JOURNAL OF COASTAL SCIENCES

Journal homepage: www.jcsonline.co.nr

ISSN: 2348 – 6740 Volume 3 Issue No. 2 - 2016 Pages 1-7

Sediment dynamics and depositional environment of Coleroon river sediments, Tamil Nadu, Southeast coast of India

P. Parthasarathy[1*], G. Ramesh[2], S. Ramasamy[1], T. Arumugam[1], P. Govindaraj[1], S. Narayanan[1], G. Jeyabal[1]

[1]*Department of Geology, University of Madras, Chennai, Tamil Nadu – 600025, India*
[2]*Department of Earth Sciences, Annamalai University, Chidambaram, Tamil Nadu – 608002, India*

A B S T R A C T

The present research has been focused on the textural characteristic of the river sediments. Grain size is the fundamental descriptive measure of the sediments and sedimentary rock. A large part of information about the mode of transport and deposition of the sedimentary particles can be obtained from the grain size and the sedimentary environment can be identified by the grain size parameters. A total of twenty surface sediment samples were collected in the Coleroon river, Nagapattinam District, Tamil Nadu. The samples were collected along the channel at an interval of 500m. Various statistical parameters such as Mean size (Mz), Standard deviation (σ_I), Skewness (Ski) and Kurtosis (K_G) were intended. The mean grain size demonstrate medium to fine size sand dominance, standard deviation (sorting) shows the sediments are moderately sorted to moderately well sorted nature, skewness indicates positively skewed and kurtosis values indicates the samples are mesokurtic to very leptokurtic in nature. Linear Discriminant Analysis (LDA) of the sediment samples indicates shallow marine condition in a fluvial (deltaic) environment deposited under aeolian processes. Based on the CM pattern the sediments fall in rolling field.

*Corresponding author, E-mail address: petrosarathy@gmail.com
Phone: +919790553675,

A R T I C L E I N F O

Received
21 April 2016
Accepted
17 October 2016
Available online
20 October 2016

Keywords
Grain size
Sediment dynamics
Linear discriminate analysis
Coleroon river
South India

1. Introduction

Grain size properties of sediment particles provide important clues to the sediment provenance, transport and depositional history (Folk and Ward 1957; Friedman 1979; Flemming 2007). The important roles of rivers are erosion, produce, transport and deposition of the sediment and change the earth's morphology. This issue is lead to broad studies by different researchers about rivers and the effective processes in this environment as suggested by McLaren (1981); Sun et al., (1996); Rice (1998); Hoey and Bluck (1999); Asselman and Middlekoop (1998); Gomez et al., (2001); Paphitis et al., (2001); Kleinhans (2001); Surian (2002) and Moussavi-Harami et al., (2004). Grain size is one of the most significant physical property of sediment and commonly used parameter for understanding the processes involved in transportation and deposition of sediments (Inman 1952; Folk and Ward 1957; Mason and Folk 1958; Friedman 1961; Krumbein and Sloss 1963; Nordstrom 1977). The Cauvery and Coleroon river has been widely studied for the sedimentological parameters (Seralathan and Seetharamasamy 1979; 1982; 1987; Vaithiyanathan et al., 1992; Alappat et al., 2010; Venkatramanan et al., 2010 and 2011; Anithamary et al., 2011; Singarasubramanian et al., 2009 and 2011; Sujatha et al., 2011 and 2013; Suganraj et al., 2013 and Venkatesan et al., 2015). Sediments are mechanically and/or chemically weathered rocks, they are loose, unconsolidated materials. They are eroded (picked-up) and transported (moved-along) to a new location. The most common mode of transport is the running water in rivers, ocean currents, etc. Winds, glaciers, and mass movements (such as landslides) are other less common modes of transport. River sediments originate from the erosion of near surface, exposed igneous, metamorphic or sedimentary rocks. Some of these are easily eroded, whereas others, especially the igneous and metamorphic rocks, are affected by streams only when altered in the surface (Joshua and Oyebanjo 2010). The sediments are then deposited and may eventually be buried to produce a sedimentary rock. The grain size distribution is a simple yet informative test routinely performed in soil mechanics to classify soils (Fredlund et al., 2000). The environmental interpretation of grain-size distributions found in sedimentary deposits has been, and still is, a fundamental goal of sedimentology (Patric and Donald 1985). Investigation of grain size distribution has been widely used by sedimentologists to classify sedimentary environments and elucidate transport dynamics. Grain size distribution is affected by other factors such as distance from the shoreline, distance from the source (river), source material, topography and transport mechanisms. The purpose of the present study is to determine statistically the significant of grain size distribution of Coleroon river sediments.

2. Study area

The study area is drained by Coleroon river and its distributaries. These entire streams are ephemeral and carry floods during monsoon. They generally flow from west towards east and the pattern is mainly sub parallel. The eastern coastal part near Pazhayar is characterized by backwater. Coleroon river, a major waterway of the Trichy and Thanjavur district, is formed by the bifurcation of the Cauvery, which flows through the Chidambaram taluk for 36 miles and finally joins the Bengal 6 miles south of Portonova (Parangipettai). Since the district is underlined by sedimentary formation, the major landforms that occur are natural levees near Mayiladuthurai coastal plain covering almost the entire district with beaches, beach ridges, mudflats swamps, and backwater along the coastal stretch. The humidity recorded in the study area ranges from 60-83%. Higher humidity rates are observed during the months of northeast monsoon period, whereas low rates are observed during the summer period. In this area, southwest monsoon and northeast monsoon are predominant; the long-term annual average rainfall is 1160 mm of the study area. The deltaic plains are found near the confluence of river Coleroon with sea in the east and in the south (Fig.1).

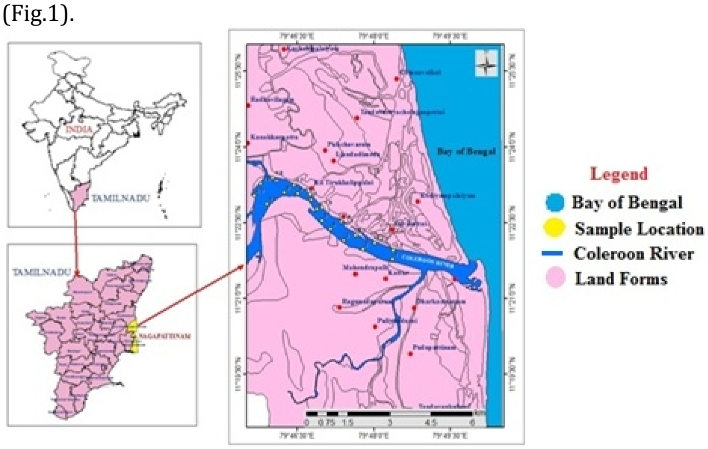

Fig.1 Location map of the study area

3. Materials and Methods

The methods of study broadly confined to field investigation, which includes survey, auguring the samples up to 50 cm. Representative samples were taken and subjected to determine textural analysis. The Coleroon river downstream sediment samples were collected up to 50cm depth at 500 m interval in twenty specific locations along the river belt between Alakkudi to Mahendrapalli in the downstream. The location of each sampling point (Table 1) was taken using a Global Positioning System (GPS) GARMIN 76 CSx. Sediment samples were then frozen to 4°C prior to analysis. The sediments were dried for 24 hours in a hot air oven at 60°C to remove the moisture before analysis. Initially 100 g of sample is prepared by removing carbonate and organic matters by treating with 10% dilute hydrochloric acid and 6% hydrogen peroxide respectively. From the dried samples, 100 g was taken by the conning and quartering method. The 100 g of sample is then subjected to sieve analysis in ASTM sieves at half phi intervals for about 30 minutes in Ro-tap sieve shaker. The sieved material in each fraction were collected and weighed. The weights of the individual fractions were tabulated for textural analysis. This basic data i.e. weight percentage frequency data is converted into cumulative weight percentage data, that served as basic tool for the generation of other statistical parameters. For the present study, GRADISTAT, version 4.0 program developed by Blott and Pye (2001) is used. It is provided in Microsoft Excel format to allow both spreadsheet and graphical output.

Location	Latitude	longitude
1	11°22'15.86"N	79°47'16.96"E
2	11°22'21.14"N	79°47'8.86"E
3	11°22'31.30"N	79°46'56.89"E
4	11°22'37.76"N	79°46'52.37"E
5	11°22'47.24"N	79°46'49.95"E
6	11°22'55.62"N	79°46'46.61"E
7	11°23'0.12"N	79°46'38.81"E
8	11°23'3.38"N	79°46'23.15"E
9	11°23'2.72"N	79°46'13.31"E
10	11°22'56.18"N	79°46'2.63"E
11	11°23'9.58"N	79°45'43.84"E
12	11°23'17.05"N	79°45'49.28"E
13	11°23'24.54"N	79°45'58.40"E
14	11°23'22.99"N	79°46'8.87"E
15	11°23'20.01"N	79°46'15.71"E
16	11°23'15.48"N	79°46'26.61"E
17	11°23'6.11"N	79°46'40.60"E
18	11°22'59.46"N	79°46'49.88"E
19	11°22'52.77"N	79°46'56.43"E
20	11°22'36.21"N	79°47'9.89"E

Table 1. Geographical locations of Coleroon River sediment samples

4. Results and discussion

The grain size parameters and transport processes/depositional mechanisms of sediments have been established by exhaustive studies for several recent and ancient sedimentary environments (Folk and Ward 1957; Mason and Folk 1958; Friedman 1962; Visher 1969; Valia and Cameron 1977; Wang et al., 1998; Asselman 1999; Malverez et al., 2001). In the present study, textural parameters are discussed.

4.1. Mean (Mz)

Mean size of the sediments are influenced by the source of supply, transporting medium, and the energy conditions of the depositing environment (Folk and Ward 1957). Mean size indicates the central tendency or the average size of the sediment and in terms of energy; it indicates the average kinetic energy/velocity of depositing agent (Sahu 1964). The mean phi size of the Coleroon river sediments varying with a maximum of 1.84φ to a minimum of 2.94φ with an average of 2.38 φ (Fig. 2). Predominantly 95% of the samples exhibit fine sand and 5% of the samples fall under medium sand category (Table 2). The slow decrease in mean size clearly exhibits that the gradual increase in energetic condition of fluvial regime towards coast. Fine grained nature of sediments shows that they were deposited by river processes with low fluvial discharge and week wave conditions (Venkatramanan et al. 2011). Mean size indicates that the sediments were deposited in a moderately low energy environment. This suggests that the sediments were deposited under medium to low energy condition, as sediments usually become finer with decrease in energy of the transporting medium (Folk 1974; Eisema 1981).

4.2. Standard deviation (Std)

Standard deviation measures the sorting of sediments and indicates the fluctuations in the kinetic energy or velocity conditions of the depositing agent (Sahu 1964). Fine sediments are better sorted than coarser to medium sediments (Griffith 1951; Inman and Chamberlain 1955). The observed sorting variation attributes to the difference in water turbulence and variability in the velocity of depositing current. It is expressed by inclusive graphic standard deviation of Folk and Ward (1957). The standard deviation of sediments in study area ranged from 0.52φ to 0.99φ, with an average of 0.73φ (Table 2 and Fig. 3). Sediment sample are dominated by moderately sorted 55% to moderately well sorted 45%, indicates the influences of stronger energy condition of depositing agents or prevalence of strong energy condition in the basin (Lakhar and Hazarika 2000). This is indicative of low to fairly high energy current (Friedman 1961a; Blott and pye 2001).

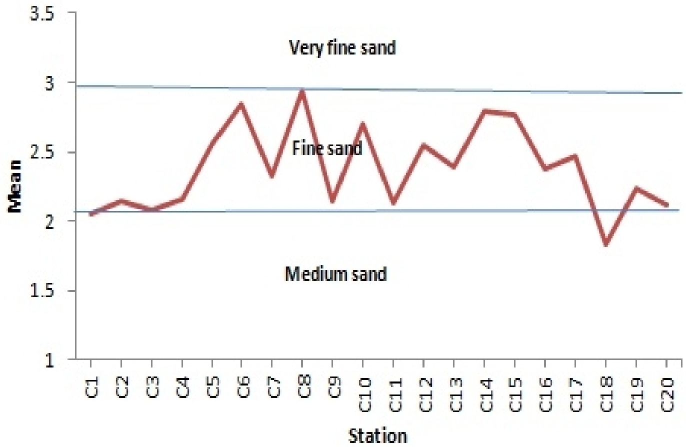

Fig. 2. Distribution of Mean

energy environment prevailing there. The skewness values ranges from 0.15 φ to 0.39 φ with an average of 0.25 φ (Table 2 and Fig. 4). The values indicate fine skewed 85%, very fine skewed 15% category. The dominants of fine skewed nature of sediments indicates generally imply the introduction of fine material or removed of coarser fraction (Friedman 1961) or winnowing of sediments (Duane 1964). Fine skewed sediments generally imply the introduction of the fine materials, very fine skewed skewed nature of sediments indicates excessive riverine input (Angusamy and Rajamanickam 2007). This study suggests positive skewness adverting unidirectional transport or deposition of sediments in a low energy sheltered environment (Folk and Ward 1957).

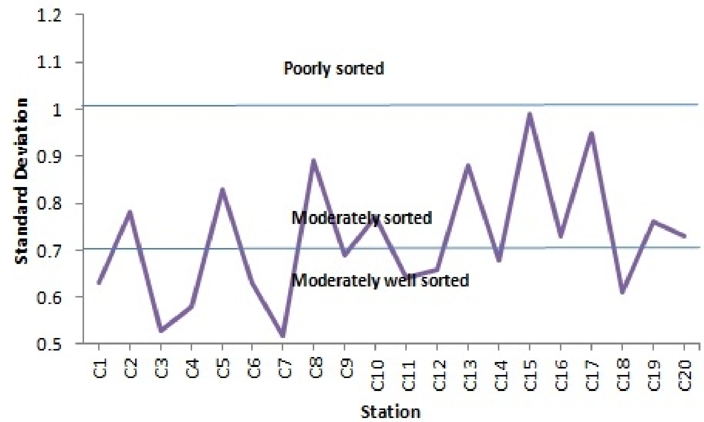

Fig.3. Distribution of Standard deviation

S.No.	Mean	Median	Standard Deviation	Skewness	Kurtosis	Remarks
C1	2.05	2.12	0.63	0.21	1.23	MS, MWS, FS, LK
C2	2.14	2.28	0.78	0.24	1.42	FS, MS, FS, LK
C3	2.08	2.1	0.53	0.15	1.4	FS, MWS, FS, LK
C4	2.16	4.23	0.58	0.22	1.41	FS, MWS, FS, LK
C5	2.56	1.63	0.83	0.25	1.26	FS, MS, FS, LK
C6	2.85	1.92	0.63	0.29	1.44	FS, MWS, FS, LK
C7	2.33	2.27	0.52	0.26	1.31	FS, MWS, FS, LK
C8	2.94	2.03	0.89	0.22	1.34	FS, MS, FS, LK
C9	2.14	2.09	0.69	0.37	1.24	FS, MWS, VFS, LK
C10	2.7	1.46	0.77	0.23	1.35	FS, MS, FS, LK
C11	2.13	2.13	0.64	0.26	1.62	FS, MWS, VLK
C12	2.55	2.19	0.66	0.37	1.46	FS, MWS, VFS,
C13	2.39	2.06	0.88	0.26	1.58	FS, MS, FS, VLK
C14	2.79	2.54	0.68	0.25	1.19	FS, MWS, FS, LK
C15	2.76	2.41	0.99	0.2	1.55	FS MS, FS, VLK
C16	2.38	2.22	0.73	0.21	1.1	FS, MS, FS, LK
C17	2.47	2.43	0.95	0.2	1.31	FS, MS, FS, LK
C18	1.84	2.07	0.61	0.25	0.97	MS, MWS, FS, MK
C19	2.24	2.63	0.76	0.23	1.56	FS, MS, FS, VLK
C20	2.12	2.46	0.73	0.39	1.36	FS, MS, FS, LK
Max	2.94	4.23	0.99	0.39	1.62	
Min	1.84	1.46	0.52	0.15	0.97	
Avg	2.38	2.32	0.73	0.25	1.35	

Table 2. Textural parameter of Coleroon river sediments

Note: MS: Medium Sand, FS: Fine Sand, MS: Moderately Sorted, MSW: Moderately Well Sorted, LK: Leptokurtic, VLK: Very Leptokurtic

4.3. Skewness (Ski)

Skewness measures the asymmetry of a frequency distribution. Duane (1964) observed that positive skewness characterizes the area of deposition and the sediments are negatively skewed owing to the influence of the cyclic current pattern, indicative of the high-

4.4. Kurtosis (K_G)

The graphic kurtosis (K_G) is the peakedness of the distribution and measures the ratio between the sorting in the tails and central portion of the curve. If the tails are better sorted than the central portions, then it is termed as platykurtic, but if the central portion is better sorted then it is leptokurtic. If both are equally sorted then mesokurtic condition prevails. The Coleroon river sediments show kurtosis values from 0.97 φ to 61.62 φ with an average of 1.35 φ (Table 2 and Fig. 5). The samples fall under leptokurtic nature (75%) very leptokurtic (20%) and mesokurtic (5%). This strongly suggests a fluvial or tidal environment, confirming that the sands are river deposited. The dominant mesokurtic to leptokurtic nature of sediments refers to the continuous addition of finer or coarser materials after the winnowing action and retention of their original characters during deposition (Avramidis et al. 2012). Fine sand size particles dominated in the study area sediments reflect maturity of the sand variation in sorting are likely due to continuous addition of finer and coarser materials in varying proportions.

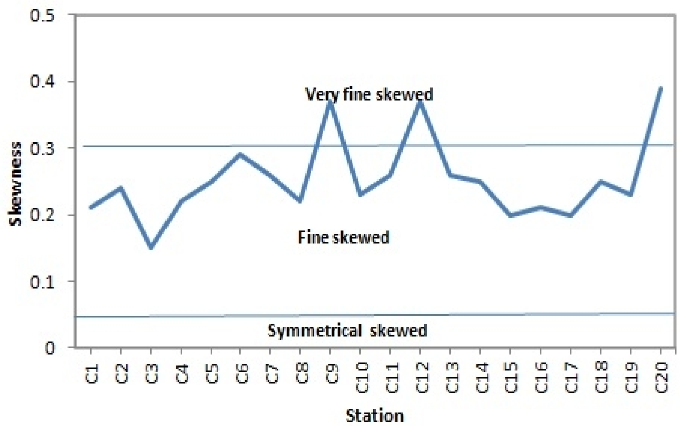

Fig.4. Distribution of Skewness

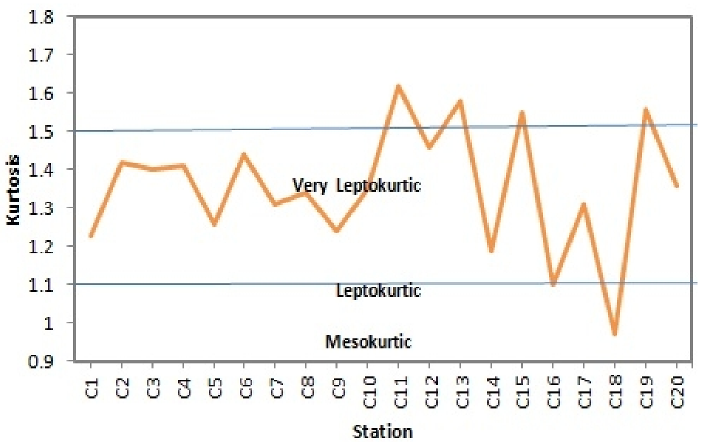

Fig.5. Distribution of Kurtosis

4.5. CM pattern

According to Passega (1957), the logarithmic plots of the coarsest 1-percentile grain size (C) and the median grain size (M) of deposits may reveal patterns characteristic of distinct sedimentary environments. If this is true, the depositional environments of sediments may be determined partly by CM patterns, which distinguish between the sediments of different environments of fluvial and deltaic deposits. The relationship between C and M is the effect of sorting by bottom turbulence. Good correlation between C (one percent by weight of the sample) and M (grain size as a whole), shows the precision of control of sedimentation by bottom turbulence. CM pattern is subdivided into segments, namely NO, OP, PQ, and RS. NO and OP represent rolling sediments and rolling sediments with some suspension respectively. In the present study, an attempt has been made to identify the mode of deposition in sediments of Coleroon river using CM pattern (Fig. 6). This group reflects suspension and rolling mode of transportational history, indicating the complexity in the hydrodynamic process operating in these systems.

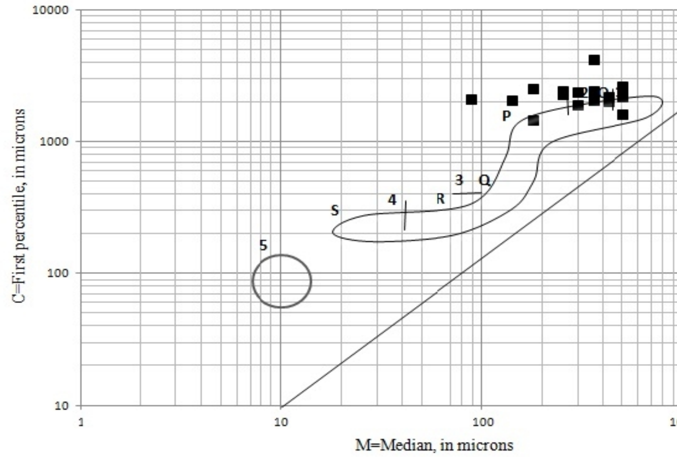

Fig. 6. CM-Pattern showing surface sediments

4.6. Bivariant plots

Bivariate plots between the different sensitive textural parameters throw light on information regarding the depositional environment of sedimentation and demarcate the fields of overlapping of closely related depositional environments. Inman (1952); Folk and Ward (1957); Friedman (1961 and 1978) have successfully used the scatter plots for understanding the geological significance of the four size parameters. Simple bivariant plots (Fig's. 7 to 8) were used to elucidate patterns related to different environments. The bivariant plot of mean vs. standard deviation (Fig. 7) shows that the sediments are moderately well sorted fluvial and beach environment. This plot clearly indicates these sediments are the influence of fluvial environment because the river input is more than the littoral current. The scatter plot of standard deviation vs. skewness (Fig. 8) also helps to characterize as a separate cluster. The study region shows the influence of fluvial and beach environments. The energy processes of Coleroon river samples falls in both river processes and inner shelf processes (Fig. 9).

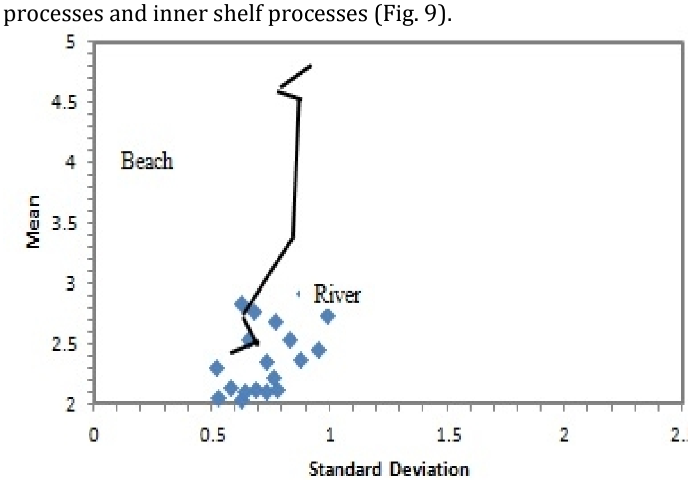

Fig.7. Mean vs. Standard Deviation (Moiola and Weiser 1978)

4.7. Linear discriminate function (LDF)

The linear discriminant function of Sahu (1964) has been used for multivariate analysis of beach sediments. According to Sahu, the statistical method of analysis of the sediments to interpret variations in the energy and fluidity factors seems to have excellent correlation with different processes and environment of deposition. The following formulae and their limitation to a particular environment were utilised to interpret the environment of deposition of sediments.

1. Aeolian/beach:
Y1 (A:B)= -3.5688 M +3.7016 r^2 -2.0766 SK + 3.1135 KG
If Y is >−2.7411, the environment is 'Beach' but if Y is <−2.7411, the environment is 'Aeolian'.

2. Beach/shallow agitated water
Y2 (B:SM) = 15.6534 M + 65.7091 r^2 +18.1071 SK + 18.5043 KG
If Y is <63.3650, the environment is 'Beach' but if Y is >63.3650, the environment is 'Shallow marine'.

3. Shallow marine/fluvial environment
Y3 (SM:F) = 0.2852 M- 8.7604 r^2 – 4.8932 SK + 0.0482 KG

If Y is >−7.4190, the environment is 'Shallow marine' but if Y is <−7.4190, the environment is 'Fluvial'.

4. Fluvial/turbidity
Y4 (F:Turb)= 0.7215 M + 0.403 r^2+ 6.7322 SK + 5.2927 KG

If Y is >10.000, the environment is 'Turbidity' but if Y is <10.000, the environment is 'Fluvial'. (Y1 0 aeolian/beach, Y2 0 beach/shallow marine, Y3 0 shallow marine/fluvial, Y4 0 fluvial/turbidity).

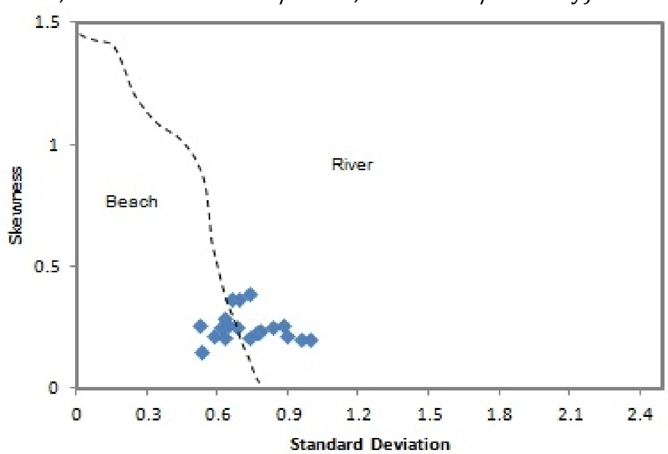

Fig.8. Skewness vs. Standard Deviation (Friedman 1967)

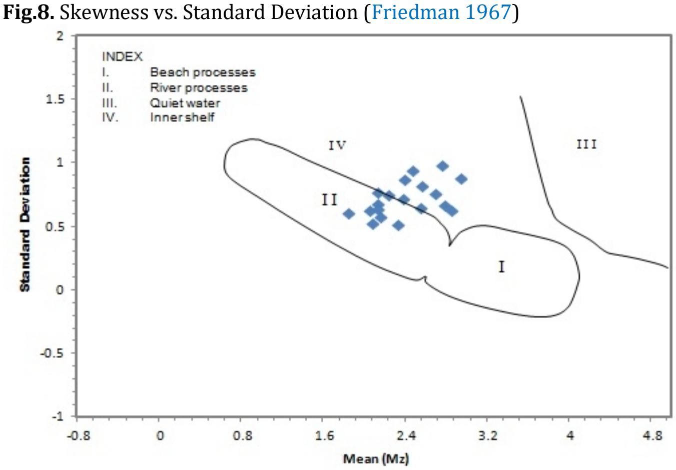

Fig.9. Mean vs. Standard deviation (after Stewart 1958)

Variations in the energy and fluidity factors seem to have excellent correlation with the different processes and the environment of deposition (Sahu 1964). The process and environment of deposition were deciphered by Sahu's linear discriminate analysis. Y1 (Aeolian, beach), Y2 (Beach, shallow agitated water), Y3 (shallow marine, fluvial) and Y4 (Turbidity, fluvial) were used to decipher the process and environment of deposition. With reference to Y1 value, aeolian process contributes 45% and 55% by beach at Coleroon river. With reference to Y2 value, 100% of the sample falls under shallow agitated water process. With reference to Y3 value, 90% of the sample falls under shallow marine and 10% of the sample under fluvial (deltaic) environment condition respectively. With reference to Y4, 70% of the samples falls in fluvial (deltaic) and 30% sample falls in turbidity action respectively (Table 3). The results of the present study indicate that the sediments are derived from both fluvio (sediments discharged by rivers) and marine environments. It can be inferred that the sediments in the present-day beaches must have been deposited in a shallow marine environment and in due course of time, marine regression must have led to the development of the present-day shorelines (Angusamy and Rajamanickam 2007).

4.8. Multigroup multivariant discriminant functions V1-V2 plot

Discriminant function analysis (linear and multigrain) proposed by after Sahu (1983) was applied for discriminating the depositional environment of the surface sediments. A rigorous statistical method of multigroup multivariant linear discriminant functions proposed by Sahu (1983) was applied for discriminating the depositional environment of Colleroon river. When the values of the discriminant functions of V1 and V2 were plotted on the multigroup multivariant discriminant diagram (Fig. 10). The Coleroon River sediments fall in the field of the river and turbidity environment deposition. An overall turbidite environment is indicated by linear discriminant function analysis suggest the sediments were transported by inequipropotional mechanism of the river sediments.

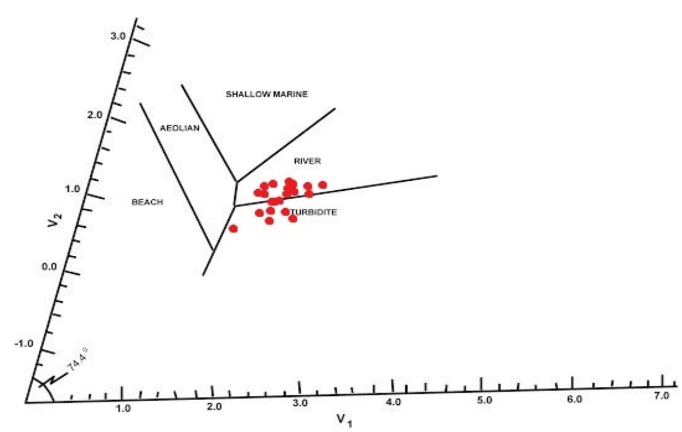

Fig.10. V1 and V2 plot after Sahu (1983) showing river and turbidite of deposition of Coleroon river sediments

5. Conclusions

The investigation of the textural characteristics revealed that the size distributions of the mean values are indicates the dominance of fine grained nature. The sediments in generally moderately well sorted to moderately well sorted, indicating texturally immature to sub-mature sediments of a fluvial environment. Skewness is fine

S.No.	Linear Discriminant Function (LDF)								Discriminant Function	
	Y1	Remarks-Y1	Y2	Remarks-Y2	Y3	Remarks-Y3	Y4	Remarks-Y4	V1	V2
C1	-2.45	Beach	84.73	Sh. Agitated water	-3.86	Shallow Marine	9.24	Turbidity	2.40	0.99
C2	-1.46	Beach	104.10	Sh. Agitated water	-5.83	Shallow Marine	10.43	Fluvial (deltaic)	2.73	1.04
C3	-2.34	Beach	79.64	Sh. Agitated water	-2.53	Shallow Marine	9.81	Turbidity	2.34	1.22
C4	-2.53	Beach	85.99	Sh. Agitated water	-3.34	Shallow Marine	10.37	Fluvial (deltaic)	2.48	1.22
C5	-3.18	Aeolian	113.18	Sh. Agitated water	-6.47	Shallow Marine	9.92	Fluvial (deltaic)	2.93	0.96
C6	-4.82	Aeolian	102.59	Sh. Agitated water	-4.01	Shallow Marine	11.47	Fluvial (deltaic)	2.91	1.37
C7	-3.78	Aeolian	83.19	Sh. Agitated water	-2.91	Shallow Marine	10.26	Fluvial (deltaic)	2.45	1.23
C8	-3.84	Aeolian	126.85	Sh. Agitated water	-7.11	Shallow Marine	10.38	Fluvial (deltaic)	3.21	1.06
C9	-2.78	Aeolian	94.43	Sh. Agitated water	-5.31	Shallow Marine	10.41	Fluvial (deltaic)	2.59	0.99
C10	-3.72	Aeolian	110.37	Sh. Agitated water	-5.48	Shallow Marine	10.40	Fluvial (deltaic)	2.95	1.12
C11	-1.58	Beach	94.94	Sh. Agitated water	-4.17	Shallow Marine	11.70	Fluvial (deltaic)	2.65	1.34
C12	-3.71	Aeolian	102.25	Sh. Agitated water	-4.83	Shallow Marine	11.88	Fluvial (deltaic)	2.85	1.30
C13	-1.28	Beach	122.24	Sh. Agitated water	-7.30	Shallow Marine	11.53	Fluvial (deltaic)	3.05	1.15
C14	-5.06	Aeolian	100.60	Sh. Agitated water	-4.42	Shallow Marine	9.81	Turbidity	2.82	1.10
C15	-1.81	Beach	139.91	Sh. Agitated water	-8.70	Fluvial (deltaic)	11.15	Fluvial (deltaic)	3.33	1.10
C16	-3.53	Aeolian	96.43	Sh. Agitated water	-4.96	Shallow Marine	8.74	Turbidity	2.63	0.87
C17	-1.81	Beach	125.83	Sh. Agitated water	-8.12	Fluvial (deltaic)	9.70	Turbidity	3.03	0.86
C18	-2.69	Beach	75.73	Sh. Agitated water	-3.91	Shallow Marine	7.99	Turbidity	2.18	0.74
C19	-1.48	Beach	106.05	Sh. Agitated water	-5.47	Shallow Marine	11.19	Fluvial (deltaic)	2.81	1.20
C20	-2.17	Beach	100.43	Sh. Agitated water	-5.91	Shallow Marine	11.14	Fluvial (deltaic)	2.69	1.05

Table 3. Linear Discriminant Function (LDF) Sahu (1964) and Discriminant Function (Sahu 1983)

skewed to very fine skewed nature and most of the samples fall in leptokurtic nature. From the energy process LDF of the sediments were deposited predominantly by aeolian and beach process under shallow agitating environment and carried by turbidity action. The CM plots indicate that the Coleroon river sediments underwent the rolling and suspension under tractive current.

Acknowledgements

I am thankful to Dr. S. Vasudevan, Annamalai University, for his precious help. I am grateful to the reviewers for their constructive reviews of our manuscript. I would like to thank Editor of the Journal.

References

Alappat, L., Tsukamoto, S., Singh, P., Srikanth, D., Ramesh, R., Frechen, M., 2010. Chronology of Cauvery delta sediments from shallow subsurface cores using elevated-temperature post-IR IRSL dating of feldspar. Geochronometria, 37: 37-47.

Allen, J.R.L., 1965. A review of the origin and characteristics of recent alluvial sediments, Sedimentology, 5: 89-191.

Angusamy, N., Rajamanickam, G., 2007. Coastal processes of central Tamil Nadu, India: Clues from grain size studies. Oceanologia, 49: 41-57

Angusamy, N., Rajamanickam, G.V., 2000. Distribution of Heavy minerals along the beach from Mandapam to Kanyakymari, TN. Jour. Geol. Soc. India, 56: 199-211.

Anithamary, I., Ramkumar, T., Venkataraman, S., 2011. Grain size characteristics of the Coleroon estuary sediments, Tamilnadu, East coast of India. Carpathian Jour. Earth and Envi. Sci., 6(2): 151-157.

Anthony, E., Hequette, A., 2007. The grain-size characterisation of coastal sand from the Somme estuary to Belgium: Sediment sorting processes and mixing in a tide- and storm-dominated setting. Sedimentary Geology, 202: 369-382.

Asselman, N.E.M., 1999. Grain size trends used to assess the effective discharge of flood plain sedimentation. River Waal. Netherlands Journal of Sediment Research, 69 (1): 51–61.

Asselman, N.E.M., Middlekoop, H., 1998. Temporal variability of contemporary floodplain

Avramidis P., Samiotis A., Kalimani E., Papoulis D., Lampropoulou P., Bekiari V., 2012. Sediment characteristics and water physicochemical parameters of the Lysimachia Lake, Western Greece, Environ Earth Sci., 70 (1): 383-392.

Blott, S. J., Pye, K., 2001. GRADISTAT: A grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surfaces Processes and Landforms, 26: 1237–1248.

Cadigan, R.A., 1961. Geologic interpretation of grain size distribution measurement of Colorado Plateau sedimentary rocks. Jour. Geol., 69: 121-144.

Chauhan, O.S., 1990. Sedimentological parameters of beach sediments on the east coast of India, J. Coastal Res., 6: 573-585.

Duane, D.B., 1964. Significance of skewness in recent sediments, western Pamlico Sound, North Carolina, J. Sediment, Petrol, 34 (4): 864-874.

Eisema, D., 1981. Supply and deposition of suspended matter in the North Sea. Special Publication of the International Association of Sedimentologists, 5: 415-428.

Flemming, B.W., 2007. The influence of grain-size method and sediment mixing on curve shapes and textural parameters: implications for sediment trend analysis. Sedimentary Geology, 202 (3): 425-435.

Folk, R.L., 1974. Petrology of sedimentary rocks. Austin Texas: Hemphili Publication, Company, p. 182

Folk, R.L., Ward, W.C., 1957. Brazos River bar: a study in the significance of grain size parameters. Journal of Sedimentary Petrology, 27: 3-26.

Fredlund, M.D., Fredlund, D. G., Ward Wilson, G., 2000. An equation to represent grain size disribution. Can. Geotech J., 37: 817-827.

Friedman, G.M., 1961a. Distinction between dune, beach and river sands from textural characteristics. Jour. Sed. Petrology, 31: 514-529.

Friedman, G.M., 1961b. Distinction between dune, beach and river sands from their textural characteristics. Journal of Sedimentary Petrology, 28: 151-153.

Friedman, G.M., 1962. On sorting, sorting coefficient, and the log-normality of the grain-size distribution of sandstones. Journal of Geology, 70: 737-53.

Friedman, G.M., 1967. Dynamic processes and statistical parameters compared for size frequency distribution of beach river sands. Journal of Sedimentary Petrology, 37: 327-354.

Friedman, G.M., 1978. Principles of sedimentology, John Wiley and Sons, New York, p.792.

Gomez, B., Rosser, B.J., Peacock, D.H., Hicks, D.M., Palmer, J.A. 2001. Downstream fining in a rapidly aggrading gravel bed river. Water Resour. Res., 37 (6): 1813 - 1823.

Griffiths, J.C.,1951. Size versus sorting in some Caribbean Sediments., J. Geol., 59: 211-243.

Gujar, A.R., Angusamy, N., Rajamanickam, G.V., 2007. Characterization of Opaques off Konkan Coast Maharashtra, Central West Coast of India. Journal of Minerals & Materials Characterization & Engineering, 6 (1): 53-67.

Hoey, T.B., Bluck, B.J., 1999. Identifying the controls on downstream fining gravels, Journal of Sedimentary Research, Section A: Sedimentary Petrology and Processes, 69 (1): 40-50.

Inman, D.L., 1952. Measures for Describing Size of Sediments, Journal of Sedimentary Petrology, 19: 125–145.

Joshua, E.O., Oyebanjo, O.A., 2010. Grain-size and heavy mineral analysis of river Osun sediments. Australian Journal of Basic and Applied Sciences, 4(3): 498-501.

Kleinhans, G.M., 2001. The key role of fluvial dunes in transport and deposition of sand-gravel mixtures, a preliminary note. Sedimentary Geology, 143 (1-2): 7-13.

Krumbein, W.C., 1934. Size Frequency Distribution of Sediments, Journal of Sedimentary Petrology, 4: 65–77.

Krumbein, W.C., Sloss, L., 1963. Stratigraphy and Sedimentation, Ch. 4, Properties of Sedimentary Rocks, pp 93-149.

Malverez, G.C., Cooper, J.A.G., Jackson, D.W.T., 2001. Relationship between waves induced currents and sediment grain size on a sandy tidal flat. J Sediment Res, 71(5): 705–712.

Martins, L.R., 1965. Significance of skewness and kurtosis in environment interpretation, J. Sedi. Petrol., 35: 768-770.

Mason, C.C., Folk R.L., 1958. Differentiation of beach, dune and aeolian flat environment by size analysis, Mustang Island, Texas, Jour. Sed. Pet., 28: 211-226.

Mc Cave, I.N., 2008. Size sorting during transport and deposition of fine sediments: Sortable silt and flow speed. In: Contourites. Developments in Sedimentology. Elsevier, Amsterdam, pp. 121-142.

Mc Laren, P., 1981. An interpretation of trends in grain size measures. Journal of Sedimentary Petrology, 51 (2): 611-624.

Moiola, R.J., Weiser, D., 1968. Textural parameters: An evaluation. Jour. Sed. Petrol., 38 (1): 45-53.

Moussavi-Harami, R., Mahboubi, A., Khanehbad, M., 2004. Analysis of controls downstream fining along three gravel bed rivers in the Band-e-Golestan drainage basin, NE Iran. Geomorphology, 61: 143-153.

Nordstrom, K.F., 1977. The use of grain size statistics to distinguish between high and moderate energy beach environments. Journal of Sedimentary Petrology, 47 (3): 1287-1294.

Paphitis, D., Velegrakis, A. F., Collins, M. B., Muirhead, A., 2001. Laboratory investigation into the threshold of movement of natural sand-sized sediments under unidirectional, oscillatory and combined flows. Sedimentology, 48: 645-659.

Passega, R., 1957. Texture as a characteristic of clastic deposition. Amer. Assoc. Petrol. Geol., 41: 1952-1984.

Passega, R., 1964. Grain size representation by CM patterns as a geological tool, J. Sediment. Petrol., 34 (4): 830–847.

Patric, M., Donald, B., 1985. The effects of sediment transport on grain size distribution. Journal of Sedimentary Petology, 55(4): 0457- 0470.

Rajamanickam, G.V., Gujar, A.R., 1988. Interpretation of environment of deposition from multivariate discriminant analysis, Indian J. Earth. Sci., 15: 234–247.

Rao, P.V.N., Suryam, R.K., Rao, V.R., 2005. Depositional environment inferred from grain size parameters of the sediments between False Devi Point to Kottapatnnam, Andra Pradesh Coast, J. Geol. Soc. India., 65: 317-324.

Rice, S., 1998. Which tributaries disrupt downstream fining along gravel Bed River? Geomorphology, 22: 39-56.

Sahu, B.K., 1964. Depositional mechanism from the size analysis of clastic sediments. J. Sediment Petrol, 34(1): 73–83.

Sahu, B.K., 1983. Multigroup discrimination of depositional environments using size distribution statistics. Indian J. Earth Sci, 10(1): 20–29.

Schhweggaeer, A.E., 1965. On the dynamics of deposition. Bull. Int. Ass. Sci. Wydrol., 10: 49-57.

Seralathan, P., 1979. Studies on some aspects of texture, mineralogy and geochemistry of modern deltaic sediments of Cauvery river, India. Unpublished Ph.D thesis submitted to Andhra University, Waltair.

Seralathan, P., 1988. Use of Textural CM pattern for identification of depositional processes in the sediments of the Cauvery delta. Bull. Dept. Mar. ScL, 14: 17 - 26.

Singarasubramanian, S.R., Mukesh, M.V., Manoharan, K., Seralathan, P., Srinivasulu, S., 2011. Geological and geomorphological perspectives of the tsunami on the Tamilnadu Coast, India- "Indian Ocean Tsunami, The Global response to a Natural Disaster", (Ed).Pradyumna Karan and Shanmugam P. Subbiah. University press of Kentuky, US. pp.65-97.

Singarasubramanian, S.R., Mukesh, M.V., Manoharan, K., 2005. A preliminary report on coastal sediment characteristics after M 9 tsunami event along the central Tamilnadu, East coast of India. Proc. of the special session at APAC, Korea. (Ed). Bryung Ho Choi, FumihikoImamuna. pp. 209-221.

Singarasubramanian, S.R., Mukesh, M.V., Manoharan, K., Seralathan, P., Sujatha, K., Bakkiaraj, D., 2009. Geomorphological and Sedimentological changes during and after the December-2004 Indian Ocean Tsunami near the Vellar river and the M.G.R. Island area of the central Tamilnadu Coast. International Jour. of science of Tsunami hazards. 28 (1): 67-74.

Stewart, H.B., 1958. Sedimentary reflections of depositional environment in San Miguel Lagoon, Baja. Calfornia, Mexcio. Am Assoc Pet. Geol. Bull, 42: 2576–2618.

Suganraj, K., Singarasubramanian, S.R., Rajmohan, S., Sathya, S., Sundararajan, M., 2013. Grain Size Statistical Parameters of Coastal Sediments at Kameswaram, Nagapattinam District, East Coast of Tamil Nadu, India, Inter. Jour. of Recent Scientific Res., 4 (2): 102-106.

Sujatha.K and Singarasubramanian.S.R., 2013. Sediment characterization and depositional processes from the pit samples of Poompuhar, Ambanar River Mouth and Tarangambadi, east coast of Tamilnadu, India. Inter. Jour. of Recent Scientific Res. Vol.4 (3). pp.177-184.

Sujatha, K., Singarasubramanian, S.R., Mukesh, M.V., 2011. Sediment characterization and depositional processes from pit samples between Tarangambadi and Kottucherimedu, Nagapattinam district, East Coast of Tamilnadu (India). Inter. Jour. of Physical Sciences, Ultra Scientist. 23(3): 557-570.

Sun, D., Bloemendal, J., Reak, D.K., Vandenberg, J., Jiang, F., An, Z., Su, R., 2002. Grain Size distribution function of polymodal sediments in hydraulic and Aeolian environments, and numerical partitioning of the sedimentary components. Sedimentary Geology, 152: 263-277.

Surian, N., 2002. Downstream variation in grain size along an Alpine river: analysis of controls and processes. Geomorphology, 43: 137-149.

Theil, G.A., 1940. The relative resistance of abrasion of mineral grain of sand size. J Sedi. Petrol., 10: 102-124.

Vaithiyanathan, P., Ramanathan, Al., Subramanian, V., 1992. Sediment transport in the Cauvery River basin: sediment characteristics and controlling factors. Journal of Hydrology, 139 (1-4): 197-210.

Valia, H.S., Cameron, B., 1977. Skewness as paleoenvironmental indicators. J Petrol, 47(2): 784–793.

Venkataraman, S., Ramkumar, T., Anithamary, I., 2011. Grain size statistical parameters of coastal sediments around Tirumalairajanar river mouth, east coast of India. Jour. Ind. Assoc. Sedimentology. 30 (1): 65-73.

Venkatesan, S., Singarasubramanian, S.R., 2015. Depositional Environmental studies of sediments near Arasalar river mouth, Karaikal region Pondicherry Union Territory, East coast of India, International Research Journal of Engineering and Technology, 2 (2): 677-678.

Venkatramanan, S., Ramkumar, T., Anithamary, I., Ramesh, G., 2011. Variations in texture of beach sediments in the vicinity of the Tirumalairajanar river mouth of India. International Journal of Sediment Research, 26: 460-470.

Visher, G.S., 1969. Grain-size distributional processes. J. Sediment Petrol, 39(3): 1074–1106.

Wang, P., Davis, R.A., Kraus, N.C., 1998. Cross shore distinction of sediment texture under breaking waves along low energy coasts. J. Sediment Res, 68(3): 497–506.