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Salient features of West Bengal coastal ecosystem and effective management of environment

Abstract

The thickly populated coastal region of West Bengal has a unique combination of valuable mineral resources blanketed by mainly medium to fine grained sands, silts and clays and is the focal area for rapid development of societal structure. A number of multi mineral placer deposits existing in the Bakkhali, Sagar and Digha coastal belt of West Bengal are being used up rapidly. There is an urgent need for exploration of mineral resources in these areas. Economic heavy minerals in this coastal area include ilmenite, rutile, magnetite, leucoxene, zircon, monazite, sillimanite and garnet. All these resources are renewable and attention should be given to explore and exploit these deposits which are often available in large quantity. A tremendous resource crunch is inevitable due to constant exploitation of land based resources and thus there is an urgent need to look for resources in the coastal zone and offshore areas. Important processes are energy flows, sunlight, water flow, recycling, temperature, dissolved gas, presence of chemicals, availability of nutrients. The salinity, water condition and visual appearance of the basin is also important. Attention should be paid to develop indigenous technology for exploration and development. The cost effectiveness of tapping the resources should be kept in mind, Monitoring of environmental parameters viz. air, water, soil, noise, vibration, flora, fauna is essential. Analyses and preservation of biodiversity is necessary. The administrative area for management must be a coupled unit of coastal water basins and adjacent shorelines. The objectives of a Coastal Zone Management Programme for the state should be kept in mind to develop a national policy and legislation and ensure integrated approaches to assess and evaluate a sustainable development policy, some of the local and special management plans should be carefully developed. The impact of socioeconomic environment considering the financial, technological and features in decision making should improve the proper planning. Resource utilization, coastal planning and management are critical issues. The existing and projected impacts for future must help the government to enforce decisions based on environmental impact assessment and improve proper planning.

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Introduction

The West Bengal coast of India is characterized by the presence of largest tide dominated Ganges Delta with numerous channels, creeks and impressive digitate architecture supported by the extensive mangrove of the Sunderbans. The coastal tract is about 160 km long and there is a continuous interaction of the coastal processes mainly waves, tides, winds etc. The study area is extremely complex because of the geo morphological situation and huge amount of sediment is being discharged by the great Ganges- Brhamaputra river system, the major sediments of which are transported to the Deep sea by the Submarine canyon i.e. Swatch of No Ground. The present coast line is affected by the geological, tectonic factors, waves, currents tidal range and volume of water flow, wind speed and direction, effect of storm surges, sea level fluctuation etc. All these factors have played a significant role in modifying the coast line. Even extensive bioturbation has resulted in the erosion of certain coastal sectors. More than 60 % of the population lives in the coastal zone which attracted the people from the point of view of shelter, availability of food, transport facility, pollution free air etc. .Even then the coast line in the various sectors of West Bengal faces enormous hazards. The beach acts as the buffer zone between the land and the sea and is unstable as waves, currents, winds constantly shift the sands.

Objectives

3 most sensitive and vulnerable sectors of West Bengal was studied to identify the sedimentological, mineralogical, environmental, ichnological and planimetric changes of the beaches. The results will highlight the problems of societal concern like erosion and other related issues of Coastal Zone Management and implementation of coastal regulation. A correct understanding of the various issues will help the State for future planning and sustainable development of various industries that are vital to the state and community.

Important study areas

Broad Outline of work in the 3 sectors is given below:

a. **Digha-Shankarpur sector:** It is a famous tourist place and the area is very important for fishing activities. Emphasis has been given on coastal erosion, its prevention and protection. Mineral potential including laboratory studies has been highlighted.

b. **Sagar Island sector:** It is a well known pilgrimage and people are coming here from all corners to visit Kapil Munis Temple located here. Sediment distribution pattern, beach profiling, pollution studies, mineral investigation and change of shore line will give crucial information about the area.

c. **Bakkhali-Frasergung sector:** This is also a tourist spot and the port here supports mainly the fishing industry. Sedimentological, mineralogical and ichnologicl set up has been examined to give a clue to environmental problem.

The coast line in the present area is tricky and an attempt has been made to demarcate the Coastal Regulation Zone in these areas taking

into account various issues related to Coastal Zone Management. Based on the results a Coastal Zone Management Programme along the selected important sectors has been suggested.

Discussion

The Southern part of West Bengal with numerous channels in the area provided an ideal site for visualizing the mineralogical variability influenced by a number of rivers in the deltaic environment.

The surface sediment samples show that major part consists of fine to medium sand with some patches of clay, silt and sandy clay is found in the Western Channel of Hooghly River. In shallower part, patches of silty sand and sandy clay are also present. Bathymetric data revels contours exhibiting NNW-SSE trending ridges and valley pattern. Eastern and Western Channel, Muriganganga and Saptamukhi channel are clearly depictable. Pioneering work on the sediments and mineralogical aspects were carried out by Subba Rao,[1] Siddiquie[2] and Mallik[3] when not many basic facilities were available. The rate of sedimentation is 20-25cm or 90 to 95cm. Subsequently lot of information has been collected by Research vessels of NIO and GSI.

Off Digha admixtures of sand, silt and clay are present. The tidal value shows that sand shows dominance of terrigenous influx with little admixture of biogenic material. The detritals have been channelized through Subernarekha river. A landward progression of the sea is also very characteristic. East of Sagar Island sediment type is silt with tracts and pockets of sands and subordinate silty sand, sandy silt or clayey silt. Sedimentation rate in the channel is 10cm per year. Western Bank is accretional and eastern bank sand is erosional.

Sediments formed by formation of ripples, dunes, planes and antidunes, parallel and wavy lamination with current bedding can be seen in pit sections. Linguoid shaped current ripples; cross bedding and convolute lamination are also present.

Wet sieving of the samples was carried out to collect the silt fraction. The clay fraction was used for X-ray and DTA studies. The minerals identified are mainly quartz and carbonate. Dolomite is also present at times. Feldspar and amphibole are also present.

Important heavy minerals present, the assemblage and the source rock is given below Table 1:

Table 1 Important heavy minerals present , the assemblage and the source rock

Heavy mineral assem blage	Source
1) Apatite, biotite, hornblende, monazite Muscovite, rutile, tourmaline, zircon	Acid igneous rock
2) Garnet, topaz, tourmaline, monazite	Granite, pegmatite
3) Augite, diopside, hypersthenes, magnetite, olivine	Basic rock
4) Kyanite, sillimanite, staurolite, andalusite Epidote and zoisite	Metamorphic rock
5) Barite, rutile, tourmaline, zircon (rounded)	Reworked sediment

The presence of unaltered feldpers indicates that the sediments did not get enough time for decomposition to clay minerals. The study area represents the distal part of the prograded tide dominated delta where the sediments are brought and deposited in the prodeltaic area by suspension current.

Coastal plain of Digha

Considering the importance of Digha beach details of the geomorphic units are given below.

Beach face unit: Area lying between High water level and Low water level and is very wide all along the area.. The width varies from 75m in Premonsoon to 250m in Post monsoon period with a gentle seaward slope of around 1 Degree .Different types of primary sedimentary structure like complex ripple marks, swash and back wash structure trail marks created by gastropod and structures created by ocypod crab.

The width of the beach face becomes minimum near Old Digha which gradually increases both towards east and west.

Remobilised sand: Remobilised sands are located within the supratidal zone in between beach face unit and beach face dune. This zone is characterized by unoxidised to partly oxidized spreads of sand.

Beach face dune: The zone is created by a number of superposed dunes which are formed by dune complexes. The dune complex is represented by three sub parallel ridges separated by two inter dunal depressions.

Inter dunal mud flat zone: The mud flat zone occupies the area between the beach face dune complex and stabilized old dune complex. The area is essentially flat and relatively low lying.

Stabilised Old dunes; beyond the tidal flat zone stabilized series of old dunes occur in the landward side. These dunes are characterized by massive highly oxidized fine sand grains.

Based on satellite images and from the traces of earlier coast line and beach ridges a shift of coastline by nearly 13 km in the Digha-Shankarpur area has occurred which is an area of erosion. Profiling at Bakkhali-Frasergunj the beach is experiencing erosion as a whole except in small pockets where accretion takes place .Entire beach face is a zone of erosion.

Enmass block erosion is present in the central part. Lowering of beach face and coastal dune is continuously taking place with variable intensity in different seasons. In winter several sectors of the beach face deposition takes place which with the advent of summer becomes unnoticed due to severe erosion. In general, the total erosion in summer greatly exceeds the winter deposition. The heavy mineral wt% in Digha-Shankarpur area contains about 1-26% while some of the Bakkhali. Samples contain about 68-98%. The mineralogy of the heavies indicates mostly opaques, hornblende, garnet, kyanite, sillimanite, pyroxene, biotite, apatite, sphene, zircon, monazite, rutile etc. are present in different amounts. The mineralogy indicates a mixed igneous and metamorphic source. Chotonagpur granite gneiss, Rajmahal traps are contributing Khondalites of Eastern Ghats. Several sectors of the Digha-Shankarpur beach are facing severe erosion and

the different aspects have been dealt in a different paper.[4] Relict forest is a conspicuous feature of the beach in some places. The feature indicates effect of sea level changes which also plays an important role in sorting the heavy minerals. The following Table 2 shows " the environment and processes in the coast;

Table 2 The environment and processes in the coast

Terrain unit	Geomorphic unit	Process	Material	Age
Recent flood plain	Active flood plain	Fluviotidal	Grey clay,silt, Med to F.Sand	Present
Present day intertidal Flood (Fluviotidal mud/ Sandy flat)	Active coastal plain	Fluviotidal, marine	Greyish black mud	Present
			light gy.silt and	to Late
			sand (coarse to fine)	Holoc
Beach face	Active coastal plain	Marine	Light gy coarse to	Present
Complex			Fine sand,clay ball	Present
Beach face dune	Active coastal plain	Marine	Light gy coarse to fine-sand with ripples,lamination	Present
Older dune complex	Older coastal plain	Marine,Aeolin	Yell.Br,med to c.sand	Present
Ancient,interdunal	Ancient	Fluviotial, marine	Bl sticky clay with	Late
			Carbonaceous material	Mid
			and wood frg.	Holoc

SEM studies indicate a number of micro features formed during different stages of transportation and deposition. Impact features were produced due to physical activity in the near shore zone. Occassional contact with sea water caused chemical reaction resulting various etch features sometimes controlled by the properties of the grain. Perfect rounding of some grains indicates long transport history. The various micro features have been produced by different processes in different environment.

A process-response-environment-deposition model is very interesting

Important processes - Collision during Wave Action, Aqueous collision resulting grain fracture, mechanical impact, Wearing and removal of blocks, grinding, chemical action, dissolution, precipitation.

Responses are conchoidal fractures, grooves, pitting, irregular pits, upturned plates, etch marks, etch V s, furrows, comb structures, precipitation structure etc.

Depositional environments includes medium to high energy environment in littoral exerts.

Coastal processes

Waves and wave induced currents control the littoral transport, erosion and accretion pattern in the tract. A strong littoral drift along the shoreline exists in the northerly direction. Long shore current usually in the SW to NE flows. The horizontal nature of the beach and interfering nature of waves affects the coast badly causing erosion. Sediment movement in the beach is caused by long shore current and onshore offshore movement.

The coastal stretches of Digha in West Bengal mainly experiences action of sea waves. The wave dynamics and related parameters like wave height, wave period, wave approach angle have a direct bearing on the erosion/accretion regime. Intense and vigorous wave energy domains are erosional segments and zones of less intense energy comprise the accretion segment. A bewildering array of traces and biogenic structures are present in the area. The application potential of these studies have been illustrated in the book by the Author.[5] A number of burrow holes are present in area. The beach environment is clearly marked by crab burrow population of different types.

Long Y forms, moderate length, V forms and short L or J occur in good numbers. In Upper, Middle or Lower intertidal areas. Concentration of collapsed I type burrows are more in numbers in shelf and intertidal zones. Predominance of L and Y forms mixed with collapsed burrows may originate by storm events.

Polychate burrow Diopatra cuprea is useful to determine the rate of erosion and accretion. The nature of the exposed part and concealed part has to be noted carefully. The dwelling worm cannot modify the position and nature of the concealed part (CP) and exposed part (EP). In case of effective deposition EP is further extended and the CP gets gradually exposed under eroding condition. The burrows usually take about 2 years on average for the adults. Considering this, the erosion/accretion rate can be calculated. Bioerosion is an important activity in marine sediments. .Burrowing activity caused by crabs is a major cause of erosion of the beach. Crabs were observed as habitual burrowers in immense number all over the coastal profile. They produce complex network burrow system along backshore, foreshore and down below to destroy the beach easily. The relict hard mangrove surface is exposed in the intertidal zone. These surfaces provide resistance to beach erosion. Bioerosion of these hard grounds in Bakkhali and Frasergunj is notable. Extensive bio erosion caused by profuse crab burrowing is one of the major cause of coastal erosion in West Bengal.

The stretch of West Bengal around Digha and nearby area is known for its erosional nature. Most of the hotels are built in restricted CRZ without the coastal tract has been controlled by the complex action of the various operative processes like fluvial, deltaic, marine, aeolian etc. with great impact of biological activity. The structural measures like laying of boulders in Old Digha , construction of sea walls, laying laterite boulders, construction of brick walls of Fencing in Bakkhali

areas or laying of sand bags in several places have not been able to solve the problem. Also these structures have endangered the natural sediment drift which causes loss of equillibrium. The structures have prevented the major fishing activity and the asthetic beauty of the coast which is most important from tourism point development of the coast. Preventive measures for protection include seawalls, embankment riprap, groin, breakwater, beach nourishment etc. Netlon in Protection work, tree shield and construction of artificial dunes etc, can protect the coast. The coastal zone of West Bengal is inhabited by large number of coastal communities with different specialities like fishing, agriculture and crafts. There is not much education involving such people and sustainable development is possible only when the problems of these coastal communities are understood by taking correct programmes to uplift the economy of the coastal communities, as they are facing various kinds of pressure on the coastal zone like construction, increase of Population. Degradation of mangroves, extensive tourism, dumping hazardous wastes polluting the biodiversity. Also the industries in the coastal zones are coming up in so many dimensions that there may be a shortage of water resource and depletion of ground water level. Hence problem of ground water storage should be kept in mind.

The marine pollution in the coastal zone related to shipping is also important. The waste water disposal and solid waste disposal should be within tolerant limits. Protection of mangroves, planting should also form a part of management. It is expected this short write up will solve the much needed strategic problems faced by the West Bengal coast and suggestions stated earlier can be used for other coastal areas also.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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