ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2016; 2(12): 164-171
www.allresearchjournal.com
Received: 26-10-2016
Accepted: 27-11-2016

S Venkatesan
Ph.D. Research Scholar,
Department of Earth Sciences,
Annamalai University,
Tamil Nadu, India

SR Singarasubramanian
Associate Professor,
Department of Earth Sciences,
Annamalai University,
Tamil Nadu, India

Correspondence
S. Venkatesan
Ph.D. Research Scholar,
Department of Earth Sciences,
Annamalai University,
Tamil Nadu, India

Textural analysis of surface sediments in Arasalar River, Tamil Nadu and Pondicherry Union Territory, India

S Venkatesan and SR Singarasubramanian

Abstract
The studies on textural characteristics are valuable information to understand the source of evolution for sediments under river environment. In the present investigation surface samples were collected from Arasalar river and subjected to textural analysis. The phi values were determined and used to calculate the statistical parameters such as mean (Mz), standard deviation (σ_I), skewness (Ski) and Kurtosis (K_G). It is found that the mean value varies from (0.667Ø to 2.367Ø), indicating that the size of the river sand is medium to fine grained nature. The standard deviation (sorting) indicates moderately well sorted to moderately sorted with a range of 0.478Ø to 1.042Ø, while the skewness values of the sediment samples ranges from -0.581Ø to 0.389Ø. The Kurtosis varies between 0.679Ø to 1.437Ø, indicating mesokurtic to leptokurtic nature. Linear discriminant values indicate that the sediments were mostly deposited as Aeolian process under turbidity environment. C-M plot inferred that Arasalar river sediments are dominantly characterized by rolling of transportation.

Keywords: Arasalar River, Surface sediments, Grain size, Linear discriminate function (LDF) and CM pattern

1. Introduction

River sediments originate from the near surface exposed igneous, volcanic and sedimentary rocks. Some of these are easily eroded, whereas others, especially the Crystalline and metamorphic rocks are altered and carried by streams. Additional sources of river sediments are soils which inherited their mineral content (with some alteration) from bedrock or which in the tropic may consist completely of newly formed minerals (Irion, 1987). Grain size is the most basic physical property of sedimentary deposits (McManus, 1988; Poppe *et al.*, 2000). Grain size studies provide important clues to the sediment provenance, transportation history and depositional conditions (Folk and Ward, 1957; Friedman, 1979; Bui *et al.* 1990, Ganesh *et al.* 2012). Thus, the knowledge of sediment size and textural parameters is one of the better tools to differentiate various depositional environments of recent as well as ancient sediments (Mason and Folk, 1958; Friedman, 1961; Nordstorn, 1977, Kumar *et al.* 2010). Different agents such as wind, water commonly separate particles by their size (Friedman and Sanders, 1978). The sediment texture has also a close relationship to the topography, wave and current pattern and depositional conditions (Rao *et al.*, 1997; Singh *et al.*, 1998).

The rivers worldwide transport about 15-16 × 109 tonnes per year of sediments to the oceans (Milliman and Meade, 1983; Walling and Webb, 1983). Subramanian *et al.* (1987) has reported that the Indian rivers transport about 1.2 × 109 tonnes of sediments per year. Earlier many attempts have been made by several sedimentologists (Udden, 1914; Mason and Folk, 1958; Friedman, 1961, 1967; Sahu, 1964; Veerayya and Varadachari, 1975; Ramamohan Rao *et al.*, 1982; Jagannadha Rao and Krishna Rao, 1984; Dhanunjaya Rao *et al.*, 1989; Frihy *et al.*, 1995; Hanamgoda, and Chavidi, 1998; Mohan and Rajamanickam, 1998; Prabhakara Rao *et al.*, 2000; NageswaraRao *et al.*, 2005; Singarasubramanian *et al.*, 2006, 2009, 2011; Rajesh *et al.*, 2007; Ergine *et al.*, 2007; Ramanathan *et al.*, 2009; Usha Natesan *et al.*, 2012; Ganesh *et al.*, 2013; Karuna Karudu *et al.*, 2013; Ramesh *et al.*, 2015; Venkatesan *et al.*, 2015; Zhang Weiyan *et al.*, 2015) to differentiate the sediments of various environments such as fluvial, fluviatile, estuarine, river and other coastal environments.

Study area

The study area Arasalar river is the major tributary of Cauvery river in the central part of Tamil Nadu. The study area (Fig. 1) forms part of Karaikal, Nagapattinam and Thanjavur district. It falls between the latitude N 10° 50′ to 11° 10′ and longitude E 79° 20′ to 79° 50′ forms part of survey of Indian Topographic sheets number 58 N/13, 58 N/9 and 58 N/5. The study area is surrounded by Trichy district in the west, Cuddalore district in the north, Nagapattinam district in the South and Bay of Bengal in the East. Arasalar is the main tributary of Cauvery River diverted at Papanasam near Kumbakonam. River Arasalar separated from Cauvery River in Tanjavur district of Tamil Nadu state and discharges its load into the Bay of Bengal near Sakkottai. Arasalar is generally flows from west towards east and the pattern is mainly sub parallel.

The river flows the through recent alluvium deposits which are composed of clays and silts. The estuarine environment from the mouth of the river in downstream to fresh water in upstream direction which extents about 9km.

Methodology

The surface sediment samples were collected from the 12 selected location. Samples were collected in clean dry polythene bags for laboratory analysis. The exact sample location are noted with the help of Global Positioning System (GPS) receiver. For the size analysis the samples were dried and subjected to coning and quartering. The pre weighted samples were washed with 10% HCl to remove carbonates and washed with distilled water. Dried samples were subjected to ¼ phi interval ASTM sieves for sieving in Ro-tap sieve shaker. Results were used to draw the cumulative frequency curves and the statistical parameters were calculated using standard methods of Folk, and Ward (1957). Linear Discriminant Function were calculated as suggested by Sahu (1964), were used to interpret the depositional conditions of the sediments and CM plot prepared as suggested by Passega (1964) to understand the transportation mechanism.

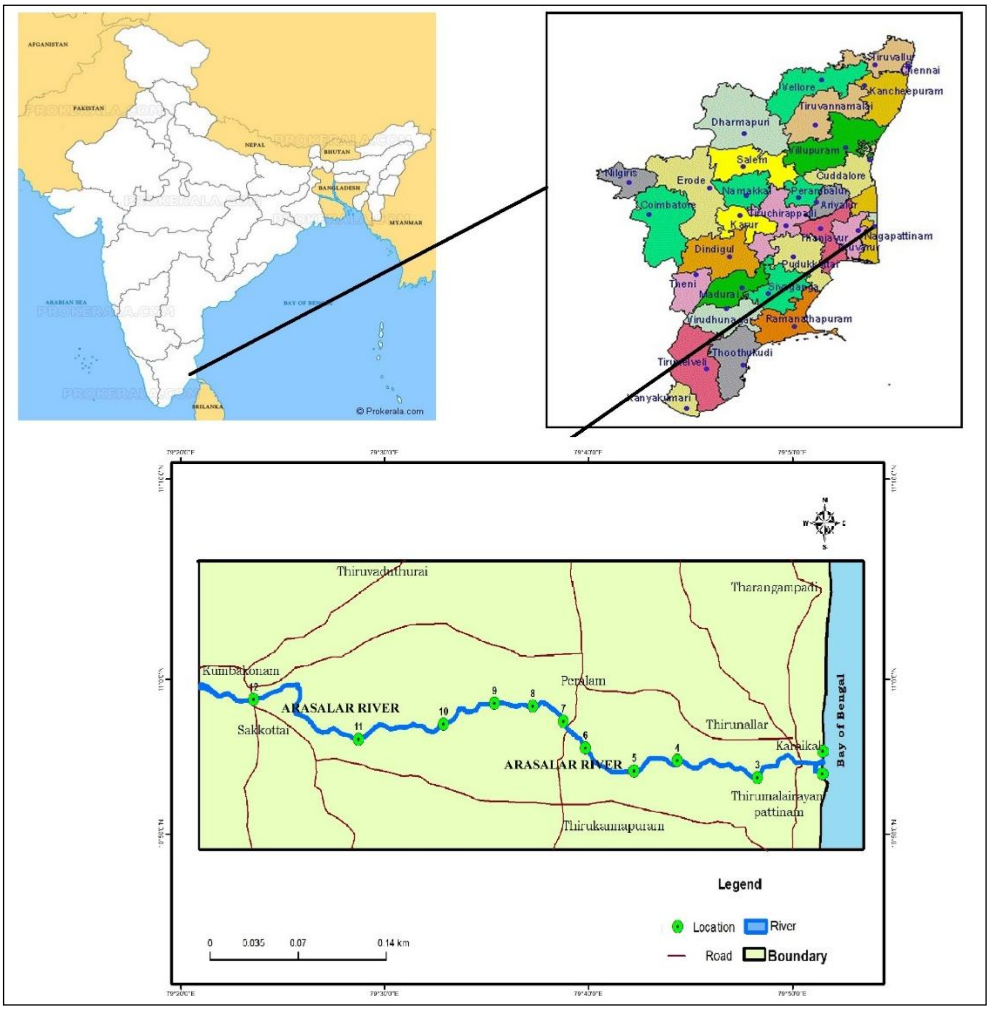


Fig 1: Study area map

Results and Discussion

The various parameters namely, mean size; sorting, skewness and kurtosis are used to evaluate cumulative frequency distribution (Trask, 1932; Otto, 1938; Inman, 1952; Mc common, 1962). The values of the textural parameters and grain size distribution of the samples were computed by the formulae suggested by Folk and Ward (1957).

Mean size (Mz)

Mean size of the sediments are influenced by the source of supply, transporting medium and the energy conditions of the depositing environment. Phi mean size of samples varies from 0.667Ø to 2.367Ø with an average mean of 1.462Ø (Table no: 1). Majority of the sediments are medium sand (75%). Rest of the samples fall in fine sand category and coarse sand (25%). The mean size indicates that the medium sand was deposited at a moderate energy conditions. The variations in Phi mean size reveal the differential energy conditions, resulting in their deposition (Singarasubramanian *et al.*, 2006; Ganesh *et al.*, 2013).

Standard Deviation (σ_I)

The graphic standard deviation (σ_I) measures sorting of sediments and indicate the fluctuations in energy conditions of depositional environment but it does not necessarily measure the degree to which the sediments have been mixed (Spencer, 1963). Standard deviation of the present samples range between 0.478Ø to 1.042Ø, with an average value of 0.718Ø (Fig) (Table). About 50% samples of the sample were moderately well sorted and 33.33% samples were moderately sorted. Well sorted and poorly sorted sediments also contributed. Dominant moderately well sorted character of sediments indicating the influence of stronger energy conditions in the basin (Rita Chauhan *et al.*, 2014).

Skewness (Ski)

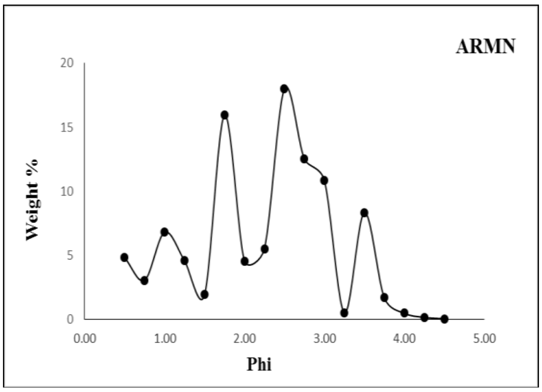
The graphic skewness measures the symmetry of distribution, i.e. predominance of coarser or fine-sediments. The negative value denotes coarser material in coarser-tail i.e., coarse skewed, whereas, the positive value represents more fine material in the fine-tail i.e., fine skewed. Skewness value ranges between -0.581 Ø and 0.389 Ø with an average of -0.072Ø. Symmetry of the sediments dominated by near symmetrical (41%) followed by very coarse skewed and fine skewed. Positive skewness on the phi scale indicates a relative excess of fine grains, usually from the preferred transport and deposition off fine material. Near symmetrical sediments indicates the due to the mixing of bimodal sources (Venkatramanan *et al.*, 2011).

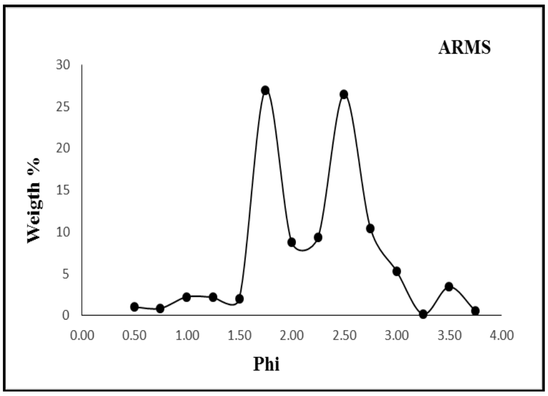
Kurtosis (K_G)

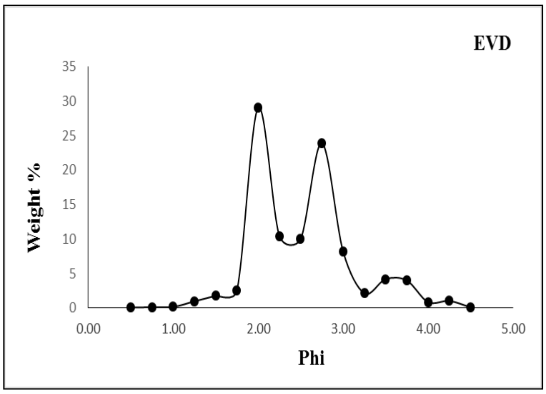
The graphic kurtosis is the peakedness of the distribution and measures the ratio between the sorting in the tails and central portion of the curve. The values of graphic kurtosis ranges from 0.99 Ø to 1.304 Ø, with an average of 1.104 Ø. The samples fall under mesokurtic (41%), leptokurtic (33.33%) and of platykurtic nature (25%). Friedman (1961) suggests that extreme high or low values of kurtosis imply that part of the sediments achieved its sorting elsewhere in a high energy environment. The 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., 2012). The wide range of kurtosis values is reflection of the flow characteristics of the depositional medium (Ramamohan Rao *et al.*, 1982; Seralathan and Padmalal, 1994; Hanamgond *et al.*, 1998).

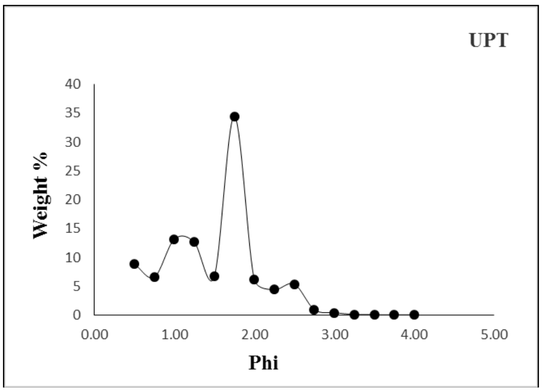
Frequency Curves

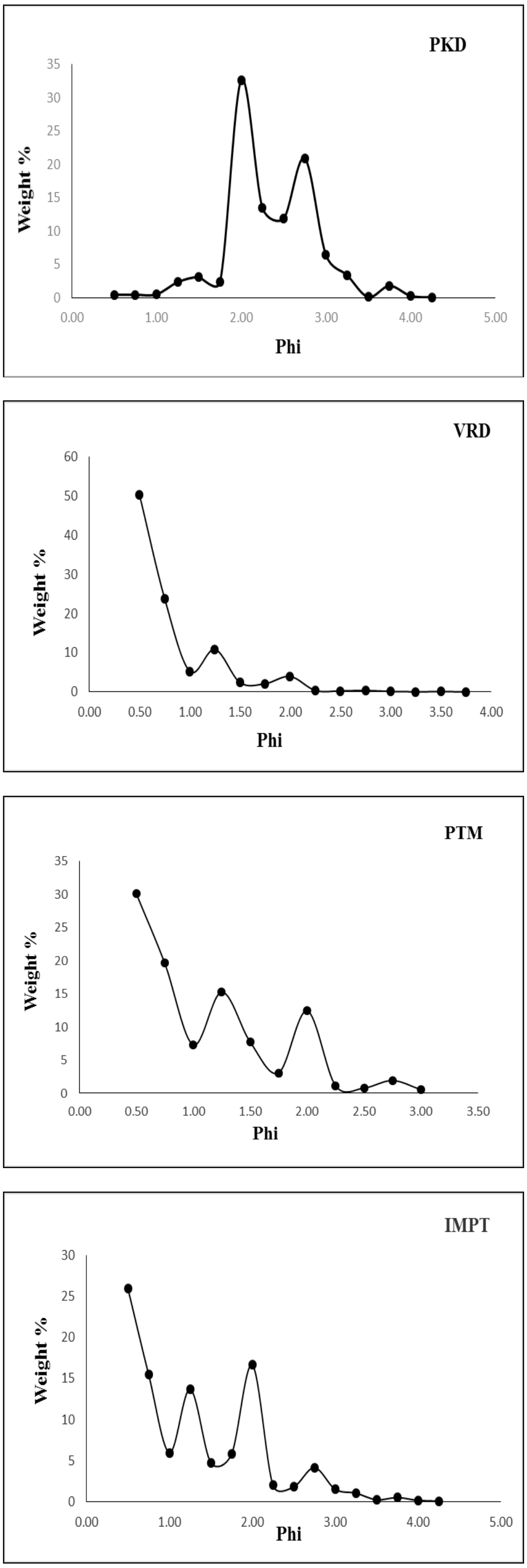
Frequency Distribution Curves (FDC) are pictorial representation of weight percentage of different fractions of sediments. FDC are used to describe the nature of sediments. The FDC from different locations of the Arasalar river are shown in (Fig. No: 2). Frequency distribution curves illustrate that ARMS, EVD, PKD, PTM, IMPT and SKT have bimodal sediments. At UPT, VRD and KVR sediments inferred unimodal distribution and ARMN and ECI inferred polymodal. Bimodality of the curves may be due to extreme variation in the velocity of the depositing agent, or lack of certain grain size in the size range of source materials (Sahu, 1964); diversity in the size range of source of material and due derivation of sediments from two or more sources (Pettijohn, 1984); the sediments were carried by different modes of transportation such as rolling, sliding, saltation and suspension processes (Visher, 1969). In the study area the bimodality is mostly due to extreme variation in the velocity of the depositing agent due to the seasonal influence.











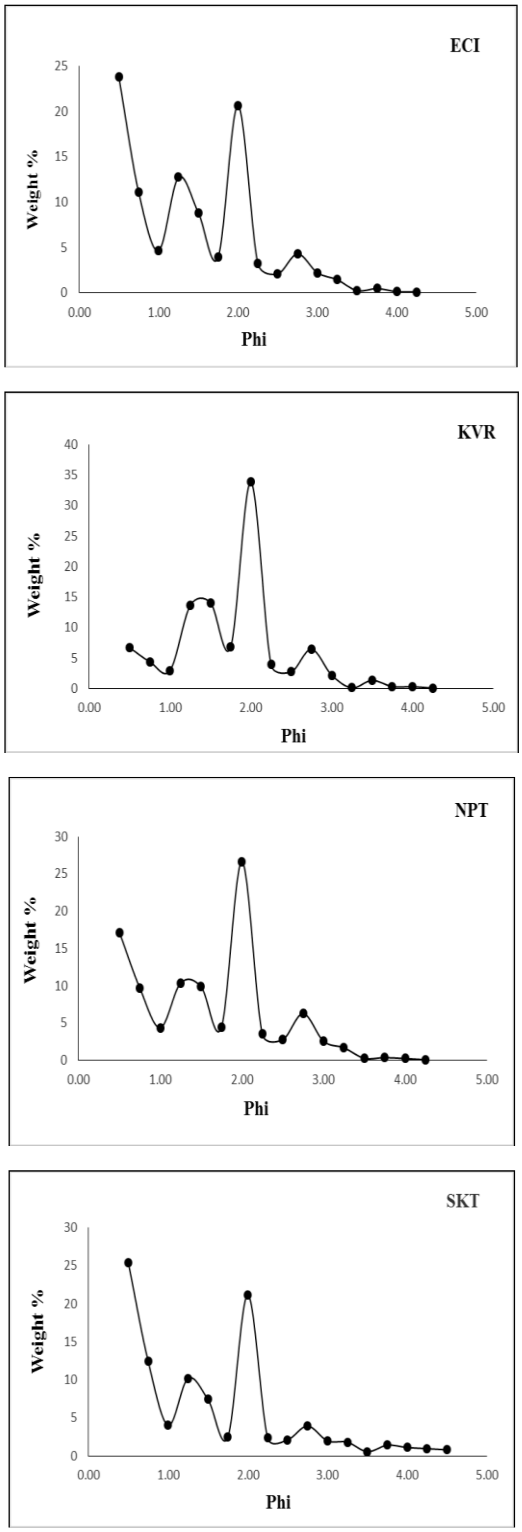


Fig 2: Frequency Distribution Curves showing the behaviour of sediments of Arasalar river

Scatter diagram

Scatter plots between certain parameters are also helpful to interpret the energy conditions, medium of transportation, mode of deposition etc. Passega (1957), Visher (1969), Folk and Ward (1957) and others described that these trends and interrelationship exhibited in the bivariate plots might indicate the mode of deposition and in turn aid in identifying the environments. However, Mason and Folk (1958), Friedman (1961) claimed to establish the differentiation between aeolian, beach and river sediments based on these scatter plots. An attempt has been made to utilize these scatter plots in the Arasalar river sediments. Mean vs Standard Deviation (Fig. 3A) reveals that the grain size increases, which decreases sorting. In the plot mean vs skewness (Fig. 3B) as the mean size increases sediments becomes negatively skewed. It is noticed that moderately sorted, sediment are negatively skewed, probably fluvial origin. The relationship between mean vs kurtosis (Fig 3C) indicates that kurtosis value decreasing with increasing size of sediments. The plot describing standard deviation vs skewness (Fig. 3D) products shows increase in skewness, decrease in standard deviation. This is may be due to the action of littoral currents. The plot between standard deviation vs kurtosis (Fig. 3E) shows that kurtosis value increases with increase in sorting of sediments. The plot between skewness vs kurtosis (Fig. 3F) shows that as the kurtosis value decreases, the sediments are getting negative skewed. Negative value indicate greater winnowing action in the depositional medium (Rajasekhara Reddy, *et al.*, 2008).

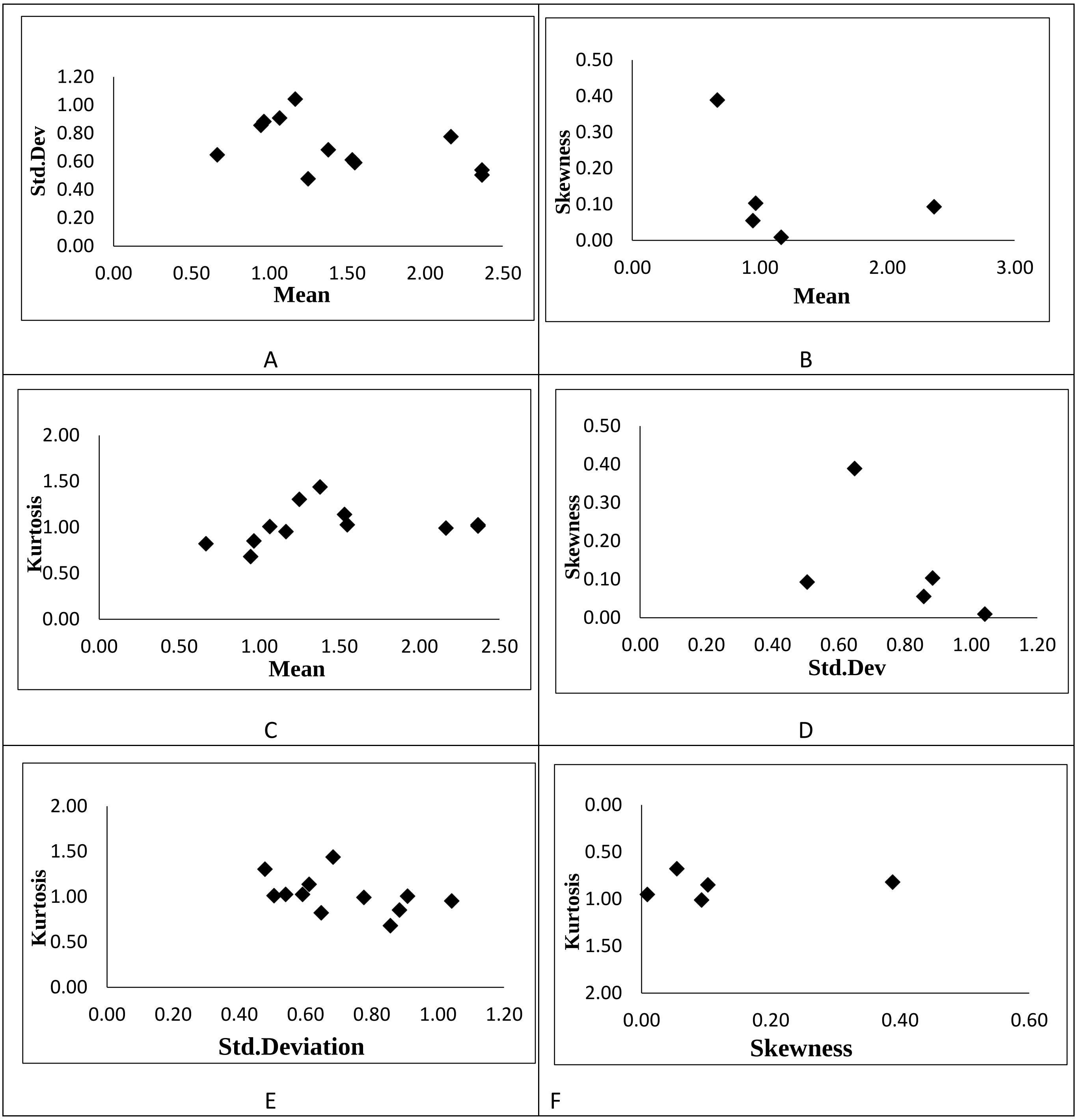


Fig 3: Scatter plots showing the model plot as proposed by Folk and Ward (1957). (A) Mean vs Standard deviation, (B) Mean vs Skewness, (C) Mean vs Kurtosis, (D) Skewness vs Standard deviation, (E) Standard deviation vs Kurtosis and (F) Skewness vs Kurtosis

Linear discriminate function (LDF)

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 functions of Y1 (Aeolian, beach), Y2 (Beach, shallow agitated water), Y3 (shallow marine, fluvial). With reference to the Y1 values, 58.33% of the samples from the study area fall in aeolian process and rest of the samples indicates the beach process (41.66%). According to Y2 values, 66.67% of samples fall under beach process and rest of the sample (33.33%) fall in shallow agitated process. 91.67% samples fall under shallow marine process inferred from Y3 and rest of the samples fall under fluvial (deltaic) (8.33%). All the samples were deposited under turbid environment according to Y4 values. The results of the present study indicate that the sediments were derived from both fluvio (sediments discharged by rivers) and marine environments.

Table No: 1 Graphic measures from the grain size analysis of the Arasalar River

Location No	Mean (Mz)	Std. Dev (σI)	Skewness (Ski)	Kurtosis (KG)	Remarks			
1	2.167	0.777	-0.581	0.99	FS	MS	VCS	MK
2	2.367	0.54	-0.06	1.025	FS	MWS	NS	LK
3	1.25	0.478	-0.365	1.304	MS	WS	VCS	LK
4	2.367	0.505	0.093	1.011	FS	MWS	FSK	MK
5	1.550	0.591	-0.115	1.025	MS	MWS	CS	MK
5	1.550	0.591	-0.115	1.025	MS	MWS	CS	MK
6	0.667	0.648	0.389	0.82	CS	MWS	VFS	PK
7	0.947	0.857	0.055	0.679	CS	MS	NS	PK
8	0.967	0.884	0.103	0.851	CS	MS	FS	PK
9	1.067	0.909	-0.044	1.006	MS	MS	NS	MK
10	1.380	0.684	-0.046	1.437	MS	MWS	NS	LK
11	1.533	0.611	-0.254	1.137	MS	MWS	CSK	LK
12	1.167	1.042	0.009	0.951	MS	PS	NS	MK
Minimum	**0.667**	**0.478**	**-0.581**	**0.679**				
Maximum	**2.367**	**1.042**	**0.389**	**1.437**				
Average	**1.462**	**0.718**	**-0.072**	**1.025**				

Table No. 2: Showing linear discriminant function values (Sahu, 1964)

S. No	Mz	σI	Ski	KG	Y1	Y1	Y2	Y2	Y3	Y3	Y4	Y4
1	2.167	0.777	-0.581	0.990	-5.498	Aeolian	73.575	Sh. Agi. wat	-4.670	Sh. Marine	1.320	turbidity
2	2.367	0.540	-0.060	1.025	-7.366	Aeolian	56.218	Beach	-1.881	Sh. Marine	1.590	turbidity
3	1.250	0.478	-0.365	1.304	-3.615	Aeolian	34.580	Beach	-1.645	Sh. Marine	0.810	turbidity
4	2.367	0.505	0.093	1.011	-7.501	Aeolian	53.824	Beach	-1.562	Sh. Marine	1.605	turbidity
5	1.550	0.591	-0.115	1.025	-4.239	Aeolian	47.214	Beach	-2.618	Sh. Marine	0.978	turbidity
6	0.667	0.648	0.389	0.82	-0.826	Beach	38.032	Beach	-3.488	Sh. Marine	0.312	turbidity
7	0.947	0.857	0.055	0.679	-0.661	Beach	63.084	Beach	-6.164	Sh. Marine	0.387	turbidity
8	0.967	0.884	0.103	0.851	-0.558	Beach	66.486	Sh. Agi. wat	-6.570	Sh. Marine	0.383	turbidity
9	1.067	0.909	-0.044	1.006	-0.749	Beach	70.996	Sh. Agi. wat	-6.934	Sh. Marine	0.437	turbidity
10	1.380	0.684	-0.046	1.437	-3.193	Aeolian	52.344	Beach	-3.705	Sh. Marine	0.807	turbidity
11	1.533	0.611	-0.254	1.137	-4.089	Aeolian	48.527	Beach	-2.833	Sh. Marine	0.956	turbidity
12	1.167	1.042	0.009	0.951	-0.146	Beach	89.612	Sh. Agi	-9.179	Fluvial(del)	0.404	turbidity

Sh. Agi. Wat- Shallow agitated water, Sh. Marine- Shallow Marin

C M diagrams

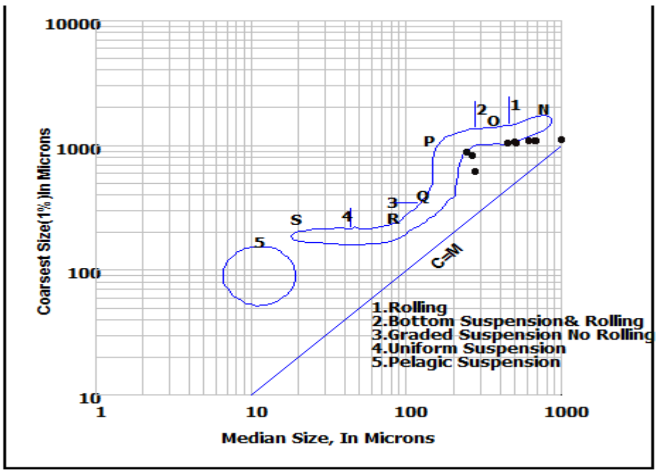


Fig 4: Showing CM diagram

Grain size parameters and the plots of CM patterns to distinguish between the sediments of different environments of fluvial and deltaic deposits (Passega 1964). In the present study an attempt has been made to identify the modes of deposition of sediments in the Arasalar river using CM pattern. Passega (1957) interpreted the distinct patterns of CM plots in terms of different modes of transportation by plotting coarsest first percentile grain size (C) and the median size (M) of sediment samples on a double log paper. The relation between C and M is the effect of sorting by bottom turbulence. The good correlation between C, determined by only one percent by weight of the sample, and M, which represents grain size as a whole, shows the precision of the control of sedimentation by bottom turbulence. CM pattern represents a complete model of tractive current (depositional process) as shown by Passega (1964) which consists of several segments such as NO, OP, PO, OR and RS indicating different modes of sediment transport. Most of the samples (75%) fall in NO region (Fig. 4). They deposited as rolling while rest of the sediments fall in graded suspension no rolling condition (25%).

Conclusions

The present work was carried out to study the nature of the grain size distribution of studied along the Arasalar river sediments. Various statistical parameters (i.e. mean size, mode, standard deviation, skewness and kurtosis) are evaluated. The textural parameters indicate that the sediments were medium to fine grained, moderately well sorted to well sorted and moderately sorted with dominantly near symmetrical to very coarse and very fine skewed. Kurtosis indicate mesokurtic to leptokurtic nature. The mean size indicates that the fine sands were deposited at a moderately low energy conditions. Moderately well sorted character of sediments indicating the influence of stronger energy conditions in the basin. Near symmetrical sediments indicates the due to the mixing of bimodal sources. The 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. Scatter diagram inferred the negative value indicate greater winnowing action in the depositional medium. Frequency Distribution Curves drawn between different textural parameters clearly established that the sediments were dominantly bimodal in nature. From the energy process discriminate functions of the sediments were deposited predominantly as aeolian and beach process under shallow marine environment and carried by turbidity action. CM- plots indicates the sediments were dominantly transported under rolling process.

Reference

1. Avramidis P, Samiotis A, Kalimani E, Papoulis D, Lampropoulou P, Bekiari V. Sediment characteristics and water physicochemical parameters of the Lysimachia Lake, Western Greece, Environ Earth Sci. 2012.
2. Bui EN, Mazullo J, Wilding LP. Using quartz grain size and shape analysis to distinguish between aeolian and fluvial deposits in the Dallol Bosso of Niger (West Africa). Earth Surface Processes and Landforms. 1990; 14:157-166.
3. Dhanunjaya Rao G, Krishnaiah Setty B, Raminaidu, Ch. Heavy mineral content and textural characteristics of coastal sands in the Krishna- Godavari, Gosthani-Champavati, and Penna river deltas of Andhra Pradesh, India: a comparative study. Journal of Atomic Mineral Science (Joams), Earfam. v.2. 1989.
4. Ergine M, Seref Keskin, Umaran Dogan A, Yusuf KK, Zehra Karakas. Grain Size and heavy mineral distribution as related to hinterland and environmental condition for modern beach sediments from the Gulf of Antalya and Finke, Eastern Mediterranean. Mar. Geol., v.240, 2007, 185-196.
5. Folk RL, Ward WC. Brazos River bar: a study in the significance of grain size parameters. Journal of Sedimentary Petrology. 1957; 27:3-26.
6. Friedman GM, Sanders JE. Principles of Sedimentology. Wiley: New York. 1978.
7. Friedman GM. Differences in size distributions of populations of particles among sands of various origins. Sedimentology 1979; 26:3-32.
8. Friedman GM. Dynamic processes and statistical parameters compared for size frequency distributions of beach and river sands. Jour. Sed. Petrol., 1961; 32:327-354.
9. Friedman GM. Distinction between Dune, Beach and River sands from their textural characteristics. Jour. Sed. Pet, 1961; 31:514-529.
10. Friedman GM. Dynamic processes and statistical parameters compared for size frequency distribution of Beach and River sands, Jour. Sed. Pet., 1967; 37:327-354.
11. Frihy OE, Lofty MF, Komar PD. Spatial variation in heavy minerals and patterns of sediment sorting along the Nile Delta, Egypt. Sed. Geol., 1995; 97:33-41.
12. Ganesh B, Naidu AGSS, Jagannadha M, Rao T, Karuna K, Avatharam P. Studies on textural characteristics of sediments from Gosthani River Estuary-Bheemunipatnam, A.P., East Coast of India. Jour. Indian Geophys. Union, 2013; 17(2):139-151.
13. Hanamgond PT, Chavadi VC. Sedimentological study of Kwada and Belekeri bay beaches, Uttara Kannada, west coast, India. Jour. Geol. Soc. India, 1998; 51:193-200.
14. Inman DL. Measures for describing the grain size distribution of the sediments. Jour. Sedim. Petrol., 1952; 22:125-145.
15. Irion G. Sedimentologish-Mineralogische untersuchuungen. 1987.
16. Jagannadha Rao M, Krishna Rao JSR. Textural and mineralogical studies on red sediments of Visakhapatnam Bheemunipatnam coast. Geo views, 1984; 12(2):57-64.
17. Karuna Karudu T, Jagannadha Rao M, Ganesh B, Avataram P, Naidu AGSS. Studies on textural characteristics of Erra Kalva River, west Godavari District, Andhra Pradesh, East Coast of India. International Journal of Geomatics and Geosciences. 2013; 4(2):280-295.
18. Kumar G, Ramanathan AL, Rajkumar K. Textural characteristics of the surface sediments of a Tropical mangrove ecosystem Gulf of Kachchh, Gujarat, India. Indian Jour. Mar. Sci., 2010; 39(3):415-422.
19. Mason CC, Folk RL. Differentiation of beach, dune and aeolian flat environment by size analysis, Mustang Island, Texas, Jour. Sed. Pet. 1958; 28:211-226.
20. Mccammon RB. Efficiencies of percentile measures for describing the mean size and sorting of sedimentary particles. Jour. Geol., 1962; 70:453-465.
21. McManus J. Grain size determination and interpretation. In: Tucker, M. (Ed.), Techniques in Sedimentology. Blackwell, UK, 1988; 63e85.
22. Milliman JD, Meade RH. World Delivery of river sedimentd to the oceans. Jour. Geol. 1983; 1:1-21.
23. Mohan PM, Rajamanickam GV. Depositional environment: Inferred from grain size along the coast of Tamil Nadu. Jour. Geo. Soc. of. India. 52:95-102.
24. Nageswara Rao N, Suryam RK, Ranga Rao V. Depositional environment infer red from grain size parameters of the beach sediments between False Devi Point to Kottapatnam, Andhra Pradesh Coast. Jour. Geo. Soc. of India. 2005; 65:317-324.
25. Nordstrom KF. Bayside beach dynamics: Implications for simulation modeling on eroding sheltered tidal beaches. Marine Geology, 1977; 25:333-342.
26. Otto GH. The sedimentation unit and its uses in field sampling. Jour. Geol., 1938; 46:569-582.
27. Passega R. Texture as characteristic of clastic deposition, Am. Assn. Pet. Geol. Bull. 1957: 41:830-847.
28. Pettijohn FJ. Sedimentary rocks 3rd Ed. CBS publ. and distributors Delhi, 1984; 628.
29. Poppe LJ, Eliason AH, Fredericks JJ, Rendigs RR, Blackwood D, Polloni, CF. Chapter 1. Grain-size analysis of marine sediments methodology and data processing. In: Poppe LJ, Hastings ME, Eliason AH,

Fredericks JJ, Rendigs RR, Blackwood DS. (Eds.), U.S.G.S. East-coast Sediment Analysis: Procedures, Database, and Geo referenced Displays. U.S. Geological Survey, Woods Hole, MA. U.S. Geological Survey Open File Report. 2000; 358.
30. Prabhakara Rao A, Panda NK, Subrahmanyam, AV, Ravi GS, Deshmukh RD. Textural characteristics of sands in the interpretation of depositional environments between River Varaha and Mulapeta Creek, East Coast of India. Jour. Ind. Acad. Geosci., 2000; 43:1-8.
31. Rajasekhara Reddy D, Karuna Karudu T. Textural characteristics of the sediments of Mahanadi Delta, East Coast of India. Jour. Ind. Assoc. of. Sed., 2009; 30(1):73-85.
32. Rajasekhara Reddy D, Karuna Karudu T, Deva Varma D. Textural characteristics of Southwestern part of Mahanadi Delta, East Coast of India. Jour. Ind. Asso. Sed. 2008; 27(1):111-121.
33. Rajasekhara RD, Karuna KT, Deva VD. Textural characteristics of south western part of Mahanadi Delta, east coast of India. Jour. Indian Assoc. Sed., 2008; 27(1):111-121.
34. Rajesh E, Anbarsu K, Rajamanickam GV. Grain size distribution of silica sands in and around Marakkanam Coast of Tamil Nadu. Jour. Geo. Soc. of India. 2007; 69:1361-1368.
35. Rajmohan S, Singarasubramanian SR. Granulometric Studies of Beach Sediments between Ponnaiyar and Gadilam Rivers, Cuddalore, East Coast of India. International journal of earth sciences and engineering. ISSN 0974-5904, 2013; 6:02.
36. Ramamohan Rao T, Shanmukha Rao Ch, Sanyasi Rao, K. Textural Analysis and Mineralogy of the Black Sand Deposits of Visakhapatnam-Bhimunipatnam Coast, Andhra Pradesh, India. Jour. Geo. Soc. of. India. 1982; 23:284-289.
37. Ramanathan AL, Raj Kumar K, Jayjit Majumdar, Gurmeet Singh, Behera PN, Santra SC, Chidambaram S. Textural characteristics of the surface sediments of a tropical mangrove Sundarban ecosystem India. Indian Journal of marine sciences, 2009; 38(4):397-403.
38. Ramesh *et al.* A Study on the textural characteristics of Arasalar River Estuary sediments of Karaikal, East Coast of India. International Journal of Recent Scientific Research. 2005; 6(2):2779-2782.
39. Rita Chauhan. Patterns of seasonal variability in granulometric characteristics of Bhitarkanika Mangrove - estuarine complex, East coast of India. Indian Journal of Geo-Marine Sciences. 2014; 1083-1090.
40. Roi KL. Indias Water Wealth. Orient Longman, New Delhi, 1997; 267.
41. S Venkatesan, SR Singarasubramanian. 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 (IRJET). e-ISSN: 2395-0056, p-ISSN: 2395-0072. 2015.
42. Sahu BK. Depositional mechanisms from the size analysis of classic sediments. Jour. Sed. Petrol., 1964; 34:73-83.
43. Seralathan P, Padmalal D, Textural studies of surficial sediments of Muvattupvzha river and central vembanad estuary, Kerala. Jour. Geol. Soc. India, 1994; 43:179-190.
44. Singarasubramanian SR, Mukesh MV, Manoharan K. Seralathan P and Srinivasulu S. Geological and geomorphological perspectives of the tsunami on the Tamilnadu Coast, India-Indian Ocean Tsunami, The Global response to a Natural Disaster, (Ed). Pradyumna P. Karan and Shanmugam P. Subbiah. University press of Kentuky, US. 2011; 65-97.
45. Singarasubramanian SR, Mukesh MV, Manoharan K, Bakkiraj D, Murugan S, John Peter A, Seralathan P. Sediment characteristics of the M9 tsunami event between Rameswaram and Thoothukudi, Gulf of Mannar, Southeast coast of India. International Jour. of Science of Tsunami hazards. 2006; 25(3):160-172.
46. Singarasubramanian SR, Mukesh MV, Manoharan K, Seralathan P, Sujatha K, Bakkiaraj D. 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. 2009; 28(1):67-74.
47. Singh AK, Hasnain SL. Major ion chemistry and weathering control in a hisih altitude basin: Alaknanda river, Garhvval Himalaya, India. Hydro. Sci. Jour. 1998; 43(6):825-843.
48. Subrahmanyam V, Bisham G, Ramesh R. Environmental geology of the peninsular river basins of India. Jour. Geol. Soc. India, 1987; 30:393-401.
49. Suganraj K, Singarasubramainian SR. Textural characteristics of coastal sediments between Parathaparamapuram and Poovathadi, Tamil Nadu, East coast of India. 2013.
50. Trask PD. Origin and Environment of Source Sediments of Petroleum. Gulf Publishing Company: Houston. 1932.
51. Udden JA. Mechanical composition of clastic sediments. Geol. Soc. Am. Bull. Vol. 25 p. 655-744.Passega, R. (1964): Grain size representation by CM patterns as geological tool. Jour. Sed. Pet. 1994; 34:830-847.
52. Usha Natesan. *et al.* Textural and depositional processes of surface sediments of Kalpakkam, Southeast Coast of India. Issue 2012; (4):392-404. DOI: 10.1007/s11707-012-0330-2.
53. Veerayya M, Varadachari VVR. Depositional environments costal sediments of Calangute, Goa. Sedimentary Geology, v.1975; 14:63-74.
54. Venkatramanan, Ramkumar, Anithamary, Ramesh. Variations in texture of beach sediments in the vicinity of the Tirumalairajanar river mouth of India. International Journal of Sediment Research. 2011; 460-470.
55. Visher GS. Grain size distributions and depositional processes. Journal of Sedimentary Petrology, Vol. 1969; 39:1074-1106.
56. Walling DE, Webb BW. Patterns of sediment yield. In: K.J. Gregory (Ed.), Background to Palaeohydrology. John Wiley & Sons Ltd, 1983; 69-100.
57. Weiyan Zhang *et al.* Grain size composition and transport of sedimentary organic carbon in the Changjiang River (Yangtze River) Estuary and Hangzhou Bay and their adjacent waters. Volume 2015; 34(10):46-56.