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STUDY ON SEDIMENTOLOGY FROM THE MESJID RIVER ESTUARY AND ITS ENVIRONS IN THE RUPAT STRAIT, THE EAST COAST OF SUMATERA ISLAND

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ABSTRACT

The sedimentological aspects of the Mesjid River Estuary and its neighboring seas are revealed by various analytical approaches; i.e. mechanical grain size analysis, ignition loss method, metallic element analysis and sand grain composition analysis.

The estuary area is characterized by fine sediments (very fine sand to very fine silt). Based on the relation between the character of bottom sediments and the environmental condition, the the Mesjid River Estuary and its Environs is divided into the following three areas: 1) The western part of the study area characterized by rather coarse-grained sediments and low mud content under the influence of longshore current and poorly sorted sediments supplied by the Mesjid River, 2) The southern part of the study area characterized by coarse-grained sediments under the influence of strong tidal currents, 3) The northern and eastern parts of the study area characterized by fine-grained sediments and high mud content under conditions of sea water masses. The texture and organic matter content of the sediments play important role on the growth of the mangrove which thrive along the coast of the study area.

Keywords: Sedimentology, coastal management, sediment characteristics, abrasion

I. INTRODUCTION

Since establishment of Marine Science Center, Riau University in the vicinity of Mesjid River Estuary, the estuary has become one of the areas most intensively studied in relation to the pollution of water, sediments and marine fauna. Significant studies in ecological and oceanographical aspects of the area have been carried out by many scientists. However, only a few papers among them are concerned with bottom sediments from the sedimentological point of view.

In an attempt to clarify the relation between characteristics of sediments and environmental condition, the surface sediment was analyzed The sediment were collected from the Mesjid River Estuary and its Environs in which mangrove have thrived. The writer wishes to utilize the results of the present study as the fundamental information for the mangrove conservation and for the study of coastal management in future.

II. PHYSIOGRAPHIC SETTING

The Rupat Strait, a strait separated from Malaca Strait by Rupat Island, is located on the east coast of Sumatera Island, Riau Province. Rupat Strait, lying between Sumatera Island and Malaca Strait, is elongate and northward, southward-opening with a length of about 88 km from north to south and a width of about 8 km (Fig. 1a).

The area studied is restricted to the Mesjid River Estuary and its Environs of the Rupat Strait, being about 1.3 km long and bout 1.1 km wide. It is located within the lines of $01^0$42'78" N and $01^0$44' N Lat. and within $101^0$22'83" E and $101^0$24' E Long (Fig. 1b and 1c). This strait has two outlet (north outlet and south outlet) leading to Malaca Strait (Fig. 1a).

The area studied is rather irregular and flat in bottom topography and in general, get gradually deeper northeastwards (Fig. 1d). The Mesjid River with rather large drainage areas, flows into estuary of the area. The coastal zone of the Mesjid River Estuary is characterized by mangrove vegetation, such as *Avicennia* sp, *Rhizopora* sp. In addition, along the coastal line of the area can be found the remain of mangrove vegetation and this area is under influence of longshore currents.

III. MATERIAL AND METHODS

The Bottom sediment samples used for this study were collected from 27 stations in the Mesjid River Estuary and its Environs with depths from 1.0 to 19.0 m in early April 2000 (Fig. 1c and 1d). Positioning for the sampling was determined using compass aboard a small fishing boat. All bottom samples were collected by using grab sampler. Among the samples, 8 samples (Stn. 20 to 27) were raised from the area of mangrove vegetation. All bottom samples were utilized for mechanical analysis, ignition loss method, metallic element analysis, and sand-grain composition analysis.

Oceanographic observation was also carried out to measure turbidity, light intensity, pH, salinity, temperature, dissolve oxygen, and total suspended solid at 19 stations excluding station 20 to 27. Total suspended solid was measured at Laboratory of Chemical, Fisheries Faculty, Riau University, based on the method of Standar Nasional Indonesia (1994).

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3.1. Mechanical Analysis

Before the laboratory works of the 27 bottom sediment samples were conducted, all the samples at each of stations were divided into two parts. One part is kept in a refrigerator and the other used for this study. Grain size analysis of the samples were conducted by using a method of Matoba and Murata (1977) and Rifardi (1994a and b).

Results of the wet sieving and pipette method were combined and summarized into mean diameter ($Mz\ \phi$), median diameter ($Md\ \phi$), sorting coefficient (σ_I) and skewness (Sk_I) which obtained with graphical method of Folk and Ward (1957):

The textural proportions of sand, mud and gravel were plotted on Shepard's triangle (Shepard, 1957) for all samples.

3.2. The Ignition Loss Method

The ignition loss method according to Dean (1974) was used to determine the organic matter content of the sediment samples. The samples were dried at a temperature of 100^0C or less for several hours and powdered after drying. About 2 gram of the powdered samples was used for ignition analysis.

The powdered samples was heated at 100^0C a muffle furnace for an hour and then cool them, after that weighed them (this is dry weigh of sample). The samples heated again to 550^0C for an hour (the content of combustible organic matter was obtained by subtraction between the results of 110^0C and 550^0C).

3.3. Metallic Element Analysis

The residual ash of the ignition was used to be digested for bulk chemical analysis to determine the contents of three metallic elements in the sediment samples. The organic matter and carbonate free ignition-ash was weighed out and digested by HF (hydrofluoric acid) and HCl (Hydrochloric acid), the pelletal residue was dissolved into 10 ml of HCl, and the solution was brought to 50 ml with distilled water and 10 ml of 5% La solution (Yamamoto and Yuine, 1985). The concen-tration of 3 elements (Al, Fe and K) were determined from the sample solution by Atomic Absorption Spectrometry (AAS).

3.4. Sand-Grain Composition Analysis

Residue of Sand fraction of grain size analysis were also used to analyze sand-grain composition according to Ujiie and Shioya (1980).

IV. RESULTS AND DISCUSSION

The Mesjid River Estuary and its Environs is divided into the following three areas according to the character of the bottom sediments: 1) the area mainly in the western part of the study area characterized by rather coarse-grained sediments($Mz\ \phi$: 4.7 - 6.2); 2) the southern part of the study area characterized by coarse-grained

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sediments (*Mz* ϕ: 3.4 - 5.4); 3) the northern and eastern parts of the study area characterized by fine-grained sediments (*Mz* ϕ: 6.1 - 7.5). The relationship between the characters of bottom sediments and the deposition environments in these three areas is discussed below.

4.1. The area mainly in the western part of the study area charac-terized by rather coarse-grained sediments

All stations included in the western part (Stn. 2, 3, 5, 7, 10, 14, 20, 21, 22, 23, except for stations 4, and 8) show the character of bottom sediments (*Mz* ϕ: 4.7 - 6.2; Fig. 2a) which are influenced by rather strong tidal current and river flow. The sea bottom of station 4 and 8 are characterized by fine grained-sediments ((*Mz* ϕ: 7,4 - 7,6). Rather low mud content (<60%; Fig. 2b) in the north of the western part suggest that tide current flowing through this area from the north is rather strong. Judging from the distribution pattern of sorting coefficient in the Mesjid River Mouth (poorly sorted; Fig. 2c), the bottom sediment supplied by the Mesjid River are assumed to have spread toward the north through the west coastline. Wigley (1961) reported that poorly sorted sediments, those possesing a wide ranges in particles size, indicate a variable or turbulent current during depositon. The distribution of salinity in this area showing the low values, support this assumption (Fig. 4d). Station 4 and 8 are occupied by symmetrical skewed sediment (Fig. 2d), which reflect a specific of oceanographic condition in this area

Along the west coastline can be found the remain of mangrove trees. This condition indicate that the abrasion process occur in this area which is caused by strong tide current following through the area. This indication is supported by Bramawanto *et al* (2000) who found that the mangrove have decreased greatly from the coastal of the area. The sediment which are derived from the abrasion of coastline, are transported toward the east by the confluence of water masses flowing from the north as tide current, and water masses flowing from the Mesjid River. These facts suggest the existence of longshore current along the west coastline.

The longshore current is though derived from the tide current flowing from the north and is changed its direction by many small island (Fig. 1a).

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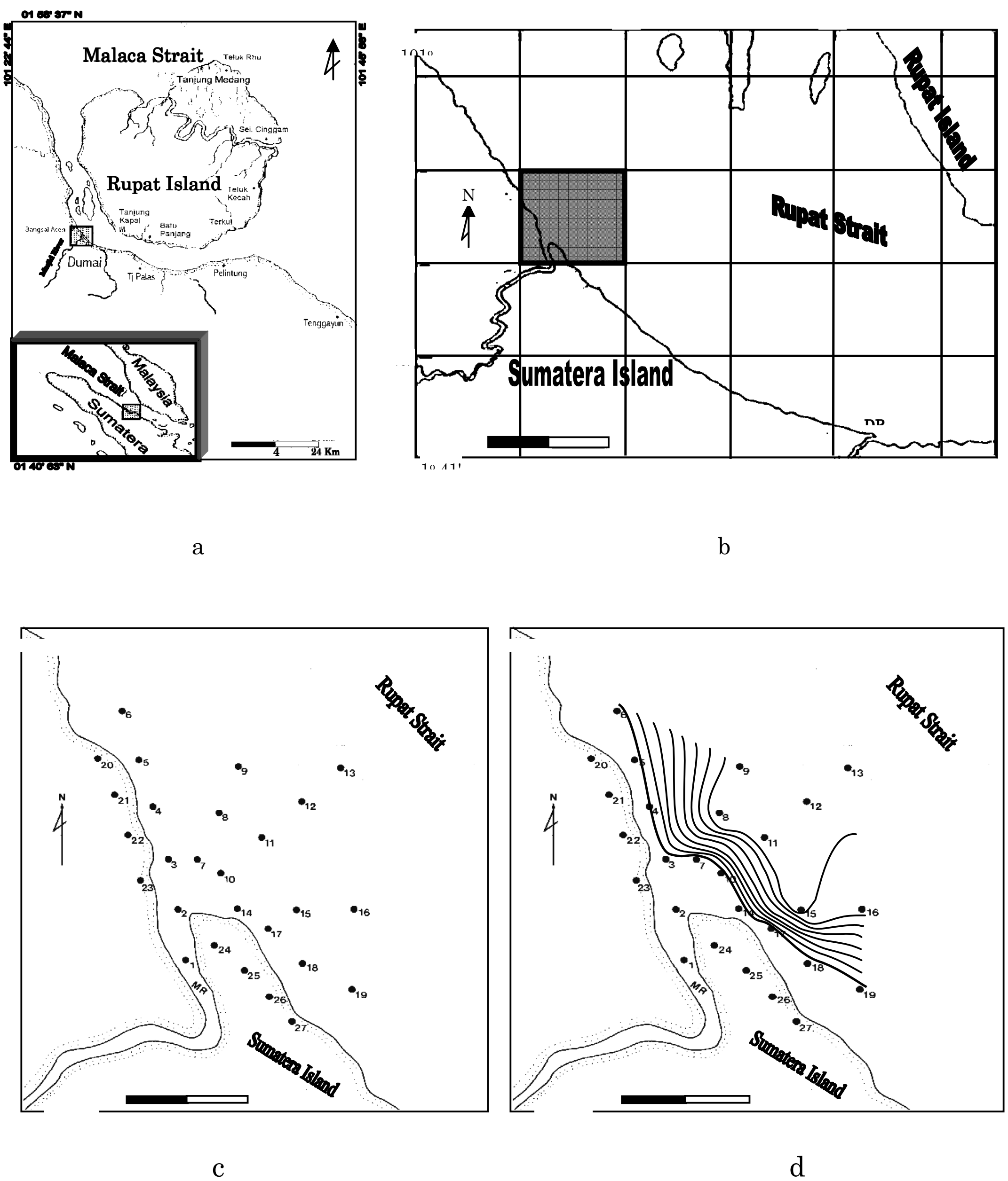

Fig. 1. a) Geographic map around the study area. Inserted box indicates the study area. b) Index map of the study area (MR=Mesjid River; DR=Dumai River; BI=Baru Island; RI=Rampang Island; MI=Mampu Island). an inserted box show the area of Fig. 3. c) Map showing the sampling station. d) Bathymetric map in the sampling station (contur interval 2m)

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Some aspects of the sediment in the area are different from the aspects of Oura River Estuary found by Rifardi and Ujiie (1993) in which mangrove have thrived until two decade ago but greatly diminished at present due to the land development of its hinterland. In this study area, the content of organic matter range from 6.10% to 38.18% (Fig. 3b), and contrastingly, the Estuary of Oura River is predominantly dominated by coarse-grained sediments (*Mz* ϕ: 0.37 - 3.03) and low organic matter content ranging from 2.11% to 7.38%. Whereas, the values of Al and Fe in this area (Fig. 3c and 3e) are not so different from the Oura River Estuary ranging from 1.43% to 4.54% for aluminum (Al) and ranging from 0.42% to 3.63% for Iron (Fe).

4.2. The southern part of the study area characterized by coarse-grained sediments

In the studied area, bottom sediments with coarse-grained size are distributed in the southern part (Stn. 1, 24, 25, 26 and 27) of the area. These sediments show mean diameter ranging from 3.4 - 5.4ϕ. Strong flood and ebb currents can be recognized in the area. The velocity of the flood current coming into the study area ranging from 4.49 to 25.08 cm/minute, whereas the velocity of the ebb current ranging from 21.07 - 28.30 cm/minute. Rifardi et al (1998) clarifies that the area near the strait characterized by coarse sediment under the influence of strong tidal and bottom current.

The distribution total suspended sediment (Fig. 4c) indicate that the route of sediment supplied through the Mesjid River is changed its direction toward the eastern part due to the effect of flood current, whereas sediments supplied by the ebb current are transported toward the southern part and deposited in the bottom of the area. The distribution of suspended sediments due to the river discharge and the ebb current can also be explained by the features of sediment type (Fig. 3a) clearly. The southern part is predominantly characterized by sandy mud extending from the mouth of Mesjid River to eastern part. The surface sediment of station 1 composed of gravel, whereas sediment of station 27 is dominated by sand fraction. Analogous to the features, Davis (1978) illustrated the general process of river-mouth sedimentation and seaward fining sediments except in cases where strong tidal currents dominate over effluent processes, the most rapid deposition and the deposition of the coarsest material take place a short distance from the river mouth. The features described above suggest that strong current constantly occur in this area. Rather stable of the current in the area is also shown by the moderately well sorted and very well sorted sediments (Fig. 2c).

Terrigenous sediments are assumed

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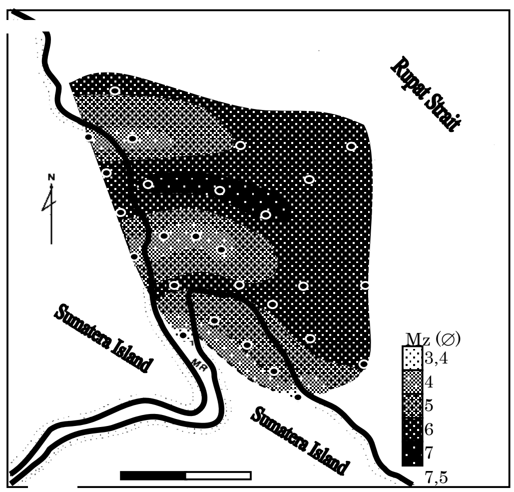
to be supplied by the Mesjid River and by tidal current from the hinterland of mangrove. This assumption can also be explained clearly by the distribution of Al, Fe and K (Fig. 1c-d). In this area, the content of Al (12,300 - 62,080 ppm) show high values as well as and Fe (3,223-16,980 ppm). The results of sand grain composition analysis indicate, the distribution of rock and mineral fragments and litter of the bottom sediments (Fig. 4a and b) support the assumption. Allen (1991) clarifies that the estuary may receive sediment from up to three chief sources: the river catchment, bedrock or order deposits exposed on the floor of the estuary and on marginal cliffs or buffs, and bedrock or order sediment accessible to erosion seaward of the estuary mouth.



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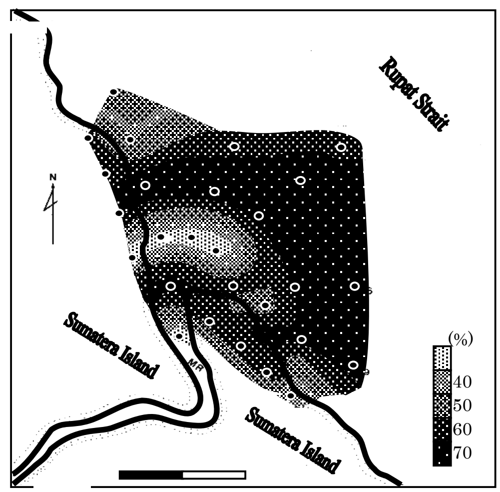

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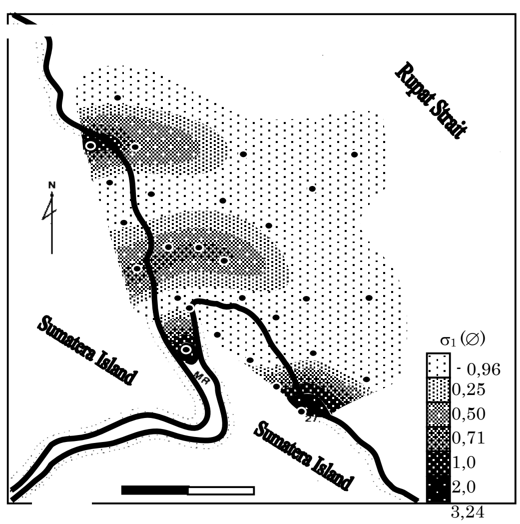

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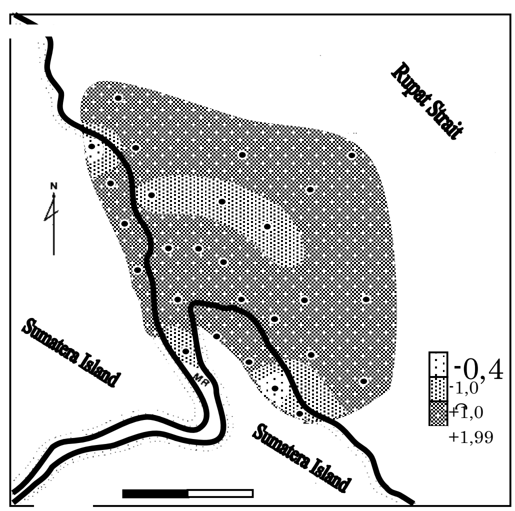

d

Fig. 2. a) Distribution of the mean diameter (Mz ∅) of bottom surface sediments. b) Distribution of the mud content (%) of bottom surface sediments. c) Distribution of the sorting coefficient (σ_1) of the ottom surface sediments. d) Distribution of the skewness (Sk1) of the ottom surface sediments.

4.3. The northern and eastern parts of the study area characterized by fine-grained sediments

Fine-grained sediments are distributed in the northern (Station: 6, 9, 13) and eastern parts of the study area (Station: 11, 12, 15, 16, 17, 18 and 19). These sediments show the mean diameter ranging from 6.1 to 7.5ϕ (Fig. 2a) and very well sorted of 0.39 to - 0.96ϕ (Fig. 2c). The distribution of mud content (Fig. 2b) shows that the eastern part is occupied by the highest mud content in the study area of more than 70%, whereas the northern part is characterized by rather high mud content ranging from 56 to 68%. Total suspended sediment (Fig. 4c) in the areas show the same tendency as the distribution of mud content. These features indicate that the eastern part is influenced by weak flood and ebb currents, whereas the northern part under the condition of rather weak the currents. Oki (1989) illustrated, the bottom sediment character is harmoni-zed quite well with the mean strength of current, it means if the current is weaker the grain size of sediment is finer.

Judging from the content of the three metallic element (Al, Fe and K; Fig. 3c-d) showing the highest content, terrigenous material supplied by the flood and the ebb currents, are deposited on the bottom of the areas. The terrigenous materials are thought derived from the coastal zone faced to Malaca Strait, as the result of abrasion process which occur along the coast. Ujiie and Oshiro (1993) find out that since the three elements are commonly bounded in silicates including clay minerals, their geographic distribution strongly suggest the route of terrigenous material supply. As well known, the coastal zone faced to Malaca Strait is eroded by strong waves and the longshore current. Based on personal communication with the villagers that some of the coastal zone are under abrasion about 5 m/year. The deposition of the material in the areas occurs constantly and stable as shown by the characteristic of very well sorted sediments.

The geographical distribution of salinity (Fig. 4d) shows that the northern and eastern parts are characterized by high salinity ranging from 27 to 30‰. This means that the areas are strongly under the influence of sea water masses.

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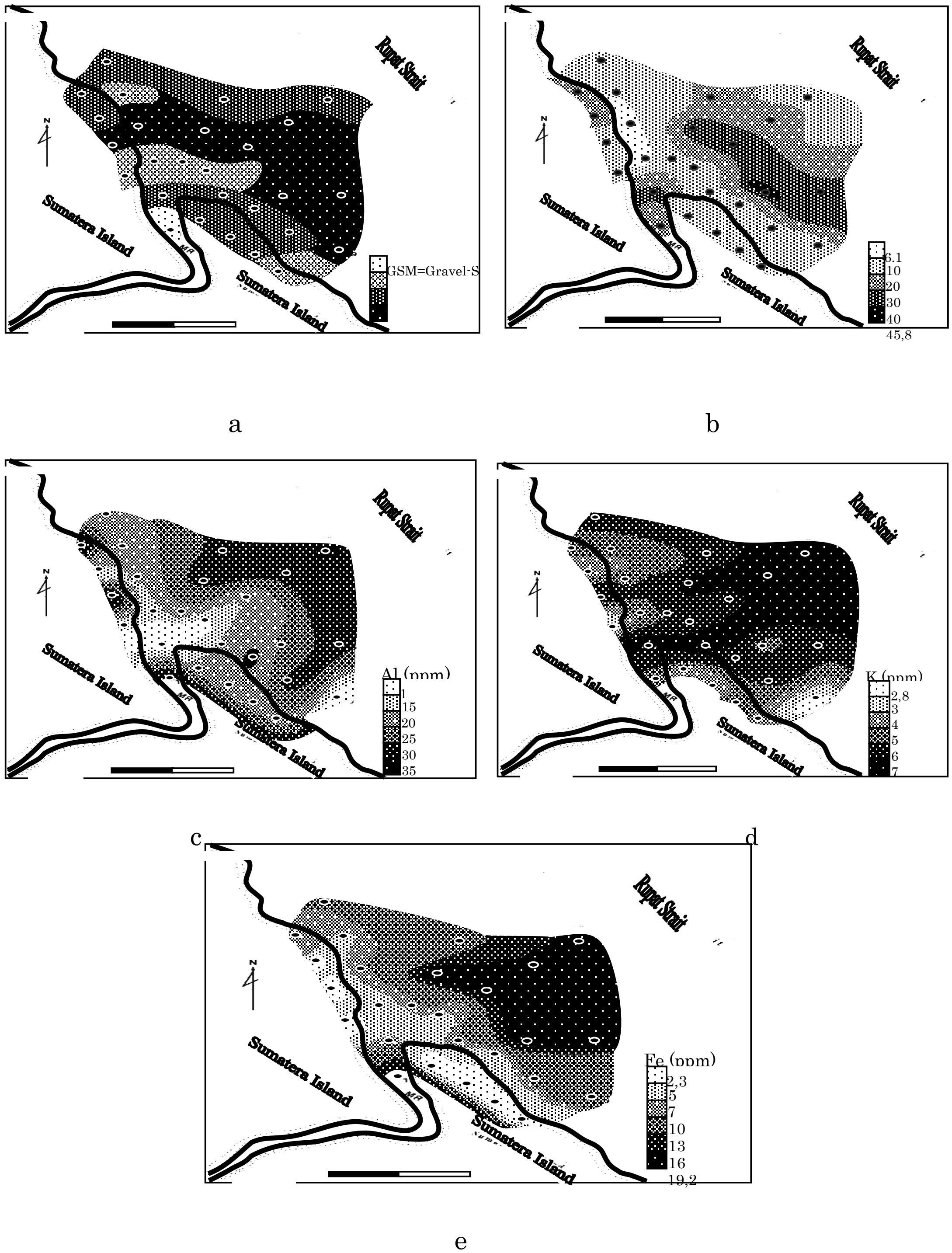
Fig. 3. a) Distribution of the sediment tipes of bottom surface sediments. b) Distribution of the organic metter content of bottom surface sediments. c,d and e) Distribution of Al, Fe and K content of bottom surface sediments



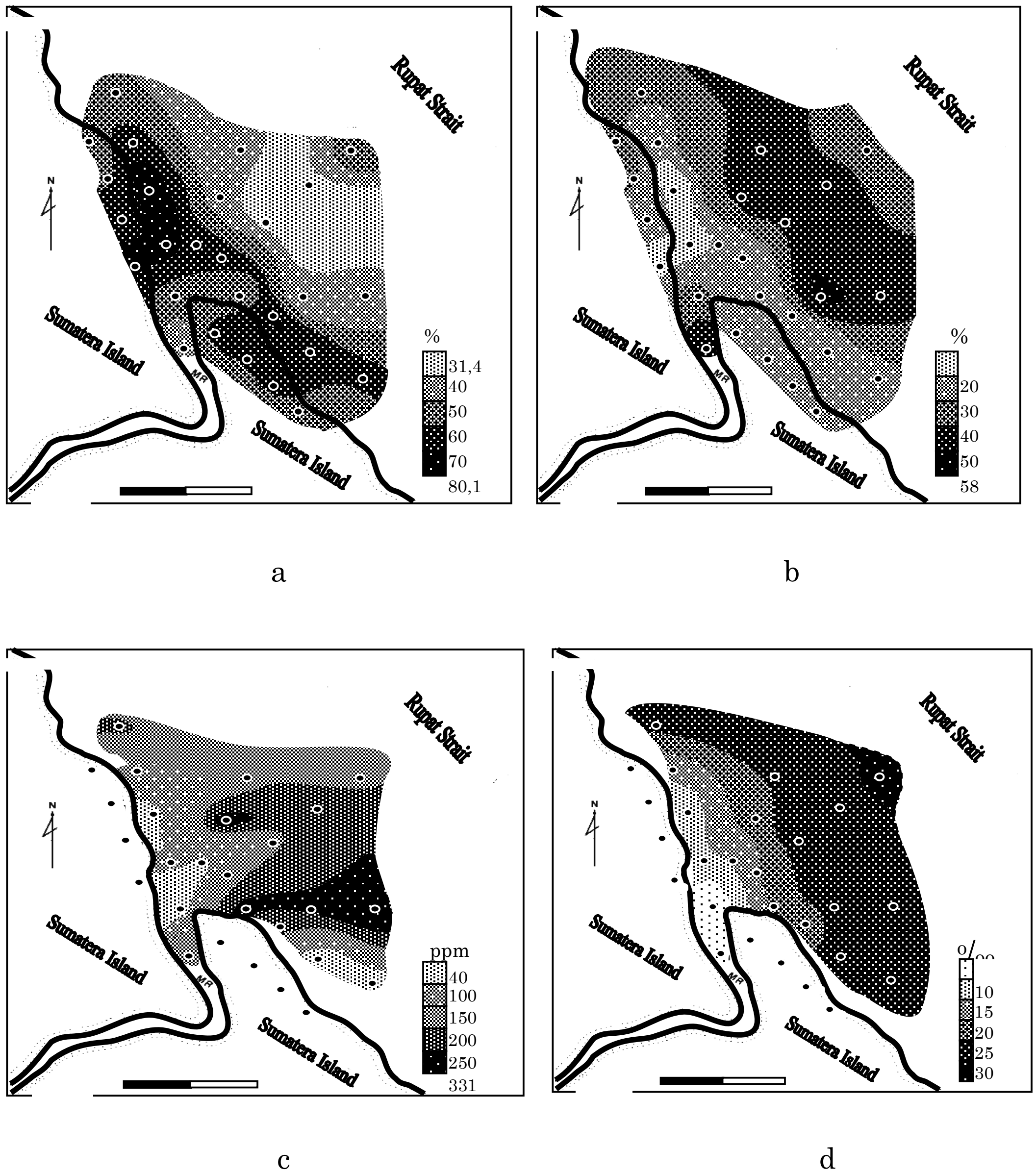


Fig 4. a) Distribution of rock and mineral fragmens. b) distribution of serasah of bottom surface sediments. c) Distribution of Total Suspendet Sediment (TSS). d) Distribution of salinity ($^{o}/_{oo}$)

The results of the present study are summarized as follows:

1. General feature of the bottom sediments in the Mesjid River Estuary and its Environs is characterized by very fine sand to very fine silt (Fig. 1a).
2. The Mesjid River Estuary and its Environs is divided into the following

three areas according to bottom sediment characters: 1) The western part of the study area characterized by rather coarse-grained sediments and low mud content, 2) The southern part of the study area characterized by coarse-grained sediments, 3) The northern and eastern parts of the study area characterized by fine-grained sediments and high mud content.

3. The confluence between the flood current and river flow occurs along the coastal of the western part, and this confluent cause the distribution of the sediments become more configurative pattern in the western part.
4. The sediments supplied by the river is characterized by coarse grained, and contrastingly sediments supplied by tidal currents are characterized by fine grained.
5. The texture and organic matter content of the sediments play important role on the growth of the mangrove which thrive along the coast of the study area.
6. The abrasion process occurs along the coast of the western part due to the rather strong tide and longshore currents flowing from the north.

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