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Characterization of Sediment Dynamics in the South-Eastern Shelf Zone of Bangladesh

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Abstract: ***The stable and deeper southeastern shelf zone of Bangladesh has a wide continental shelf including with the alongside tertiary hill, piedmont plain, intertidal plain, supratidal plain, fluviotidal plain, barrier island and channel which are always feeding the sea bed of our shelf with large sediment deposition. The primary objective of my study is to findout the sediment distribution onto the sea bed our southeastern shelf zone. Besides, I have tried to show the vertical and horizontal sedimentation based on the different sands and sizes. I have also tried to present space and depth relationship with the sediment dynamics onto the sea bed. The study was undertaken on the 27 poins os sample collection of five major places i.e. Sonadia, cox's Bazr, Inani, Teknaf(shah-parir deep) and St' Martyn. The sediment samples including water from deeper sites were collected by sediment grabber and water sampler and they were examined by the Hydrometer and Sieve techniques and filtration method for the Suspended solid determination. Vertically, the suspended solid were more at the bottom accept some i.e. Cox's Bazar were more at surface. By the study, it is clear that with onward movement towards sea the particles become more sorted and smaller resulting in more silt and clay whereas the near shore and land based samples show more sands in amount. The innermost points show coarse silt at more rates than other silt meaning these innermost points are mostly of sandy silt. The sedimentation rate is being accelerated due to different natural phenomena and human intervention.***

Keywords: Sedimentation, Continental Shelf, Sediment Dynamics, Sediment Characteristics

1. Introduction

Bangladesh lies at the mouth of two of the largest rivers in the world, the Ganges and Brahmaputra, draining from the Himalayan massif. Most of the country is part of the Bengal Basin, one of the most extensive geosynclines in the world. It has a large, and rapidly growing population (142.3 million in 2011 (BBS 2011) and forecast to be 169 million by 2021 (UNFPA 2011)), much of which is exposed to extensive flooding as the rivers overtop their banks during the monsoon season. Most of the population live on the low-lying floodplains or delta plains; more than 129 million people are considered to be living on the Holocene delta plain of the Ganges-Brahmaputra Rivers, including a proportion that is West Bengal in India (Woodroffe et al. 2006). As a consequence, Bangladesh is considered one of the most vulnerable countries in the world to the impacts of climate change, particularly sealevel rise and storm-surge intensification (Warrick and Ahmad 1996, Cruz et al. 2007, Nicholls et al. 2007; Sarwar and Khan 2007, Karim and Mimura 2008)

We all kinds of animal kingdom are directly or indirectly are nourished by the one directional grace of soil cover. All of the living or non-living, biotic or abiotic compounds are based on the mixture of different minerals weathered from the earth origin materials which is referred as soil cover. For the host characteristics of all materials of the earth system, it is called the mother of the earth. Every day a vast amount of sediment are adding on the earth surface through the weathering due to the climatic and anthropogenic influence. On the other hand, similarly a great number of sediment are settling and subducting into the different trenches containing in the different seas and oceans of the world. One way, this flowing, settling and accretion play a blessing role by the creation of new lands in the infinitive areas of the aquatic bodies especially in the oceans. Moreover, it is the main cause of the water body siltation, sedimentation and finally filling of the water beds resulting in the water entering and inundating into the terrestrial lands causing heavy damages and sufferings.

Large volume of continental sediments are being discharged by Ganges and Brahmaputra Rivers into the Bay of Bengal and the finer sediment particles reach even 7° S latitude. The Bay of Bengal is a region where thick pile of sediments covers the entire basement and renders the ocean floor bathymetry virtually featureless. The sediment cover is exceptionally thick (about 21 km) at the apex of the Bengal fan in the Bangladesh offshore region and decreases gradually to about 8 to ‹ 2 km in the central and southern parts (Curray 1991). In the distal reaches of the fan at 7° S, the sediments are a few hundred meters thick

About 1.8 to 2.4 billion tons of sediment is currently being carried by the Ganges- Brahmaputra-Meghna river system each year. (Jabbar, 1979). At present there are many research works in the context of sediment origin, transportation and dynamics to find out their impacts on the earth surface and to identify the age and evolutionary records of the terrestrial and aquatic bodies. The Quarternary geomorphic evolution of the Bengal basin was first described by Morgan and Mclntire in 1959. In this study, it was tried to find out the spatial distribution of the sediment in the shelf zone.

1.1 Objective of the Study

In the modern industrialized era, the over exploiting and stressed environment and its outcome changing climate is

ultimately changing the real nature of the sediment transportation and deposition. Through the view of different literature it is clear to all that Cox's Bazar-Teknaf-Bodarmukam section of Bangladesh coast appears to be one of the most active coasts. The coastal geometry of this region has been changing with time. Successive sea level changes along with strong exogenetic forces like wind, ocean current, wave, tide etc. have been playing dominant role for these changes. Besides natural forces, the anthropogenic activities are also enhancing the changing process of the area. The changing process is rapid. It is estimated that the Cox's Bazar-Badarmokam coast has lost about 289.21 hectares of land from 1972 to 2010 at a rate of about 7.61 hectares/year. Due to different climatic and anthropogenic causes, the Teknaf coast and ST Martyn's Island are being introduced with irregular and environmental unfriendly behavior resulting in ecological imbalances within aquatic and terrestrial environment. The main objective of this study is

1) Identification of spatial variation of distribution of ocean sediment
2) Characterization of the sedimentation comparing to the vertical movement and tidal effect.

1.2 Background

The coastal geomorphology of Bangladesh is characterized by its funnel shaped, vast network of rivers, strong tidal and wind action and enormous river discharge laden with bed, and suspended sediments. According to Pramanik(1983), the coastal belt of Bangladesh can be described as the following three distinct regions i.e. the Eastern Region, The Central Region and The western Region.

The eastern region comprises a narrow strip of plainland between the Chittagong Hills and The Sea, together with the flood plains of the Halda, the Karnafully and Sangu rivers. The coast is regular, unbroken and not very susceptible to erosion and is protected along the sea by mudflats and submerged sands. Important geomorphic landforms are sandy beaches, coastal dunes and mud flats. A continuous strip of sand has formed a long sand beach, one of the tourist attractions of the country, the Cox's Bazar beach. (Mahmud, et. al., 2011)

A set of connections or rivers originated from the Himalayas flow over the country that carries the sediment. The coastal belt of Bangladesh exhibits 3 distinct parts among which the wave dominating eastern region, i.e. Chittagong-Cox's Bazar region is more stable. Coastal part of this region signifies the importance of geology in its development process and it is vulnerable for various hazards. The drainage pattern, their distribution, landform features and their position in tidal flat areas make the area a complex geomorphic region. Cox's Bazar-Teknaf coast is more or less remained unchangeable during 1972-2010. Only the southern most tip of this coast experienced severe erosion. (Mahmud, et.al., 2011)

The unconsolidated materials, derived from various sources and deposited at the ocean floors are called marine sediments, which include weathered and eroded particles of rocks, fragments of dirt, dust, volcanic ashes, remains of marine organisms, fragments of meteorites etc. (Singh, 2008)

The unconsolidated marine sediments are lithified due to tectonic activities and thus we find layered consolidated materials on the deep ocean floors. Such consolidated marine sediments are called ocean deposits. (Singh, 2008)

Sing (2008) described about the factors of sediment as follow as below. The process of sedimentation i.e. deposition of marine sediments on ocean beds are affected and controlled by the 3 factors:

1) Quantity (density) of marine sediments
2) Size and Shape of particles
3) Energy condition of currents at the site of deposition

As stated earlier, the rivers are the major transporting agents of marine sediments. The continental rocks are eroded by surface runoff and rivers and the eroded materials are brought to the oceans by these rivers. These sediments are picked up by a sea waves and currents and are deposited on sea floor under varying conditions. It may be mentioned that terrigenous eroded sediments (of continental origin) are reworked and dispersed by sea waves and currents before they are finally deposited on sea floor. The rate of sedimentation depends on the rate of erosion of continental rocks such as slow or rapid rate of erosion.

i. Slow rate of erosion → Slow rate of sedimentation→ Well sorted sediments e.g. coarse Sands, fine sands, silt, mud etc.

ii. Rapid rate erosion → rapid rate of sedimentation→ poorly sorted sediments e.g. mixed Sediments such as gravels mixed with sands or mud mixed with sands

Sing (2008) also presented the mode of marine sedimentation in the following two issues.The processes of marine sedimentation may be grouped into the following two categories

i. Bulk Deposition (bulk emplacement)
ii. Retail Deposition

The process of **bulk deposition** of marine sediments, geologically better known as bulk emplacement, involves the slumping of sediment mass including all types of terrigenous and biogenic sediments down the undersea slope under the force of gravity. The rivers unload huge amount of terrigenous sediments of varying sizes in the waters of continental margins and inner continental shelves. The **retail sedimentation** involves deposition of sediments particle by particle in the same way as flakes of snow fall down on the land one by one. This is the reason that fall down of particles one by one on sea floor is called marine snowfall.

1.3 Problems associated sediment

With the extreme weather and changing climate, all of the natural events are occurring untimely with more or less

frequency as well as longer duration accelerating their subsequent natural specially earth phenomena. For instance the untimely, heavy and longer duration rain causes flash flood, land slide, river bank erosion, and extreme run-off giving ultimate result of more sedimentation to the lower stream finally to the ocean bed. These sediments are responsible for different physic-chemical impact on aquatic and terrestrial environment affecting and alternating the living style of the living and non-living organisms of that environment which result in the ecological imbalance and degradation of the ecosystem. The problems of changing sedimentation can be described on the following two issues given below

Bedload –Channel morphology changes (widening, filling, incision), Physical habitat issues
Suspended –light issues, burial, drinking water intakes, sedimentation, contaminants.

2. Methods and Techniques

2.1 General Context

The area comprises of coastal plains and coastal islands with hills. The area has been grouped into - a) Tertiary Hill, b) Piedmont plain, c) Intertidal plain, d) Supratidal plain, e) Fluvio-tidal plain f) Barrier island and g) Channel. Due to its geographic and complex tectonic positions along with active processes, most of the areas frequently suffer from cyclone, earthquake, landslides, slope failure and slumps, floods, erosion, salt water intrusion and water logging creating more and frequent sedimentation onto the river and giving ultimate sedimentation upto the deep sea . The study could be undertaken with the following three analysis of the field samples and data. i) Litho-stratigraphic and ii) Chrono-stratigraphic. Perhaps due to unavailability of opportunity of Carbon and other mineral dating, the lithostratigraphic techniques was applied to accomplish the expected objective. For the above expected two analysis, some sediment and water were collected from the both on-shore and off-shore of the Sonadia, Cox's Bazar, Inani, Teknaf and St Martyn's Island by the grabber and water sampler. The required tide related secondary data was collected from Bangladesh Navy. The sediments and water sample were kept under the laboratory analysis for the investigation of textual nature (e.g. sand, silt and clay), grain-size and their roughness, of a sediment layer, depth, altitude, total suspended solids, PH, DO, and BOD.

2.2 Required Materials

For the collection of samples, access of the locations, recording the onsite data, preservation, carrying, processing, analysis and presentation of the study result, some hardware and software related instruments and techniques were used to manipulate the study. Some major and mandatory devices were as follow as: sediment Grabber, water sampler, Boat for transportations, Electronic weight machines, Hydrometer, Hydrogen per-oxide, Sodium Hexa-mono-phosphate, Oven, Electronic stirrer, Seive Pans, Sieve Shaker, funnel, Beaker and so on. In the context of analysis, the computer manipulation with the Microsoft-Exel 2007 was used to make graph and charts and finally to make it suitable for presentation.

2.3 Methods

The sediments were collected from 27 sites of five places of the study areas with the direct use of grabber for 21 sites of the inside the sea water and rest of the 6 site's sediment were taken manually. Besides, water samples were collected at different depth of a fixed point of study areas from those sites which were inside the sea with the use of water sampler. For the determination of particle sizes, the sediment were analysed with two methods: one was sieving techniques and another was of hydrometer analysis. The sediments those which were of land based and near shore origin were analysed with sieve method and the rest of them taken from deep sea were manipulated with the hydrometer analysis so that the silts and clay could be identified exactly and clearly. The water taken from different depth and different points were undergone for the determination of total suspended solids by the filtration methods directly using the filter paper. For the determination of PH, DO and BOD, the required values of the desired parameters were measured at the onsite spots of sample collection using the DO and PH meters through the instant water samples from different sites using the water sampler.

2.4 Data Analysis

The primary data regarding sediment samples processed with sieve and hydrometer methods were analysed with direct use of Microsoft Exel 2007 to make and present different numerical comparative information about the spatial distribution of the particles with the use of charts and table. The particle sizes were calculated by the Wentworth ranges of diameter. Similary, the TSS value of the water sample were also analysed by the charts and table presentation with the application of Microsoft-Exel 2007. The secondary data from Bangladesh navy, Google Earth, Banglapedia etc were also processed, compared and presented by the word 2007 and Excel 2007 of Microsoft Corporation. Here in this study, different areas have been shown in the context of their horizontal and vertical distributional changes of sediments onto that's terrestrial lands and sea beds including their nature of movement, causes of distributional changes, and origin of their sediment particles. Besides, the dynamical changes due to spatial changes of tidal ranges and the anthropogenic interventions have been analyzed and graphically presented for different sites of study areas.

3. Sediment Dynamics in the Shelf Zone

3.1. Introduction

Sediment distribution varies place to place on the basis of the their particle's sizes, texture of the particles, current and tidal ranges of that places, nature and composition of the nearest main land's from which it moves and settles down onto the

seabed. In this chapter, the distribution of the sediments in the southeastern shelf zone has been presented considering with their spatial variations, tidal changes, lands types and human intervention. First one table of geographical location of the sample sites has been attached here including their highest depth.

Table 3.1: Location Information

Station no.	Location	Latitude	Longitude	Depth (m)
1	St' Martyn-1	20°45'24.68"N	92°19'34.85"E	0.00
2	St' Martyn-2	20°45'21.78"N	92°19'33.63"E	0.00
3	St' Martyn-3	20°45'0.73"N	92°19'20.79"E	8.9
4	St' Martyn-4	20°44'13.50"N	92°19'19.47"E	11.2
5	St' Martyn-5	20°41'14.87"N	92°19'35.29"E	16.00
6	St' Martyn-6	20°40'2.90"N	92°19'55.88"E	12.80
7	St' Martyn-7	20°39'12.12"N	92°19'58.49"E	8.20
8	St' Martyn-8	20°38'22.09"N	92°19'49.85"E	6.40
9	St' Martyn-9	20°37'32.50"N	92°21'30.78"E	8.00
10	St' Martyn-10	20°37'31.95"N	92°20'54.08"E	9.1
11	St' Martyn-11	20°37'6.40"N	92°20'47.56"E	10.00
12	St' Martyn-12	20°37'21.09"N	92°19'38.94"E	0.00
13	St' Martyn-13	20°37'37.94"N	92°18'47.04"E	0.00
14	St' Martyn-14	20°37'36.48"N	92°18'33.40"E	7.00
15	St' Martyn-15	20°37'35.54"N	92°18'23.48"E	7.80
16	St' Martyn-16	20°36'19.09"N	92°19'49.69"E	0.00
17	St' Martyn-17	20°36'10.82"N	92°19'50.47"E	0.00
18	Cox's bazaar-1	21°24'11.04"N	91°59'24.35"E	0.00
19	Cox's bazaar-2	21°24'11.23"N	91°59'24.36"E	4.60
20	Cox's bazaar-3	21°24'11.63"N	91°59'18.15"E	8.30
21	Cox's bazaar-4	21°24'11.62"N	91°59'05.64"E	16.70
22	Cox's bazaar-5	21°24'06.67"N	91°58'42.51"E	24.10
23	Inani-1	21°13'35.41"N	92°02'40.72"E	0.00
24	Inani-2	21°13'35.64"N	92°02'33.06"E	5.80
25	Inani-3	21°13'33.24"N	92°02'19.17"E	9.60
26	Sonadia-1	21°32'39.90"N	91°50'46.02"E	7.2
27	Sonadia-2	21°33'29.51"N	91°50'25.23"E	52.1

3.2 Spatial Change of Sediment Distribution

Here the spatial variations of the distribution of the sand's particle in case of their sizes have been shown for the all sites and areas.

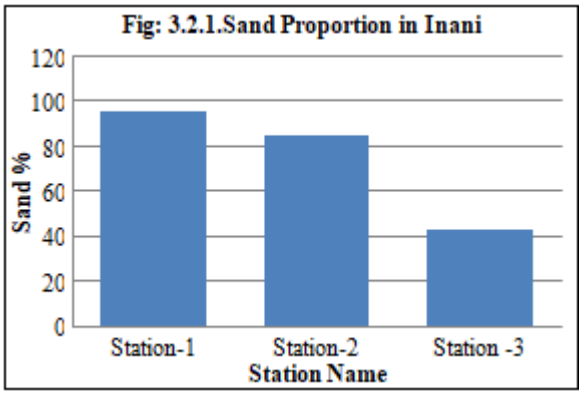

Figure: Sand proportion in Inani

Description: From the above chart presentation, it shows that with the increase of spatial distance among the three stations the sand percentages are decreasing. If we look into the locational table given above, we get the first station in the land surface, the second one is in the 5.80 meters and the last third one was in the 9.60 meters. Besides, from the map of the Inani, we also get the stations are at some gaps of distance. From the above consideration can be opined that the sand is decreasing with increasing of depth and distance because although the finer sediment can move more distance, the heavier are settled down sooner near the shore because of their relative weight.

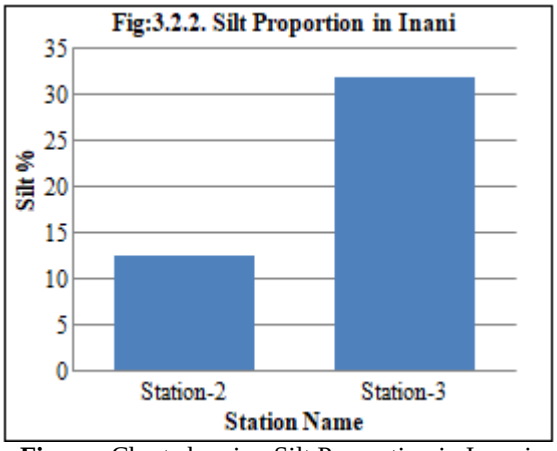

Figure: Chart showing Silt Proportion in Inanai

Description: From the above fig, we get the silt percentages is high in the station 3 than station two. With the increasing of distance and depth the sand sizes are becoming smaller to total amount. Here, from the three sites of Inani, Station 2 and 3 meaning the master station 24 and 25 have been shown.

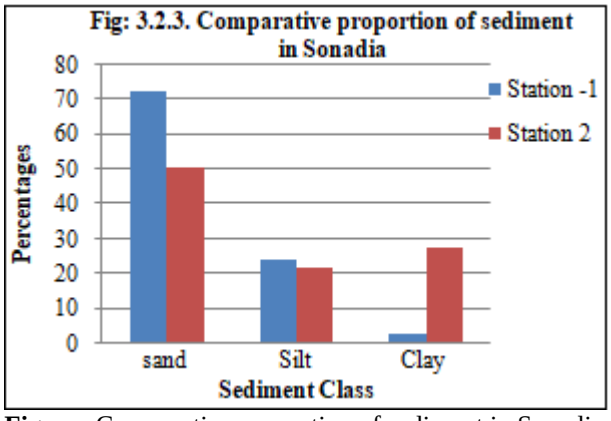

Figure: Comparative proportion of sediment in Sonadia

Description: The chart given above presents the sand, silt and clay status in percentages of the location of Sonadia. Here, the station one was near to the newly accreted island like small high land near the Sonadia island containing the depth about 7.2 meters. The other station about 1500 meters away from station one and depth was about 52.1. From the figure, we can conclude that the place Sonadia is also showing the spatial differences for the distribution of sediments of different classes. With the gradual increasing of distances and depth the particles are becoming smaller and more in clay and silt in

percentages. Subsequently, the chart shows the gradual decreasing of the sand proportion towards the deep sea.

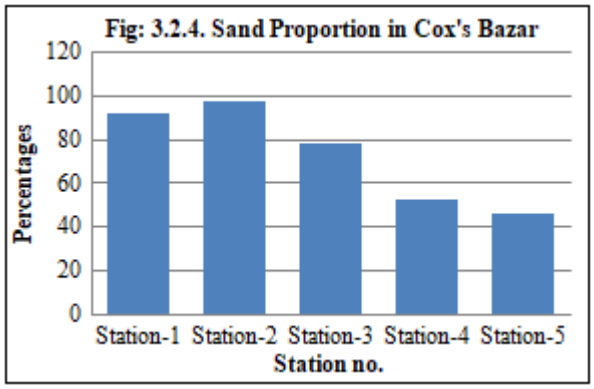

Figure: Chart showing the sand percentages in Cox's Bazar

Description: From the above figure, it is clearly visible that changes of space and depth are the reason of changes of distribution of sand like particles on the ocean bed. We get the amount of sand at percentage are decreasing following the further ongoing movement of the sediment through the ocean bed.

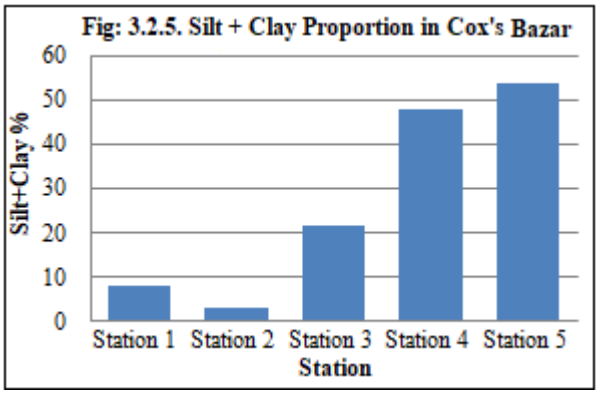

Figure: Chart showing the cumulative percentages of Silt + Clay

Description: From the above figure, we get the successive increase of the content of the silt+ clay on the bed of the Cox's Bazar shelf though there is one break for the station 2. As the station 1 and 2 were near to the shore where the current, wave and tides are high, this difference is for the collection of the sample during low tide and similarly collection of sample 1 during high tide.

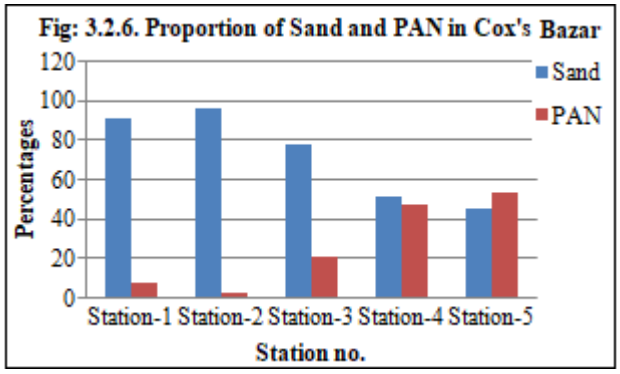

Figure: Chart showing the proportion of sand and Pan

Description: If look through the chart of above, we get the successive increase of pan particles and decrease of sand particles in Cox's Bazar for the 4 sites. The site 1 shows the opposite relation because of the timing of the sample collection which discussed in the former chart of Cox's Bazr.

Table 3.2.1: Comparative status of sand, silt and clay in Sonadia, Cox's Bazaar and Inani

Station name	Sand (%)	Silt (%)	Clay (%)
Sonadia-1	72.69	24.28	3.03
Sonadia-2	35.02	37.19	27.79
Cox's Bazar-4	51.86	41.71	6.43
Cox's Bazar-5	45.93	44.02	10.05
Inani-2	85.00	12.5	2.50
Inani-3	42.87	31.74	25.39

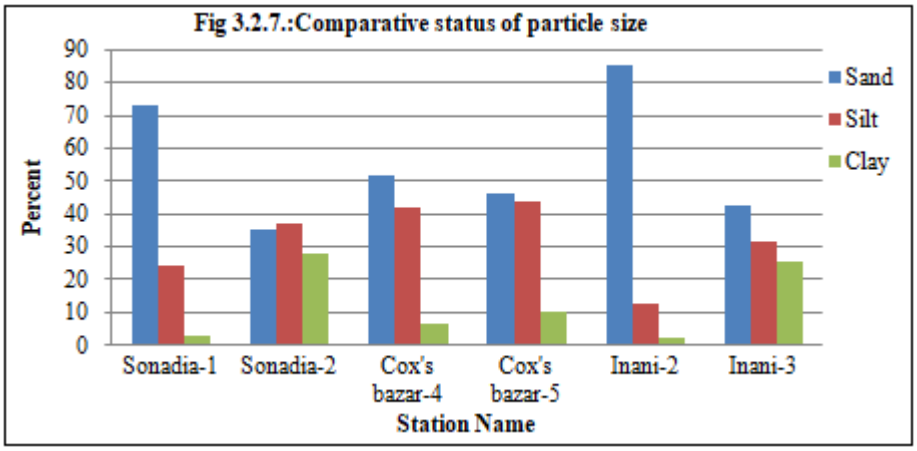

Figure: Chart showing the comparison about particle sizes in different location

Description: From the above chart, we get the highest sand Inani 2 station because it was on the near shore and this zone is mostly of sand composition. Another way Inani shows lower slope than another sites that's why the relative depth of

the Inani's points are low and the sands are more than silt and clay. The clay content is high in the sites of Sonadia-2 and Inani- 3 consecutively 27.79 and 25.39 percent. From the locational table, we got the Sonadia-2 was of depth of 52.1meters and Cox's Bazar was with the 24.10 meters and they were of more distance from the shore, these are the main reason of showing high clay and silt than sands in these two sites.

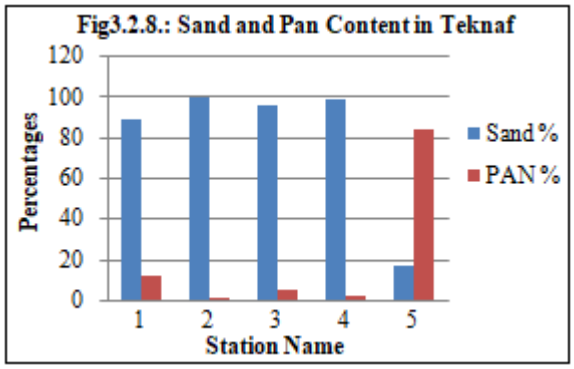

Figure: Chart showing sand and pan in Teknaf

Description: The above chart is showing that the sites near the shore are with more sand content than the deep one station 5 which depth was about 16 meters. The sites 1 and 2 were at the land based that's why they are showing more sand and the sites 3 and 4 were also on the beach, so they are also of sandy. The site no. 5 was about 1500 meters far from the Shah- Parir deep and showing the more clay content than others.

Analysis of St' Martyn:

Table 3.2.2: Sand & PAN content in St' Martyn

Stationno	Sand %	Pan %
6	26.69	73.31
7	80.84	19.16
8	95.59	4.41
9	26.37	73.63
10	41.72	58.28
11	49.31	50.69
12	99.23	0.77
13	98.45	1.55
14	65.55	34.45
15	97.22	2.78
16	92.59	7.41
17	99.03	0.97

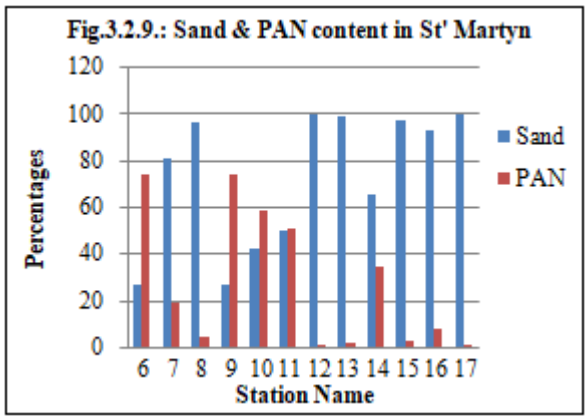

Figure: Chart showing the sand and pan content in St' Martyn

Description: The above figure is showing the sites which were in the inside the sea near to deep sea are of high content for pan whereas the sand content are high at the land based sites and on and near the beaches. The sites 6, 7, 9, 10 and 14 were on the far distance from the shore and were within about 10 to 20 meters depth that's why they are showing more amount pan content than sand comparing to the other near shore and land sites.

Analysis of teknaf and St' Martyn

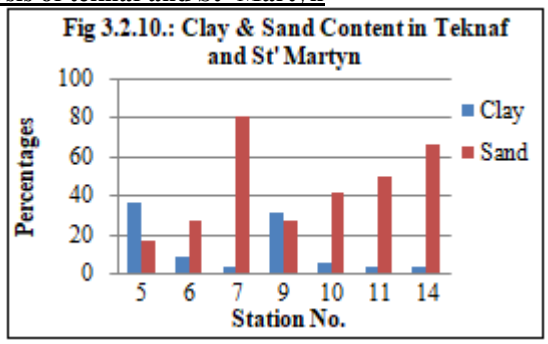

Figure: Chart showing clay and sand in Teknaf and St' Martyn

Description: From the above figure, the site is only from Teknaf and the others are from St' Martyn. These sites were of far distance from the shore. The sites 5 and 9 were on the more distant and they are showing more clay successively about 35% and 31%. The others were of less distant, so they are more sandy composition.

Analysis of all places combined

In this section, all of the sites similar with depth and distances have been discussed to show their similarities and differences with some charts below.

Table 3.2.3: Clay, silt and sand proportion in the innermost points

Station Name	Clay	Silt	Sand
5	35.76	47.69	16.55
6	8.27	65.04	26.69
9	31	42.63	26.37
22	10.05	44.02	45.93
25	25.39	31.74	42.87
27	27.79	37.19	35.02

For the above table, a chart with bar diagram has been shown below

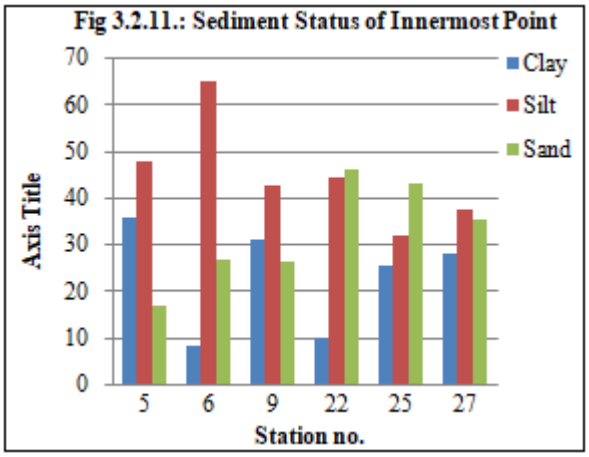

Figure: Chart showing the comparison of innermost points

Description: we get rather similarities among the three percentages of the sand, silt and clay from the above chart. The highest similarities are on the points 27 where the three vertical lines expressing sand, silt and clay amount whose stand for the successively about 35, 37 and 28 percentages. It is clear that with the increase of depth and space distant from the shore the particles become more round and smaller than the near shore. The above chart also expresses all of the innermost points are with three particles in a considerable amount instead of containing one particular size particles.

Status of sand classes at near shore points

Table 3.2.4: Status of Sand Classes

Station Name	M. Sand	F. Sand	V.F. Sand
1	17.05	35.25	31.91
2	3.4	74.06	21.44
3	17.52	59.69	14.75
4	14.65	61.11	20.34
8	11.74	29.37	49.63
12	23.11	52.76	19.37
13	8.95	19.45	9.29
15	3.12	49.81	49.05
16	0.86	2.13	4.03
17	2.42	72.22	24.13
18	35.24	40.77	11.37
19	37.61	50.51	7.6
20	16.52	33.07	27.21
23	11.23	63.95	18.57

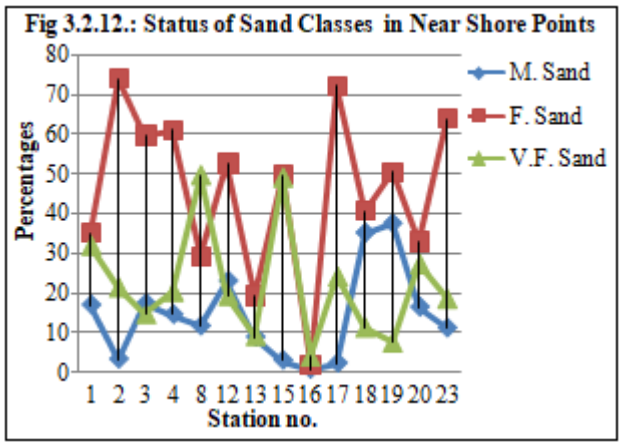

Figure: Line chart showing the sand classes

Description: From the above chart, it is clear that our southeastern coasts specially near the shoreline and beaches are made mostly with fine sand meaning the particles sizes are within 0.25mm-0.125 mm (125 microns) rather than the other medium and very fine sands. After the fine sands, the second most are the very fine sand size of 63 microns.

Table 3.2.5: Status of silt classes at near shore and innermost points

Station Name	V.F. Silt	Fine Silt	Medium Silt	Coarse Silt
5	0.1	7.86	3.96	35.77
6	2.76	15.65	17.29	29.34
7	3.17	0	3.19	9.58
9	7.75	11.63	7.75	15.5
10	9.65	28.36	6.23	9.25
11	3.38	0	13.52	30.42
14	2.81	2.8	5.61	20.43
21	5.47	15.09	9.31	11.84
22	3.35	13.41	10.05	16.76
24	2.5	2.5	2.5	5
25	9.52	6.35	3.18	12.69
26	3.04	6.07	6.07	9.1
27	3.1	6.2	3.1	24.79

There has been given a chart with line showing the silt classes below:

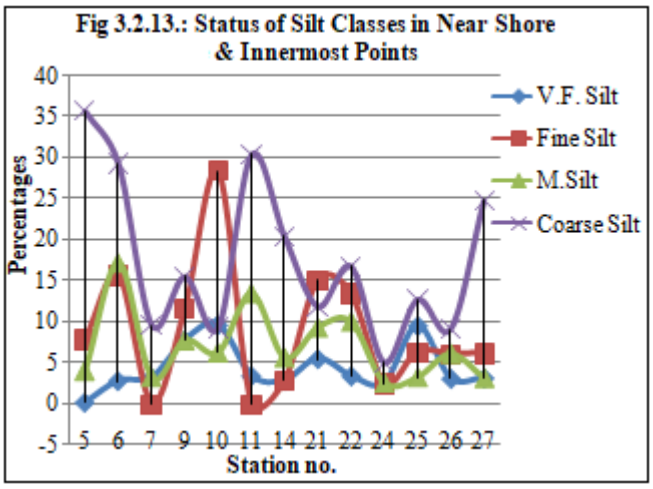

Fig: Line Chart showing the silt classes

Description: In the above chart we get the line for coarse silt are mostly dominating over all of the sites existing in the distant and innermost places from the shoreline. This means if we go forward toward deeper sea, we will get the coarse silts more than others. After the coarse silt, on average the second most dominating line is for the medium silt, next is the fine silt meaning that consecutively the particle contents are decreasing at percentages with the decreasing of their sizes. From above chart, we also conclude that as we go towards the deeper so we will find the smaller sizes particles at more rates.

3.3. Vertical Distribution of the Suspended solid

The sediments in the water exist and move vertically and horizontally from one place to another place. Though water in the ocean mixes and exchanges in a regular interval for tidal, current, monsoon wind, Coriolis effect, La-Lina and El-Nino effect, Indian ocean dipole and southern oscillation and so on, most of the water after the mixed layer depth remain unchanged and don't exchange with upper layer water. Vertically sediment shows different nature to their sediment amount based on the topography of the ocean floor, current, depth, wave etc. Some places show more sediment at surfaces and less sediment at bottom and similarly other places show more sediment at bottom and less at surfaces because of the ocean current and wave action on the ocean beds with its existing sand particles. There has been given two charts below on the total sites existing in the water of eastern shelf covering St'Martyn, Teknaf, Inani, Cox's Bazar, and Sonadia.

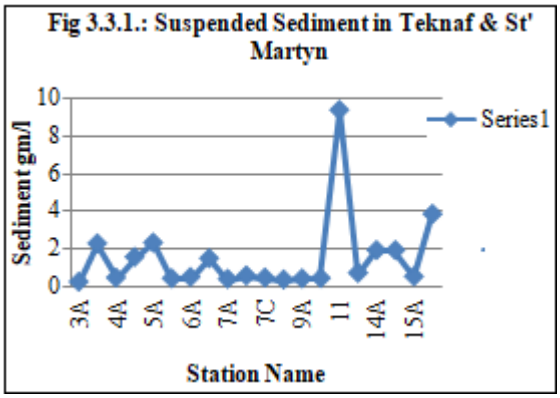

Figure: Chart showing vertical distribution of suspended sediment

Description: From above chart, it is clearly visible that most of the sites encoding with B sign meaning the bottom water referring more amount of suspended sediment in 1000 ml water than the surface water. The sites which were in the more depth show more sediment content at surfaces than bottom. Moreover, the sites with less depth show more sediment at bottom than surface because the friction of ocean bed with the moving water by wave or current causes the erratic movement and mixing of settled sediment on bottom towards rather upper direction from bottom. Another chart showing the suspended sediment vertically distributed in Inani, Cox's Bazar and Sonadia below.

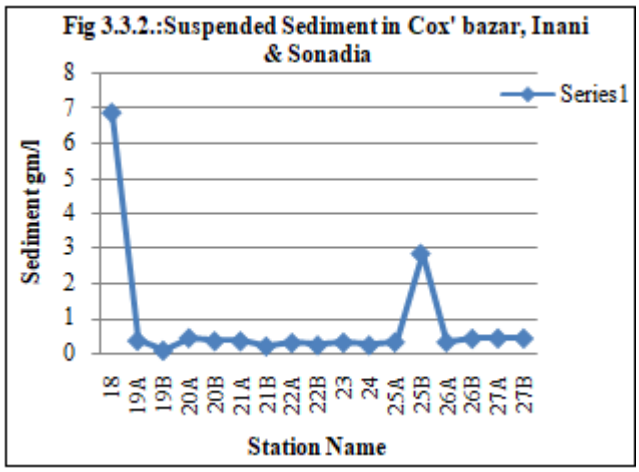

Figure: Chart showing vertical distribution of suspended sediment

Description: The chart for the vertical distribution of suspended sediment in Cox's Bazar, Inani and sonadia show more sediment at surface and less at the bottom. Accept 25B, most of other sites show more sediment at surface through which it proves that the near shore points at Cox's Bazaar, Inani present more sandy floor and with a gentle slope where the friction and turbidity making by water, current and wave is not so strong for that reason the sediment at bottom is less amount than surface. At the points 26, the sediment is more at bottom which refers it has a bottom current at the sea bed and has some clay and silt content on the bed.

3.4 Effect of Human Intervention on the Sediment Dynamics

Bangladesh is one of the largest deltas in the world, with a coastline of 710 kilometers. This coastal land is the basic natural resource, providing habitat and sustenance. About 30 million people of Bangladesh are coastal inhabitants. They are relying on agriculture, fisheries, forestry, salt panning etc for their livelihood. Thus environment of coastal zone is very important. Coastal zones refer to areas where land and sea meet. It has been delineated in various ways. Moreover the land use in the coast is diverse and often conflicting. In Bangladesh it is intensively used for agriculture, settlements, forests, shrimp culture, natural fisheries, salt production, industrial and infra-structural developments and tourism. The coastal areas are ecologically important, as they provide a number of environmental goods and services to people. The coastal zone contains critical terrestrial and aquatic habitats, such as the mangrove forests, wetlands and tidal flats.

Unfortunately, the coast of Bangladesh is identified as a zone of multiple vulnerabilities, which is prone to severe natural disasters such as cyclones, storm surges and floods. Combined with anthropogenic hazards, the coastal and marine environment is under threat. Natural catastrophe is hard to avoid but hazards like manmade pollution can be avoided or controlled at minimum level.

Human activities add another layer of complexity to the natural processes of coastal lands and materials. These activities may have direct or indirect effects on our changing coasts. They may affect sources of new sediment to the coast and the movement of sediment within the coastal environment; they may promote changes in sea level, both local and global. People's activities are often conducted without an adequate understanding of coastal geology and processes. As a result, they can lead to unforeseen degradation of coasts. Even human actions intended to save or improve the coast may inadvertently increase erosion. Cooperative scientific investigations are starting to provide the crucial information needed to minimize the unintended effects of human disturbances along coasts. There have been given some major causes of excessive sedimentation into different water bodies and sea beds below in case of Bangladesh.

3.4.1.Ship Breaking Yard

Study revealed that ship breaking activity in Chittagong coast is increasing day by day due to lack of environmental regulations. This causes huge physicochemical and biological degradation of coastal environment In two decades, the land destruction becomes double. Aerial information from temporal Landsat imagery showed that, negatively impacted coastal area increased by 308.7% from 367 ha (1989) to 1133 ha (2010) like a growing cancerous tumor in the Sitakunda coast.

3.4.2. Encroachment of Water Bodies

The most visible resources are the rivers. Over the last few decades the salinity of the river water has steadily increased, mainly because of a reduced inflow of sweet water in the dry season. This has increased the salinity of the land and the groundwater. The rivers provide an easy means of transport as well as various fisheries resources. The Bay of Bengal features key spawning grounds as well as rich offshore marine habitats. The rivers and internal channels are usually government owned land (called khas land). Nevertheless, many farmers with land adjacent to the channels have appropriated the land and/or water resources of the channel for their private use. In line with the prevailing law, the Ministry of Youth and Sports leases out stretches of channel for fisheries. Some parts of the coastal zone have low-lying areas, called beels. These used to produce a wide variety of common resources such as reeds, aquatic plants, snails, and fish, which were important resources to support livelihoods of the poorer sections of society. In many places, over drainage and encroachment have reduced the size of these beels and common access of beneficial particularly to the poor limited. The quality of the groundwater varies. In some areas the shallow 10-30 top layer is sweet, followed by a layer of saline groundwater that can extend up to several hundred feet. The deepwater layers are again sweet. Groundwater is used for drinking and domestic use, but not normally for irrigation as Sweet River water is available for part of the dry season.

3.4.3. Unplanned Development Intervention

Several coastal districts have been experiencing water logging and drainage problems for around two decades as a result of creating polders and ignoring morphological, hydrological and tectonic conditions. This has resulted in crop failure and environmental degradation. The balance that existed between sedimentation and subsidence was totally disrupted by polders, causing very rapid sedimentation in the tidal channels, and very limited sedimentation and rapid subsidence of the tidal flats. In the Khulna and Jessor regions, polders 1, 3, 4, 5, 6, 8, 15, 24 and 25 have been experiencing water logging and among these the most serious problem is observed in polder 25, the waterlogged part of which is known as Beel Dakatia. Water logging has caused serious environmental degradation and suffering to the people of BeelDakatia. It affects people, agriculture infrastructures and water resources. Villages, roads, bridges, culverts have either become isolated or gone under water. Six villages are completely isolated from other villages, about ten villages are more or less detached from the mainland and about 9,000 ha of arable land are now under water together with all the sweet water ponds and even some tube wells. Diarrhoeal disease, dysentery, gastric and skin diseases are common here. Water logging, increased salinity and siltation in and around the area have affected the flora and fauna. Trees, birds and domestic animals like cows and goats s are also disturbed due to water logging and salinity. A n agro-based economy and a colourful socio-cultural life have suffered decline. About 55 percent of farming families have turned fishermen. A sizeable number of local people have already migrated to other places.

3.4.4. Sediment Starvation

For some coastal regions, such as the Noakhali, Laxmipur and Bhola coast, a large part of their sediment budget is supplied by rivers. Dams built for flood control and water catchment along the rivers leading to these coasts inhibit the transport of large-grained sediments. Lacking new material, the sediment-starved coasts erode and migrate inland. Damming of tributary rivers reduced the movement of sediment. Attempts to counter sediment starvation along severely eroding coasts have included the artificial replenishment of beach material by placing sand directly onto the beach. Beach nourishment is not a permanent solution and is expensive, but in some regions it can be cost effective. The lack of clean sand suitable for fill often limits beach nourishment programs, but offshore surveys can locate sand bodies for dredging and transport to the beach.

3.4.5. Pollution

As the number of active landfills dwindles and coastal populations grow, offshore waste dumping and coastal pollution increase. This additional dumping increases the possibility of improper waste disposal polluting the coastal environment Living coral reefs are particularly vulnerable to pollution, but other coastal environments suffer as well. Medical waste, including used hypodermic needles, was washed onto the Chittagong, Khulna beaches, resulting in an economic disaster for the recreation industries in the region. Fishing industries have also been severely damaged by coastal pollution; more than one-third of our Nation's shellfish beds are closed or restricted as a result of contamination.

3.4.6. Sediment Trapping

The natural movement of sand is at best a nuisance for owners of beachfront property. When this movement results in a net loss of sand from the beach, the natural process may be considered by owners as a serious threat To prevent beach loss, groins are often constructed out into the water. These solid structures impede the littoral drift of sand caused by long-shore currents. The beach then expands on the up-drift side of the groin; however, the down-drift side of the groin loses sand because of continuing long-shore movement. Small groins may have little effect on sediment movement along the entire beach. Larger groins or jetties, such as the ones at the southern end of Ocean City, Chittagong, Cox'sbazar, can lead to impressive retention of beach materials on the up-drift side, but these gains must be balanced against the coastal degradation on the down-drift side. Sediment carried out past the jetty may be deposited as shoals offshore in deeper water and removed from the active coastal sediment budget, further increasing down-drift erosion. Seawalls constructed to protect property along retreating beaches often exacerbate beach erosion. They confine the wave energy and intensify the erosion by concentrating the sediment transport processes in an increasingly narrow zone. Eventually, the beach disappears, leaving the seawall directly exposed to the full force of the waves. For example, a massive seawall built to protect a highway and beach houses along the northern New Jersey coast has resulted in the complete disappearance of the beach itself.

3.4.6. Coastal Degradation

Human actions that lead to the destruction of dune grasses and the disturbance of coastal landforms promote increased erosion and movement of beach materials. Off-road vehicles and foot traffic on sand dunes compact sand, destroying plant roots and animal burrows. Other wildlife habitats, such as nesting and feeding areas for shorebirds, are disturbed by human activity; young birds are especially vulnerable to these disruptions. Sand dunes help absorb the pounding of high waves and reduce over-wash flooding during storms; bulldozing dunes to improve views of the sea destroys this natural protection. Dredging navigation channels and tidal inlets and discharging the material in deep water also remove sediment from the coastal system and interfere with long-shore transport. Canals cut in wetlands for navigation, pipelines, and drainage provide channels for salt-water invasion during storms and high tides; the increased salinity often kills marsh plants, leading to accelerated land loss and deterioration of wetlands.

3.4.7. Pumping of Ground Water

Human activities can cause local and possibly global changes in sea-level. Pumping of ground water, salt brines, and petroleum resources from coastal environments has led to significant subsidence in many regions. The increasing release of greenhouse gases, such as carbon dioxide and methane from automobile and industrial exhaust, may promote global warming, the melting of massive ice sheets in Greenland and Antarctica, and consequently the raising of sea level worldwide.

4. Conclusion

Ganges- Brahmaputra and Meghna river system is one of the large river systems in the world which a vast amount of sediment into the Bay of Bengal mostly under the Swatch of no Grounds. By naturally specially by the climate change as well as the human activities are causing excessive sedimentation into the lower areas and their water bodies resulting in the river bed and other aquatic bed siltation ultimately feeding the sea or ocean and filling of them. In the context of new land accretion, it is blessing for a country specially like our poor, densely populated and small country. But, it is must the river and other fresh water body siltation and filling with the sediment are the sources of flood, drought, salinity intrusion, fresh water scarcity, bio-diversity destruction and ecological imbalances, decreasing of agricultural productivity, deforestation and so on. Here in this study, the sedimentation of the coastal belts has been analyzed and discussed which has no direct social and human impact yet. Moreover, it may bring up new land for our country which very emergency and cruicial to us. From the study, we get the water surface water shows more temperature than bottom and the surface water contains less DO than the bottom water. BOD represents higher in some bottom sites and in some surface sites. PH is rather constant within about 6.4 to 6.8 in most of the places accept Sonadia. Most of the sites represented some acidic nature especially the bottom water were more acidic meaning the lower PH in the graph. Suspended sediment was more bottom water accept some points of Sonadia and st' Martyn. Therefore vertically, sediment was more at the bottom than surfaces. The bottom sediments were about constant in their nature. The sand graph was at the lower direction from shore to inner side of the sea, similarly silt and clay graph for all sites was increasing directions towards the deeper parts f the sea comparing to shore and land. The innermost sites were about to constant value of same content of sand, silt and clay and these innermost sites show more content of coarse silt and thereafter medium silt than the others. The sites of near shore and lands represent more fine sand and consecutively very fine sand at more rates comparing the other sites. So we can conclude that the sediment types and their sizes show the increasing trend of silt and clay with their smaller size and more sorted and roundness seaward towards the inner side or seaward direction from shore.

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