductivity concentration of water sample of Digha

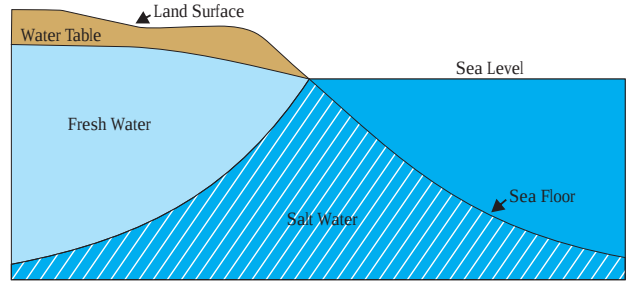

Figure 4. Salt water intrusion in freshwater (schematic illustration)

along the sea shore line is as high as 26000 micromhos/cm. It has been found that the nearby Contai town with its surrounding rural areas of 45 square miles has become a saline zone (Dr. A. K. Bhattacharya & Dr. S. Basack, 2012). This is making the groundwater unfit for drinking and other uses like irrigation.

Dumping of waste and impact on native Flora and Fauna

At present there are around 450 hotels in Digha catering to around 35 lakh tourists annually, which leads to a huge amount of waste of all kinds. Sadly there is no proper waste management system in place. As a result, all forms of waste are directly dumped into the sea without any treatment. In addition, lack of proper awareness has resulted in littering of coast with non biodegradable wastes like plastics etc. All these activities have polluted the coast as well as the sea water. As a result the native flora and fauna is getting adversely affected.

Fishing Industry

India is the 7th largest fishing nation in the world. Marine fish products contribute about 50% to the total fish production. An estimation of depth-wise potential of coastal fishery shows that about 58% of the resources are available in 0-50m depth, 35% in 50-200m depth and 7% in depths beyond 200m. (Source: Ministry of Agriculture, 2000).

Surprisingly there has been a steady decrease in the catch per unit effort (CPUE) of mechanized boat in the last five years in Digha Mohna. It was 3.26 tons per boat in 2000-01 which has gone down to 2.69 tons per boat in 2003-04. These figures are pointing to the non sustainability of fishing in this part of coast in near future. This is a real cause of concern for the future of fishing community in Digha (Source: Integrated Coastal Zone Management Project, Fisheries, Dept. of Environment, Govt. of West Bengal; http://www.iczmpwb.org/main/fisheries.php).

Most marine fishes are found within the depth of 200m and are dependent on the abundance of phytoplanktons, free floating microscopic organisms which form the base of several aquatic food webs in the ocean. These microscopic marine plants need sunlight to live and grow. But offloading of sediments from rivers into the sea is increasing the turbidity level of marine water thereby affecting the availability of sunlight for the phytoplanktons to survive. The major rivers of the Bay of Bengal drain 200 km^3 of water and 12.0 x 10^9 tons of silt during the monsoon season. Sediment deposition of this proportion increases the turbidity of water considerably. As a result, sunlight cannot penetrate to greater depths and hence reduce the phytoplankton population. This ultimately results in the decrease in fish production. Studies show that indiscriminate deforestation, construction, industrialization along the rivers is destabilizing the river banks which are increasing the level of siltation.

Overfishing to meet the ever increasing demand is also altering the overall balance of the marine ecosystem. According to Digha's local fishermen, there has been a severe decrease in the catch of *Hilsa* in this area. Moreover there has been a marked change of fish population diversity from multi species to single species with predominance of marine catfish at Digha.

The shells of the mollusks which usually dominate any beach are not seen in this area. The reason behind their disappearance is their rampant harvesting for use in poultry industry as feed. To study various anthropogenic impacts on Digha, regular studies are being conducted by different organizations. In general it has been found that there has been an appreciable decline in biodiversity richness because of several anthropogenic factors like using different types of nets which is causing death by entanglement of large fauna like turtles in fishing nets and by ingestion of marine debris etc. In addition, coastal constructions like sea walls, jetties and hotels, increase in beach littering, clearing of stabilizing vegetation of the dunes, sand compaction due to driving of vehicles on beach, beach erosion, environmental contaminants from sewage, agricultural runoffs, non biodegradable wastes etc. are causing a decline of native floral and faunal population.

Immediate steps need to be taken to save this fragile ecosystem from total destruction. This calls for a sustained awareness campaign among the local population as their cooperation is vital for carrying out restoration activities. With this in mind, Digha Science Centre, a unit of the National Council of Science Museums, has started working with the local students and teachers for creating awareness about the

seriousness of the issue and prompting corrective actions by the stakeholders. The Science Centre has launched a field study cum awareness campaign which involves field trips, sample collection, analytical experimentation and discussion with experts for a scientific understanding of Digha's deteriorating marine ecosystem and for motivating them to work for a solution in the future.

Overview of the activities

Hands on science involve integration of instructional science education and activity-based learning through direct experience with nature. This programme is a form of active learning which involves students to make observations of nature and learn from the observations through critical analysis of gathered facts and figures.

During the last two years (2012-13 and 2013-14), Digha Science Centre organized four field trips and activity camps related to the practical study of marine biodiversity in and around Digha. A total of 214 students and 36 teachers from 33 schools participated in these programmes in 4 batches. These were essentially residential camps with the participants staying inside the science center campus for 3 days and performing a number of activities. While the daytime was used for field trips, associated activities and experimentations, the evenings were scheduled for discussions and interactions with the experts. Extensive field works were conducted in two locations, which were selected on the basis of the level of anthropogenic disturbance of the marine ecosystem in these locations. At every location, similar set of experiments were carried out at four distinct zones, as shown below. This helped comparison of collected data on real time basis.

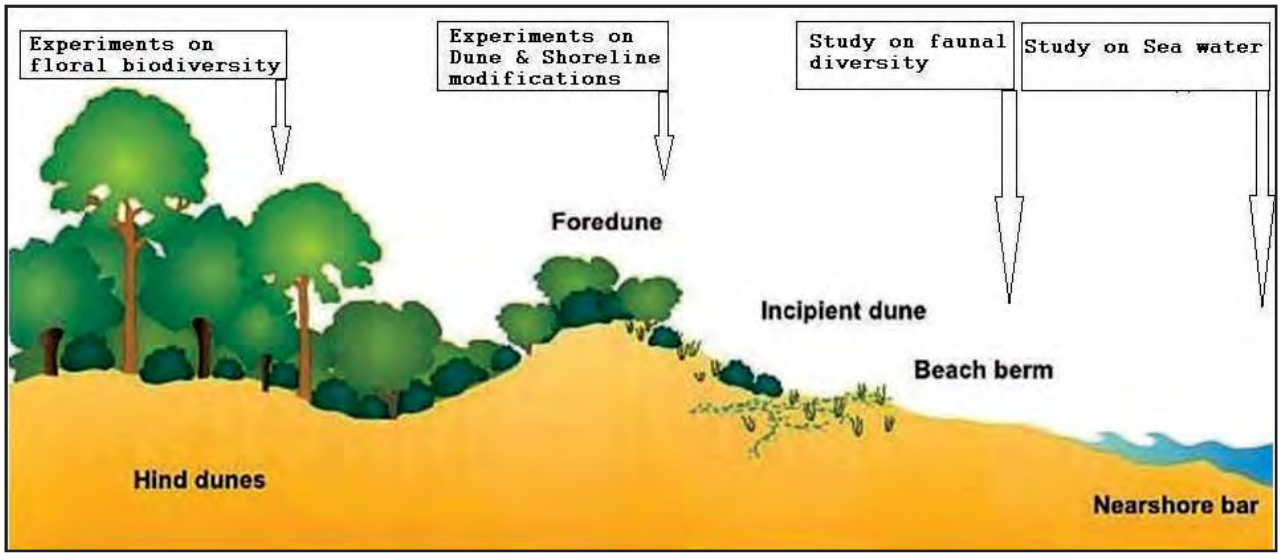

Figure 5. High anthropogenic disturbance (Site A)

Relatively Undisturbed (Site B)

Examples of hands-on experiments conducted

a) Determining the Species Biodiversity Importance Value Index (IVi)

This activity was done to assess the flora in the hind dune zone. The index gives an overall estimate of the influence of a plant species in a community. It helps to determine the degree of disturbance of an area by assessing the importance of the invasive species at a given site. Higher IVi for invasive species clearly points to the effect of anthropogenic factors like habitat fragmentation or alteration, change in nutrient status due to application of fertilizers, increase or decrease in humidity, introduction of new plants etc.

This index was calculated by determining the parameters like Abundance, Relative Frequency and Relative Density of the species in the site.

Procedure followed

To determine the above parameters, an area of approximately 500 m was selected in both the sites. Thereafter students were taken on a field trip to identify the major plants present there. This was followed by making Random Quadrates of 1m x 1m, and it is

Figure 6a. Floral identification

Figure 6b. Analyzing a Quadrate

evident from the above results that the site which is heavily disturbed is showing a decrease of IVi for the native species like Pandanus (Keya), Calotropis (Akanda) etc. On the other hand, a disturbing trend was noticed during the field trip where a relative dominance of invasive plants like Parthenium, Lantana camara etc are found. Such trends were not found in the undisturbed site where a relative dominance of halophytes was noticed.

Results :

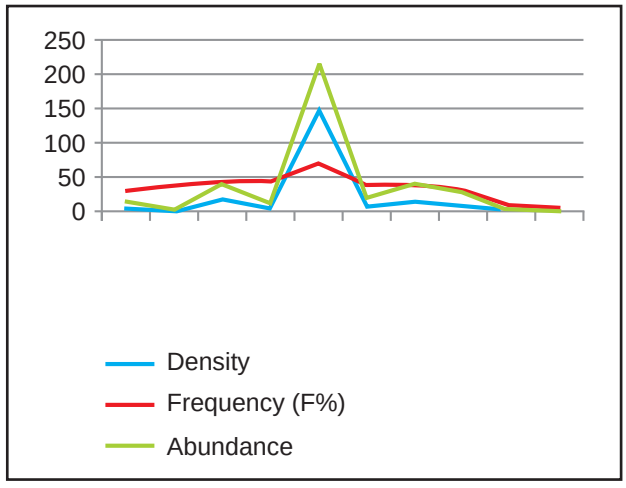

Figure 7a. Floral distribution in less disturbed site

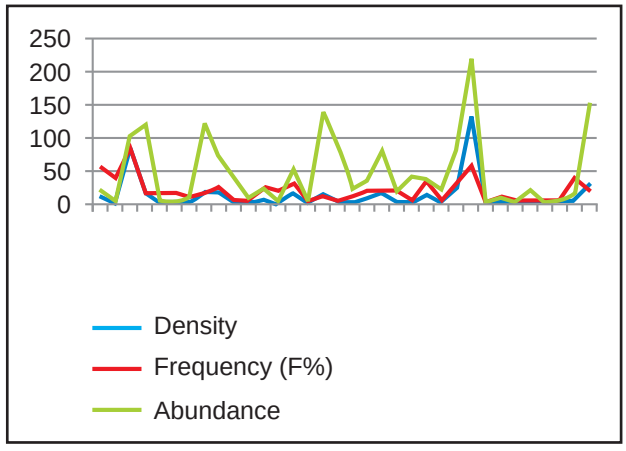

Figure 7b. Floral distribution in heavily disturbed site

Figure 8a. Studying sand dune vegetation

Figure 8b. Floral identification session

b) Determining the habitat distribution of crabs

According to a study (S. Ravichandran et al 2001) on the mangrove swamp of Pichavaram, around 23 species of crabs were found. Similarly the campers observed different species of crabs on the shore of Digha and adjoining areas too. The important ones among them are *Dotilla, Metaplex, Uca, Ocypode* etc. Scientists opine that crabs play an important role in nutrient cycling of coastal ecosystem. As such there presence and richness is a good indicator of the health of a beach.

Burrows of crabs in the sands of seashores are a common experience. Interestingly the burrow openings are different for different species. Most of them were found to be surrounded by sand balls in different fashions. These balls were made by crabs after eating all the microscopic edible stuff present in it. The unique burrow architectures represent a complex system that houses many types of beneficial micro organisms. Some of these microbes are reported to play a beneficial role in nitrogen cycling.

Figure 9. Study of crab habitat by Quadrate Method

Figure 10. Field trip of teachers on shoreline engineering

The students were introduced to this macrofauna by studying the burrow distribution along the coast. This was done by making Random designed quadrates of 3ft x 3ft, from low tide level to the dune.

Employing the Quadrate Method, the different parameters that were studied are :

a) Distribution of different species of crab in relation to tide level
b) Distribution of different species of crab in relation to nutrient distribution on the shore
c) Effect of concrete embankment on crab community
d) Comparing species richness at contrasting sites
e) Comparing hole architecture of crabs at contrasting sites

Equipments /material used : Lux Meter, Vernier Caliper, Plaster of Paris

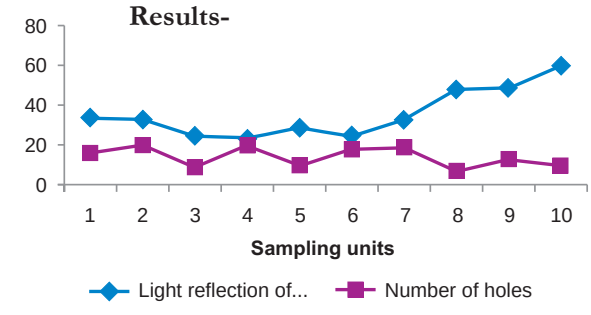

Figure 11. Distribution of crab hole vs. organic content as determined by light reflection

No of S.U	Big hole	Small hole
S.U - 1	0	4
S.U - 2	0	3
S.U - 3	0	5
S.U - 4	0	9
S.U - 5	0	6
S.U - 6	0	8
S.U - 7	0	18
S.U - 8	0	50
S.U - 9	0	52

Table : A

of S.U	Big hole	Small hole
S.U - 1	0	22
S.U - 2	0	31
S.U - 3	0	46
S.U - 4	0	249
S.U - 6	0	278
S.U - 7	0	191
S.U - 9	5	0
S.U - 9	2	120

Table : B

Figure 12. Distribution of crab hole in relation to presence of concrete embankments (Table A) and in absence of concrete embankments (Table B)

Based on the results obtained by conducting all these experiments, it could be concluded that different species of crabs inhabit different zones on the beach. But anthropogenic disturbances like sand compaction, presence of sea wall, destruction of sand dune etc. seem to adversely influence the richness of crab species as well as their burrow architecture and possibly their survival.

c) Assessing the health of the sea water

The health of the sea water is vital for the survival of the organisms living in it. As such when this water is exposed to various kinds of pollutants like untreated wastes, oil spills etc., it makes the condition inhospitable for marine organisms.

A number of tests were conducted to check the quality of seawater near Digha coast. In addition, salinity of this water was also tested so that the effect of fresh water from different rivers like Hooghly, Subarnarekha could be assessed.

Procedure

Water samples were collected from two sites; one from the mouth of the drain that dumps water directly into sea and the other where no such drains exist. Thereafter the following experiments were conducted. The results were tabulated by taking average of three observations from each experiment.

Determining the pH of the water sample

This experiment was done by two methods. At first pH strips were used and the results so obtained were rechecked using digital pH meter. Results showed that the pH of the waste water is slightly alkaline (pH 8) whereas that of sea water is almost neutral (pH 7.1). The alkalinity of the sample indicates the probable presence of soaps and detergent in it.

Determining the salinity of the water sample

The salinity of the sample was tested using Refractometer and Digital salinometer. Interestingly the sample showed much lesser salinity (18-20 parts per thousand) as compared to the standard (36 parts per thousand). This deviation could be attributed to the mixing of fresh water from rivers in this area.

Measuring the Dissolved Oxygen content

Dissolved Oxygen (DO) in water gives an indication of the overall health of the water sample as this oxygen is used by the organisms living in it. A low value indicates the phenomenon of pollution and Eutrophication.

It was seen that while the DO of the sea water is 8-9mg/l, it is almost 6 mg/l for the wastewater sample.

Measuring the water temperature and ambient air temperature
Variation in water temperature at two sites with a constant air temperature can be interpreted as a good indicator of some inherent disturbance. If the temperature of one sample is appreciably high as compared to other, it may indicate some kind of exothermic reaction in the sample. In the samples studied, we have not found large variation.

Studying planktons
Planktons are microscopic organisms which forms the base of the food chain. Photosynthetic planktons or phytoplankton harvest solar energy and supply the same to the higher trophic levels. In general planktons support commercially important fishes and biogeochemical cycles like carbon cycle. Studies show that anthropogenic stress like nutrient offloading from rivers and agricultural run offs, influx of wastewater etc. During the camp, students collected and observed planktons from sea water, under the microscope. This was done to introduce them to the wonderful world of planktons and motivate them to take up serious studies on it in future.

Conclusion

The camp activities and the hands-on experiments were designed to cover important aspects of the local coastal ecosystem in different sites and the results from contrasting sites were tallied. From the results so obtained, it became evident to the camp participants that the coastal ecosystem of Digha is facing grave challenges due to heavy anthropogenic intervention. Steps to safeguard the ecosystem were also discussed and the steps like plantation of native species, proper management of wastewater before dumping into sea, rethinking on different kinds of shoreline engineering methods, restrictions on beach driving, protection of existing sand dunes etc. were suggested.

Participating students were surveyed through questionnaires before and after the camps to assess the impact of the camp activities on them. Results of the surveys showed an appreciable increase in their power of observation and interest level for basic science. It was observed that the field studies conducted by them in the camps inspired them for scientific research on these topics in the future. Moreover, a very positive feedback was also received from the teachers as well.

Based on these positive feedbacks from the teachers and the students, more of such camps are being planned for the future too.

Acknowledgement

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