Middle-East Journal of Scientific Research 24 (6): 2123-2128, 2016
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2016.24.06.23653

The Changes of Sedimentological Characteristics in Kemaman Estuary, Terengganu, Malaysia

Nik Hani Shahira Nik Shirajuddin, Hasrizal Shaari, Khawar Sultan, Nur Sakinah Abdul Razak, Fathullah Abdullah and Rosnan Yaakob

School of Marine and Environmental Sciences,
Universiti Malaysia Terengganu, Kuala Terengganu, Terengganu, Malaysia

Abstract: This study reports sedimentological properties of core sediments (length ~200 cm) from Kemaman Estuary, Malaysia and focuses on understanding depositional environment in a tropical estuarine setting by investigating grain size and morphological characteristic of the core sediment. The mean sediment size ranged from 4.97 to 7.22 Ø and is texturally classified as coarse silt to very fine silt (~55.84%). The cyclic trend in sediment grain size indicated a complex mix of marine and land based (riverine) processes under the influence of transportative and current action. The estuarine sediments are found to be poorly sorted and skewed pointing to the normal size distribution is influenced by finer grain sizes. Morphology of grain shape showed a dominant angular to sub-angular shape. This kind of grain angularity is mostly likely due to the shorter transport period (e.g. time and distance) and lack of maturity (i.e. sphericity and roundness). The dominance of silt and clay size fractions in the estuary can be attributed to depositional process under the influence of currents. Generally, the deposited sediments in the core sample seem to be dominantly from the terrestrial. This worked is important to report changes of depositional environment of the recent past in a tropical estuarine environment.

Key words: Estuary · Core sediment · Grain size · Sediment characteristics

INTRODUCTION

Estuary is a transitional environment for sediment from terrigenous to reach the coast area [1]. This environment is naturally good in trapping sediments from rivers and streams. In some cases wave and tidal currents transports sand from the sea into the estuaries. The interaction between sediments, bottom morphology and the hydrodynamics controlled the distribution and the accumulation of sediment on the bottom of the estuary [2]. The suspended sediment are high, the particles are fine, cohesive, flocculate and rich in organic materials [3]. The circulation in the estuarine is due to the interaction between seaward flow of lower salinity surface water with a landward flow of dense and high salinity of bottom waters. This process causes the estuaries to trap particles from both riverine and marine sources [4].

Sediment core sample will help in the study of previous changes of the environmental conditions. Particle grain size of sediment core is important parameter to determine soil texture that commonly refers to the hydrodynamic and deposition processes of the sediment in the estuary [5]. For the efficient management of estuaries, the knowledge on textural variation and sedimentation is very important. This is because the studies on sediment characteristic enable us to better understand the movement and the source of sediment in the estuary [6]. There are two reports [4, 5] regarding on the sediment characteristics and sedimentological properties in Kemaman Estuary, however, both reports only focusing on the aspect of surface sediment changes. Therefore, the aim of this study is to understand the environment deposition of core sediment in Kemaman Estuary and try to distinguish the major factors that influence deposition in sediment.

Corresponding Author: Hasrizal Shaari, School of Marine and Environmental Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Malaysia. Tel: +609-6683958.

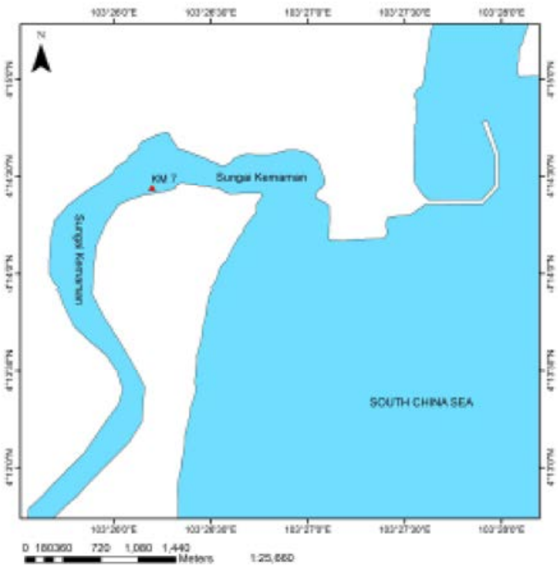

Fig. 1: Location of the collected core in Kemaman River Estuary.

MATERIALS AND METHODS

Study Site: Kemaman Estuary receives the flow of water from two major rivers, namely Kemaman and Cukai River. In term of size and annual outflow, Kemaman River is relatively larger and higher than Chukai River. The geographical features of Kemaman can be divided into three main areas which including coastal, inland and hill foot area. The coastal area is where the majority of local people focus on fishing activities. The hill foot area is rich with tin ore, oil palm plantation and timber. Meanwhile the farming activities were dominated at inland area.

Sample Collection and Preservation: Core KM7 (103'26'11.76''E; 4'14'26.10'N) was sampled in the Kemaman estuary by using PVC pipe corer and the total core length is ~200 cm (Fig. 1). The collected core sample was brought back to laboratory for further analysis. In total, 100 samples were sectioned from 0 to 200 cm at 2 cm intervals at the laboratory.

Particle Size Analysis: The grain size sediments were determined using a modified method of Folk [7]. Sediment sample (~2 g) was placed in container and diluted with 100 mL distilled water. A few drops of hydrogen peroxide (H_2O_2) and hydrochloric acid (HCl) were added in order to remove the organic matter and carbonate material. 5 mL of calgon solution was added into the solution and left overnight to disperse the sediment particles. The characteristics of grain size sediments were analyzed by using Particle Size Analyzer (PSA) Malvern Master Sizer 2000.

The mean, sorting and skewness of each sample were calculated using equation defined by McBride [8];

$$\text{Mean grain size } (X_{\varnothing}) = \frac{(\Sigma f m)}{n}$$

$$\text{Sorting } (\sigma_{\varnothing}) = \frac{v\,\Sigma f\,(m - X_{\varnothing})^2}{100}$$

$$\text{Skewness } (Sk_{\varnothing}) = \frac{\Sigma f (m - X_{\varnothing})^3}{100 \sigma_{\varnothing} 3}$$

where,
n = number of sample
f=Weight (%) or volume (%) (Frequency) of each class size
m = mid-point of each class size

RESULTS AND DISCUSSION

Sediment Characteristic: Mean grain size can be described as index of grain size measurement due to its weight [9]. Higher value of mean grain reflects smaller the grain size [9]. The mean value of sediment samples of core KM7 in Kemaman river estuary ranged from 4.97 Ø to 7.22 Ø or ranging from the coarse silt to very fine silt according to Wentworth [10]. The cyclic trend between the mean grain size and percentage of clay shows similar trend downward the core sediment. At the depth between 0 and 80 cm the low-fluctuated trends were observed meanwhile the cyclic high-fluctuated trends were observed at the depth between 130 and 200 cm (Fig. 2). The different value in mean grain size may indicate the different energy conditions during the depositional process of accumulated sediment. Kamaruzzaman *et al*. [11] stated that during high velocity events fine particle was transported to the coastal area and left the coarser particle on the riverbed. At the depth from 90 to 110 cm showed the mixing of high and low fluctuated trends which indicates mixing energy environment between fine and coarse particles. The sedimentological characteristic of the study area in Kemaman estuary, like most other coastal environment is very dependent on the combination of physical forces such as tidal currents, freshwater runoffs and waves [4]. The grain size analysis of sediment may also indicate the impact of different

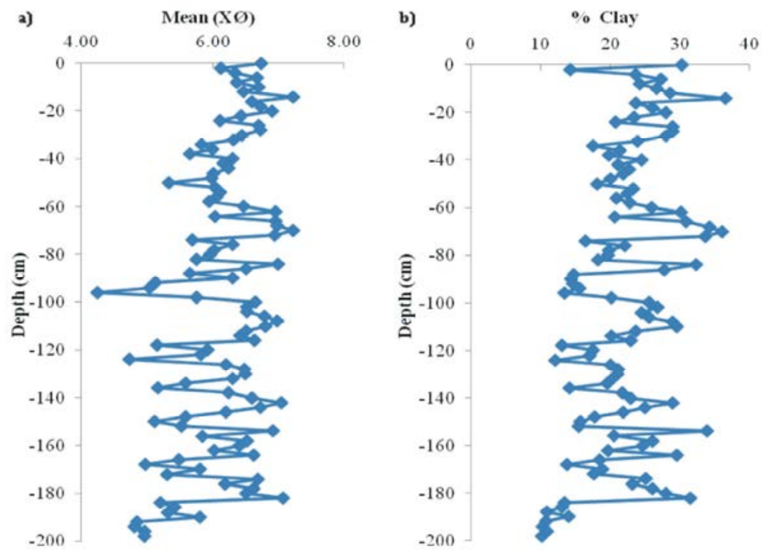

Fig. 2: a Mean (XØ) changes with the depth of sediment core (b) Percentage of clay with the depth of sediment core.

human activities on the coastal environment [12]. Thus, the activities such as boating, fishing, industrial and urbanization in this area may affect the sediment composition and grain size distribution over the time.

Skewness: Skewness is generally used to assess whether the sediment is in excess with fine and/or coarse fraction. Positive skewness values indicate that the normal size distributions are influenced by fine particles. While, the negative values imply that the sediment is dominated by coarse particles [13]. In this study, skewness are subjected to positively skewed which indicates that the distribution of grain size towards fine-grained sizes. This is might be due to the prevailing of shallow currents and wave action in the study area. Meanwhile negative value of skewness may reflect the effects of water energy that transported smaller particles seaward and leaving coarser particles on the bottom of the estuary [13]. Thus, the positive skewness indicates the sedimentation of major sediments in the studied core have been transported by low energy forces.

Textural Classification: The percentage of sand ranges from 2.97 to 57.85%, silt content ranges from 28.77 to 79% and clay content ranges from 10.3 to 36.53%. Overall, the distribution patterns of sand, silt and clay were dominated by silt with most of the sample has silty loam texture (Fig. 3 and Fig. 4). This is consistent with result of mean grain size distribution where fine sediments types are more dominated in the studied core. The transportation process of suspended and bed load material in estuaries are complicated but the observation in this study indicates that the river flow allows fine sediment to be deposited however when it reach the estuary, the energy of river flow reduce and thus allow more fine sediment to be deposited. Tides also play a role in transporting sediments offshore into the estuary, thus the sediment from the offshore may consist mostly fine sediment may also be transported into the estuary [4]. This is supported by the changing sediment texture between loam and silt loam texture (Fig. 3). The loam texture reflects the high water energy and silt loam texture mirror low water energy.

Morphology of Sediment: Sorting and angularity are two factors can affect the sediment characteristics (Fig.5). Sorting of sediment is separated according to size and can be categorized as very well sorted, well sorted, moderately sorted and poorly sorted. Poor sorting (large value of standard deviation) indicates a little selection of grain size during transportation deposition meanwhile good sorting (small value of standard deviation) reflects a selective grain size by energy action during transportation deposition [9]. The sorting value of the studied core of Kemaman estuary was ranged from 2.73 Ø (poorly sorted) to 1.53 Ø (moderately well sorted) with an average of 2.00 Ø (poorly sorted). Sorting of sediments are depends on four major factors which are the size of the materials supplied into the environment, type of deposition, current characteristics and time rate of the supply of detritus compared to the sorting agent [14]. Generally, smaller and finer sediment can be transported in longer

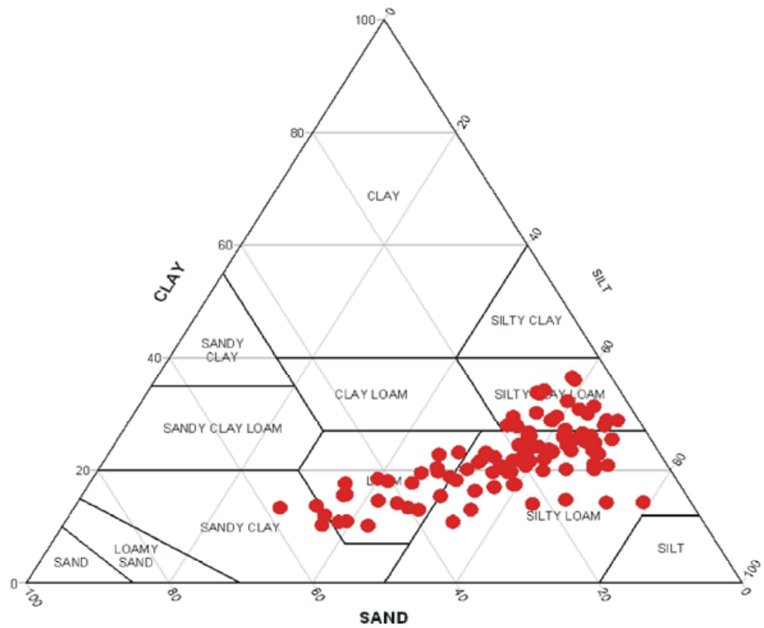

Fig. 3: Textural classification of core sediment of Kemaman Estuary.

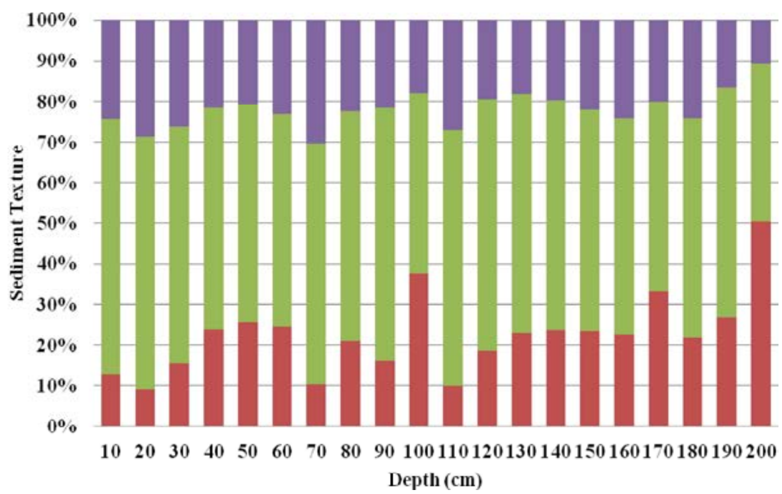

Fig. 4: Percentage of sand (■), silt (■) and clay (■) in core sediment of Kemaman Estuary.

distance compare to the larger and coarser sediment [15]. The geographical condition of the Kemaman River might reduce the water flow and allows more selection on deposited sediment in the estuary [5]. Thus, we suppose that poor sorted type in this environment reflect the fluctuated energy over a wide spectrum [13].

Angularity is the texture of sediment after it has travelled from its origin. As sediment grains travel, they collide with other sediment particles and objects. This action will change the shape and size of the particles. Sediment particles that have travelled farther from their origin tend to be smoother, more rounded and finer compare to the sediment that are moving in the short distance [15]. Overall most of the samples were categorized as poorly sorted which shows little selection of grain size during transportation deposition meanwhile the major portion of the skewness is mostly positive, indicating that the normal size distribution is influenced by finer size particles. The dominant present of silt and clay in the estuary shows that the depositional process in the estuary is under the influence of currents. Morphology of grain shape of the samples can be classifed as angular and sub-angular shape. This indicates that the sediment particles have travelled farther from their origin as it tend to be smoother, rounded and dominated by finer sizes.

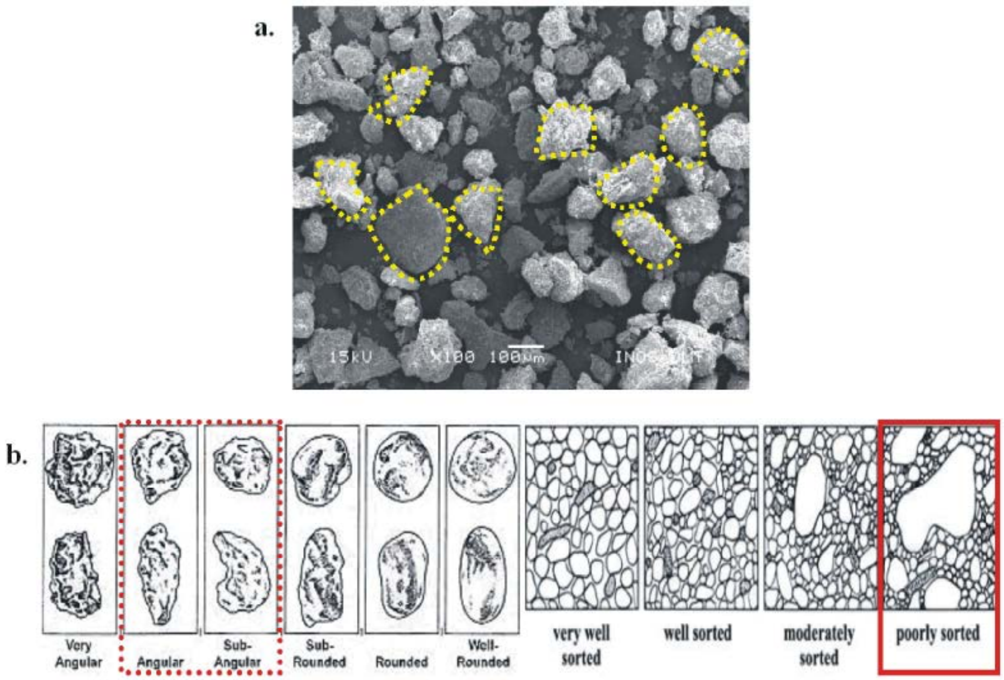

Fig. 5: (a) SEM image of sample at 168 cm depth showing angular and sub-angular size range of sediment. This sample is classified as very poorly sorted sediment. (b) Morphology of sediment classification by David [16].

CONCLUSION

Sediment composition and deposition in Kemaman Estuary is highly depends on its source and the transport agent (i.e. river flow, tidal flow, wave activity and currents). The travel distance of deposited sediment is highly depending on its size, erosion rate or speed. The characteristics and texture of sediments suggest that the deposited sediments in the studied area are dependent upon the combination of physical forces such as freshwater runoff, tidal currents and waves. In general the depositional environment in the core sediment of Kemaman River estuary was more influenced by the terrestrial deposits rather than marine input. However, we unable to discuss the influence of energy forces on sedimentation process in more detail due to the lack of river flow velocity data in Kemaman Estuary.

ACKNOWLEDGEMENT

This research was supported by the Research Acculturation Grant Scheme (RAGS) vot. 57097. The author would like to thank the staff of School of Marine and Oceanographic Laboratory of Environmental Sciences and Institute of Oceanography and Environment for their help and assistance in this project.

REFERENCES

1. Mead, S. and A. Moores, 2005. Estuary sedimentation: A review of estuarine sedimentation in the Waikato region (ISSN: 1172-4005). Environment Waikato technical report series 2005/13.
2. Kumar, S.P. and M.S. Sheela, 2013. Studies on the sediment characteristics of Manakudy Estuary, South west coast of India. International Research Journal of Environmental Sciences, 2(11): 78-83.
3. Dyer, K.R., 1995. Sediment Transport Processes in Estuaries. Geomorphology and Sedimentology in Estuaries, pp: 423.
4. Kamaruzzaman, B.Y., N.A.M. Shazili and H. Mohd Lokman, 2002. Particle size distribution in the bottom sediments of the Kemaman River estuarine system, Terengganu, Malaysia. Pertanika Journal of Tropical Agricultural Science, 25(2): 149-155.
5. Ong, M.C., B.Y. Kamaruzzaman and Noor M.S. Azhar, 2001. Sediment characteristic studies in the surface sediment from Kemaman mangrove forest, Terengganu, Malaysia. Oriental Journal of Chemistry, 28(4): 1639-1644.

6. Hedge, V.S., Kanchanagouri, D. Gosavi, PT. Hanamgond, G.K. Huchchannavar, G. Shalini and M.S. Bhat, 2004. Depositional environment and silting in the Sharavati estuary, central west coast of India. Indian Journal of Marine Sciences, 33(3): 296-302.
7. Folk, R.L., 1974.. Petrology of Sedimentary Rocks. Austin, Texas: Hemphill publishing Company.
8. McBride, E.F., 1971. Mathematical treatment of grain size distribution data. In R.A. Davies Jr (ed.). Procedure in sedimentary petrology. New York: Wiley Interscience.
9. Kamaruzzaman, Y., M.C. Ong, R. Hashim and A.J.K. Chowdhury, 2008. Seasonal bed sediment characteristic of the Kuala Sepetang River, Perak. Sains Malaysiana, 37(2): 143-147.
10. Wentworth, C.K., 1922. A Scale of Grade and Class Terms for Clastic Sediments. The Journal of Geology, 30(5): 377-392.
11. Kamaruzzaman, B.Y., M.C. Ong, N.A.M. Shazili, S. Shabudin and K.C.A. Jalal, 2008. Geochemistry of sediment in the major estuarine mangrove forest of Terengganu region, Malaysia. American Journal of Applied Sciences, 5(12): 1707-1712.
12. Hanif, H.F., T. Jamil, K. Lias and D. Norsila, 2014. Seasonal variation of rain size and heavymetals concentration in sediment of Sungai Perlis. The Malaysian Journal of Analytical Sciences, 18(1): 162-169.
13. Nor Antonina, A., M.S. Noor Azhar, Y. Rosnan and B.Y. Kamaruzzaman, 2014. Grain size and metallic trace element contents in sediments of Kemaman coast, Terengganu, Malaysia, South China Sea. Journal Of Earth Science And Engineering, pp: 80-87.
14. Rosnan, Y., Mohd H. Lokman and N.A.M. Shazili, 1995. Grain-size distribution of sediment in the vicinity of Setiu Lagoon-estuary system. Pertanika Journal of Tropical Agricultural Science, 18(1): 71-76.
15. Adrian, S.A. and V.G. Ungureanu, 2010. Understanding coastal morphology and sedimentology. Terre et Environnement, 88: 105-111.
16. David, A., 2011. Sedimentary rocks. Retrieved from http://www.tankonyvtar.hu/en/tartalom/tamop425/0038_foldrajz_mineralogy_Da/ch01s12.html[Accessed on 1 May 2015].