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Granulometric studies of the Sediments from Kolakkudi Lake, Musiri Taulk, Trichirapalli District, Tamilnadu, India

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Abstract

Grain size (Granulometric) is one of the basic attributes of sediments and hence its determination is necessary to interpret the depositional environments. The linear discriminant values prepared from statistical have concurred the respective environment in the present study. In this study of textural and geostatistical parameters are classified as Mean, Sorting, Skewness and kurtosis. This has been carried out with significance in lake sedimentological aspects. Some applications related to sediment types and bottom dynamics have also been recorded. It is important to use the grain size and geochemical study of the Lake sediment for planning and management of lacustrine environment.

Keywords: Textural parameters, Skewness and kurtosis, grain size, lacustrine environment.

Introduction

Extensive research has been carried out in the past two decades and repeated attempts were made to use grain size parameters to differentiate environment of deposition. Variations in the grain-size distribution of lake sediments may reflect earth surface processes such as the developmental processes of landforms through precipitational change[1]. Measured grain size distribution is greatly affected by pre treatment method[2]. The grain size populations having different populations are due to the transportation by rolling, suspension and saltation[3]. Textural parameters of sediments namely Mean, Standard deviation (Sorting), Skewness and Kurtosis were used to decipher the depositional environments of sediments[4]. Earlier studies largely explaining relation between grain size distribution and the depositional environments. Friedman has advocated the study of textural parameters by an arithmetic approach i.e. the moment method, whereas Folk and Ward have approached the same problem through graphic methods[5]. The grain size distribution in the vertical sediment cores was also assessed from the sieved fractions by assigning a phi (ϕ) value[6]. The number of incorrect interpretations helps us again explain that many of the same processes operate in different depositional environments making interpretation of the environment using grain size problematic[7].

Material and Methods

Coring and sampling of the lake sediments: Systematic sample collection was made from Kolakkudi Lake with the help of Rotatory Drill (figure-1). The study area forms a part of Toposheet 58 I/8 situated in the Tiruchirapalli district of Tamilnadu. It falls between Latitude 78^0 22'37" E' to' Longitude 11^0 01'19 N. The study area is nearby Kolakkudi village. (figure-2). Samples were collected at 12 stations to the entire of the lake at 200 meter intervals. At each station five to twelve samples have been collected and the samples were mixed thoroughly. The coordinates of the collection sites were determined using a hand-held GPS unit.

Analytical procedure of the Lake Sediments: The sediment samples were dried for at least 24 hours in an oven at 60^0 C to remove the moisture before analysis. From the dried samples, 100gm was taken by the coning and quartering method. After samples are repeatedly washed in distilled water for removal of salts and then dried. In the laboratory, samples were dried in the oven at 60^0C and then stirred with a mechanical stirrer for 10 minutes to remove clay and silt contents. The weight loss was weighed. Samples were pre-treated according to remove organic matter (30 % H_2O_2, 50^0C, 18 h)[8]. The dried samples were treated with 1:1 HCl to estimate the carbonate content of the samples. Then, it was oven dried. After drying and a sub sample weighing about 100 grams which it was sieved at ¼ Ø intervals in ASTM sieve sets stacked from +16 to +230 mesh sizes. It was shacked using a mechanical shaker for 10 minutes and then the samples retained in the individual mesh sizes were weighed. Using Folk and Ward formula, textural parameters of the sediments were estimated. Using graphic and moment methods, the weight percentage of data of samples were processed by using modified programme through GSTAT[9]. From the statistical parameters as frequency curves, scatter plots, log probability curves have been drawn in excel. The scatter plots, CM diagram were drawn to determine the grain size parameters and environment of deposition. A CM diagram for the sediments of the Kolakkudi Lake was worked out following Passega.

Results and Discussion

Textural and Statistical Parameters: Textural analysis or size analysis is the quantitative determination of size frequency distribution[10]. The various statistical parameters were computed from sediments of Kolakkudi Lake is elaborated table-1. The interrelationships existing between these parameters have also been worked out to elucidate the hydrodynamic conditions of the depositing medium. The size distributions of Clastic sediments have revealed the existence of strong statistical parameters such as mean size, sorting (standard deviation), skewness and kurtosis. The relation between mean size and sorting is particularly well established and many studies have shown that the best-sorted sediments are generally those with mean size in the fine sand grade[11]. The grain size parameters viz., Mean size (MZ) standard deviation (σ_1) (sorting), Skewness (Ski) and kurtosis (KG) of percentile values derived from the cumulative curves following Folk and Ward (1957) and the moment technique based upon grouped data are most widely used[12]. Grain size distribution diagrams, texture and calculation of the statistical parameters were achieved by GRADISTAT, Version 6.0. The grain size analysis was performed to find a correlation between the contamination values and the special grain size groups. The stratigraphic description of sediment layers was achieved using grain size data and other sediment characters[13]. The detailed representation of these textural parameters has been drawn of scatter plots and CM diagrams have been presented and data are analyzed.

Figure-1
Sampling in Lake by Rotatory Drill

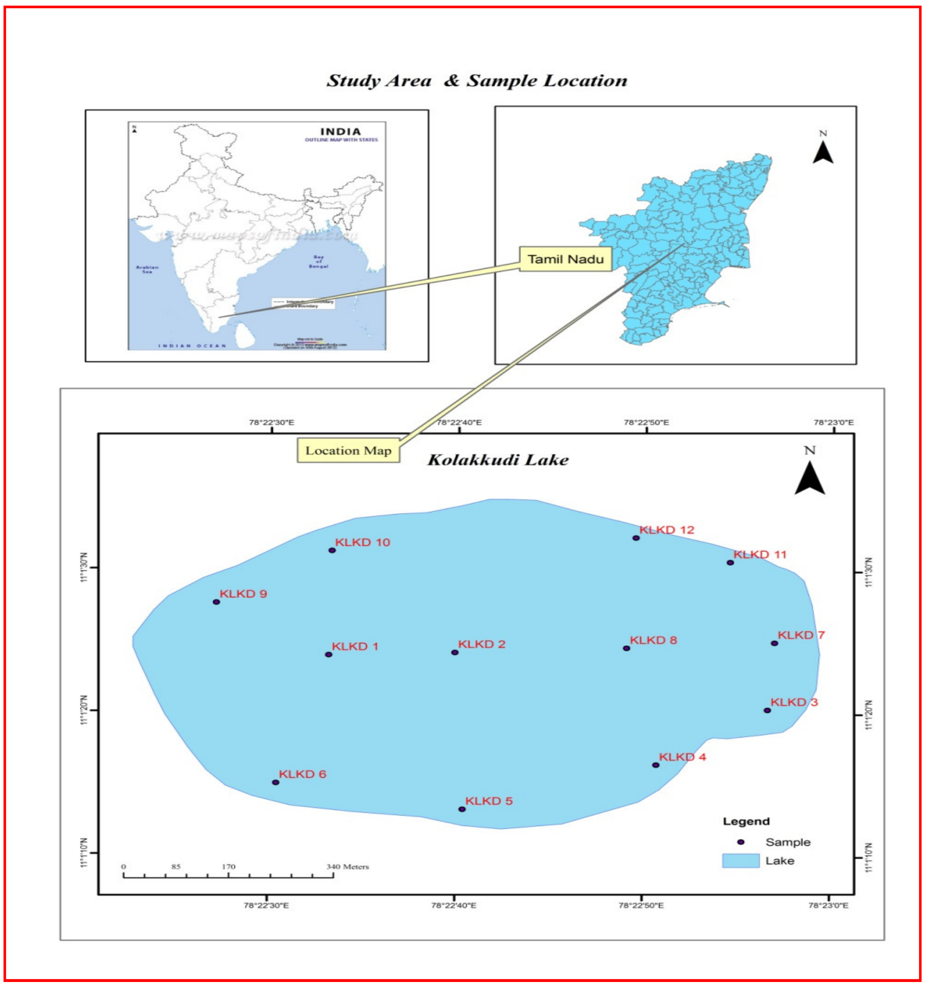

Figure-2
Location Map of the Study Area

Table-1
Textural parameters of Kolakkudi Lake sediment Samples

Lacustrine Stations	Depth in cm	Mean Size	Standard Deviation	Skewness	Kurtosis	Remarks			
KLKD-1	0-30	1.5942	0.9291	-0.1471	0.7349	MS	MSo	CSK	PKg
	30-60	0.9667	0.8098	0.7854	0.6811	CS	MSo	VFSK	PKg
	60-90	1.3651	0.9228	0.2381	0.6894	MS	MSo	FSK	PKg
	90-120	1.6519	1.0525	-0.0339	0.7337	MS	Pso	SYM	PKg
	120-150	1.5061	0.9484	0.0679	0.7015	MS	MSo	SYM	PKg
KLKD-2	0-30	1.6080	0.9814	-0.1109	0.6071	MS	MSo	CSK	VPKg
	30-60	1.5897	0.9185	-0.1519	0.7330	MS	MSo	CSK	PKg
	60-90	2.1204	0.8815	-0.3917	1.3229	FS	MSo	VCSK	LKg
	90-120	1.6853	0.9806	-0.1949	0.7343	MS	MSo	CSK	PKg
KLKD-3	0-30	1.2471	0.8874	0.3684	0.6826	MS	MSo	VFSK	PKg
	30-60	1.0138	0.7999	0.6366	0.6889	MS	MSo	VFSK	PKg
	60-90	0.9550	0.7555	0.6641	0.7740	CS	MSo	VFSK	PKg
	90-120	0.9425	0.7405	0.6713	0.8399	CS	MSo	VFSK	PKg
KLKD-4	0-30	1.4293	0.8933	0.0571	0.7359	MS	MSo	SYM	PKg
	30-60	1.4916	0.9120	0.0512	0.7894	MS	MSo	SYM	PKg
	60-90	1.4881	0.9386	0.0738	0.7133	MS	MSo	SYM	PKg
	90-120	1.5728	0.9302	-0.1667	0.6973	MS	MSo	CSK	PKg
	120-150	1.5437	0.9524	-0.0448	0.6727	MS	MSo	SYM	PKg
KLKD-5	0-30	0.9589	0.7839	0.7016	0.7416	CS	MSo	VFSK	PKg
	30-60	1.2234	0.9530	0.5662	0.7130	MS	MSo	VFSK	PKg
	60-90	0.9099	0.7792	0.8095	0.8238	CS	MSo	VFSK	PKg
	90-120	0.8894	0.7534	0.8054	0.9943	CS	MSo	VFSK	MKg
	120-150	0.9329	0.7585	0.7253	0.9332	CS	MSo	VFSK	MKg
	150-180	0.8683	0.7249	0.8062	1.0733	CS	MSo	VFSK	MKg
KLKD-6	0-30	2.1312	0.9231	-0.2441	1.2916	FS	MSo	CSK	LKg
	30-60	1.3592	0.8556	0.0692	0.7274	MS	MSo	SYM	PKg
	60-90	1.6015	0.9506	-0.1414	0.6716	MS	MSo	CSK	PKg
	90-120	1.3526	0.5933	-0.2205	0.8789	MS	MWSo	CSK	PKg
	120-150	1.5256	0.8507	-0.0899	0.8910	MS	MSo	SYM	PKg
	150-180	1.3712	0.8349	0.0324	0.7510	MS	MSo	SYM	PKg
	180-210	1.6026	0.8703	-0.1623	0.8995	MS	MSo	CSK	PKg
	210-240	1.5529	0.8006	-0.1487	1.0579	MS	MSo	CSK	MKg
	240-270	1.4878	0.7591	-0.1552	1.0118	MS	MSo	CSK	MKg
KLKD-7	0-30	1.2601	0.7405	0.0546	0.7778	MS	MSo	SYM	PKg
	30-60	1.2057	0.7381	0.1264	0.7583	MS	MSo	FSK	PKg
	60-90	1.3333	0.8122	0.1079	0.7672	MS	MSo	FSK	PKg
	90-120	1.1307	0.7626	0.2471	0.6967	MS	MSo	FSK	PKg
KLKD-8	0-30	1.8366	0.8678	-0.1072	0.8497	MS	MSo	CSK	PKg
	30-60	1.7841	0.8311	-0.1209	0.8785	MS	MSo	CSK	PKg
	60-90	1.7243	0.9234	-0.1417	0.8502	MS	MSo	CSK	PKg
	90-120	1.9618	0.7900	-0.0477	1.1113	MS	MSo	SYM	LKg
KLKD-9	0-30	2.2533	0.9400	-0.3517	1.1288	FS	MSo	VCSK	LKg
	30-60	2.3365	0.9569	-0.3060	1.2272	FS	MSo	VCSK	LKg
	60-90	2.2297	0.9737	-0.3444	1.1178	FS	MSo	VCSK	LKg
	90-120	1.7344	1.0783	-0.1048	0.6528	MS	Pso	CSK	VPKg
KLKD-10	0-30	1.7033	0.9659	-0.1610	0.7334	MS	MSo	CSK	PKg
	30-60	1.3450	0.9878	0.3266	0.7379	MS	MSo	VFSK	PKg
	60-90	1.4912	0.9323	-0.0164	0.6896	MS	MSo	SYM	PKg
	90-120	1.3456	0.9465	0.2660	0.6890	MS	MSo	FSK	PKg
KLKD-11	0-30	1.6607	0.9939	-0.1615	0.6199	MS	MSo	CSK	VPKg

Lacustrine Stations	**Depth in cm**	**Mean Size**	**Standard Deviation**	**Skewness**	**Kurtosis**	**Remarks**			
	30-60	2.4116	0.7846	-0.2517	1.3472	FS	MSo	CSK	LKg
	60-90	2.3764	0.6652	-0.0820	1.1077	FS	MWSo	SYM	MKg
	90-120	2.4739	0.6756	-0.1745	0.9841	FS	MWSo	CSK	MKg
	120-150	2.2811	0.6153	-0.0798	0.8584	FS	MWSo	SYM	PKg
	150-180	2.4330	0.6208	-0.1368	1.0362	FS	MWSo	CSK	MKg
KLKD-12	0-30	2.3608	0.6157	-0.0124	1.0567	FS	MWSo	SYM	MKg
	30-60	1.9998	0.6253	0.1268	1.1012	MS	MWSo	FSK	MKg
	60-90	2.0410	0.6019	0.1901	1.0893	FS	MWSo	FSK	MKg
	90-120	2.1548	0.6010	0.3458	1.2414	FS	MWSo	VFSK	LKg
	120-150	2.2241	0.5211	0.1091	0.9965	FS	MWSo	FSK	MKg
	150-180	2.2073	0.5111	0.1842	1.0040	FS	MWSo	FSK	MKg
	180-210	2.2272	0.4959	0.1435	0.9473	FS	Wso	FSK	MKg
	210-240	2.2590	0.5433	0.1530	0.9707	FS	MWSo	FSK	MKg
	240-270	2.2665	0.5254	0.0535	0.9791	FS	MWSo	SYM	MKg

(MS-Medium Sand, CS- Coarse Sand, FS-Fine Sand, MSo-Moderately Sorted, MWSo- Moderately Well Sorted Wso-Well Sorted,PSo-Poorely Sorted, CSK-Coarse Skewed,VCSK-Very Coarse Skewed, FSK-Fine Skewed,VFSK-Very fine Skewed,SY_M-Symmetrical, PKg- Platykurtic,VPKg-Very Platykurtic,MKg-Mesokurtic ,LKg- Leptokurtic)

Mean size (MZ): The mean size is a function of the size range of available materials and amount of energy impacted to the sediment which depends on current velocity or turbulence of the transporting medium[14]. Mean grain diameter, the most widely used distribution parameter, is regarded by most authors as an indicator of the average energy of the transport and as sedimentation agent. The different values obtained for the textural statistical parameters through the Graphic and Moment methods are given table-1. The Mean size is the average size of the sediments represented by ф mean size and mainly an index of energy conditions. In the Kolakkudi Lake, the mean size varies from 0.87 ф to 2.28 ф with an average of 1.63 ф and thus falls in the coarse Sand to Fine sand category (figure-3). The variation in mean size is a reflection of the changes in energy condition of the depositing media and indicates average kinetic energy of the depositing agent[15]. The variation in ф mean size reveals the differential energy conditions, resulting in their deposition[16].

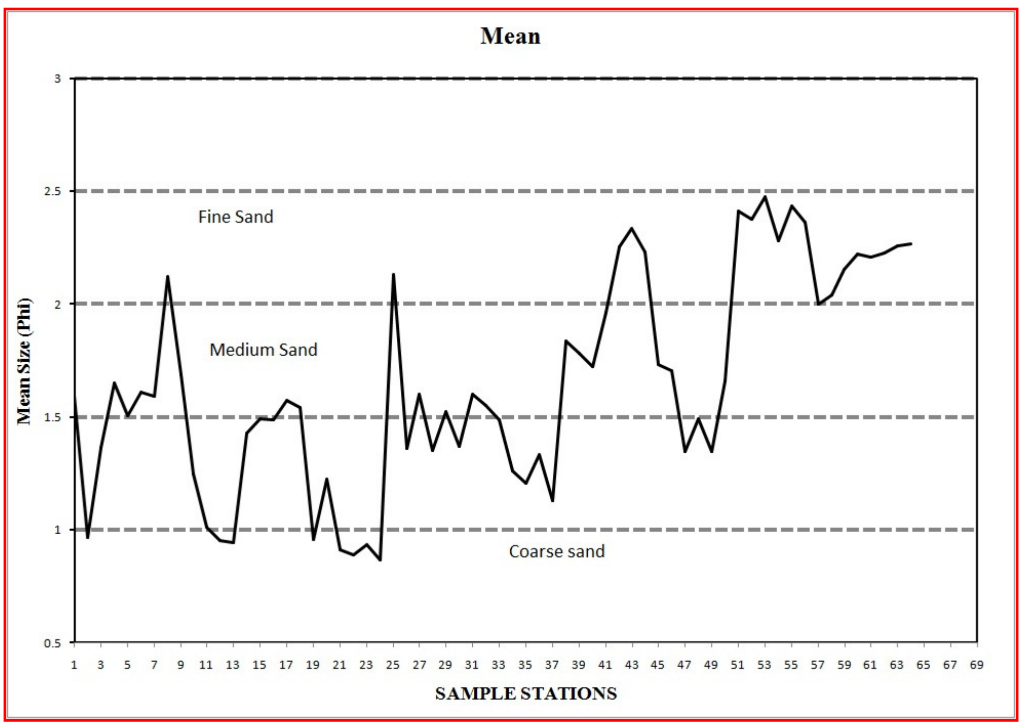

Figure-3
Variogram for Textural Parameter-Mean

Standard deviation (σ_1): Standard deviation indicates the difference in kinetic energy associated with these modes of deposition. Sorting has an inverse relation with standard deviation in the present study area, the lake sediment samples are varying from poorly sorted to moderately well sort according to the Folk and Ward's classification. In the lake Kolakkudi, the minimum and maximum values of the standard deviation are 0.49 ϕ and 1.05 ϕ respectively with the average of 0.94 ϕ. The sorting of sediments ranges from poorly sorted to moderately sorted. About 85% of samples fall in moderately sorted (figure-4). According to Friedman, the various ranges of sorting in sediments were indicates the various environments of the sand (table-1).

Skewness (Ski): Skewness measures asymmetry of frequency distribution and marks the position of mean with respect to median. In a material sufficient quantity of different sizes, a coarsely skewed sample implies that the velocity of the deposition agent operated at a higher value than the average velocity for a greater length of time. In the present study, In the lake Kolakkudi minimum and maximum Skewness values are -0.01 and 0.81 respectively with an average value of -0.15 with the representation of 35 percent in coarse skewed, 17 % of samples are fine skewed, and 25 percent is symmetrical, 20 percent is very fine in nature. The lake Kolakkudi sediment samples were falls in the Coarse skewed to very fine skewed nature (figure-5). The fine skewed nature of the sediments clearly exhibits sediment input from various sources of tributaries. In specialized literature, fluvial deposits are regarded as poorly sorted deposits and their skewness is usually positive since the material is introduced through deposits of solid suspensions[17]. The finely skewed nature is also implies a low velocity than normal. This skewness data indicate that in the sediments finer than the median class of the sediments dominate almost throughout their distribution[18].

Kurtosis (KG): Kurtosis is a quantitative measure used to describe the departure from normality of distribution. Many curves designated as 'normal' by the skewness measure turns out to markedly non-normal when the kurtosis is computed. It is the ratio between the sorting in 'tails' of the curve to that of the central portion. The minimum and maximum values of kurtosis of Lake Kolakkudi are 0.60 and 1.34 respectively with an average value of 0.69 of the total samples analyzed 57.81 percent represent platykurtic, 25.0 percent mesokurtic, 12.5 percent Leptokurtic and 4.69 percent Very platykurtic. The lake Kolakkudi samples fall within Very platykurtic to Leptokurtic nature (figure-6). The dominance of platykurtic nature of the both lake sediments exhibits mixing two populations in sub-equal amount. 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[19].

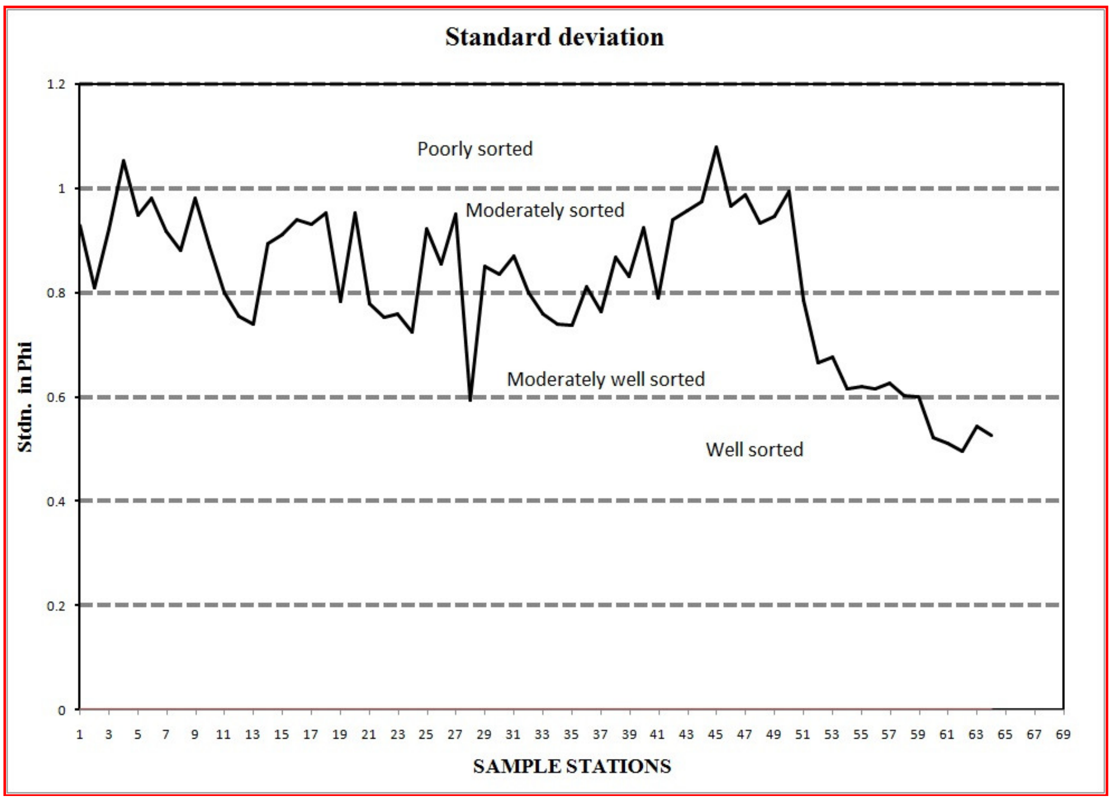

Figure-4
Variogram for Textural Parameter-Standard Deviation

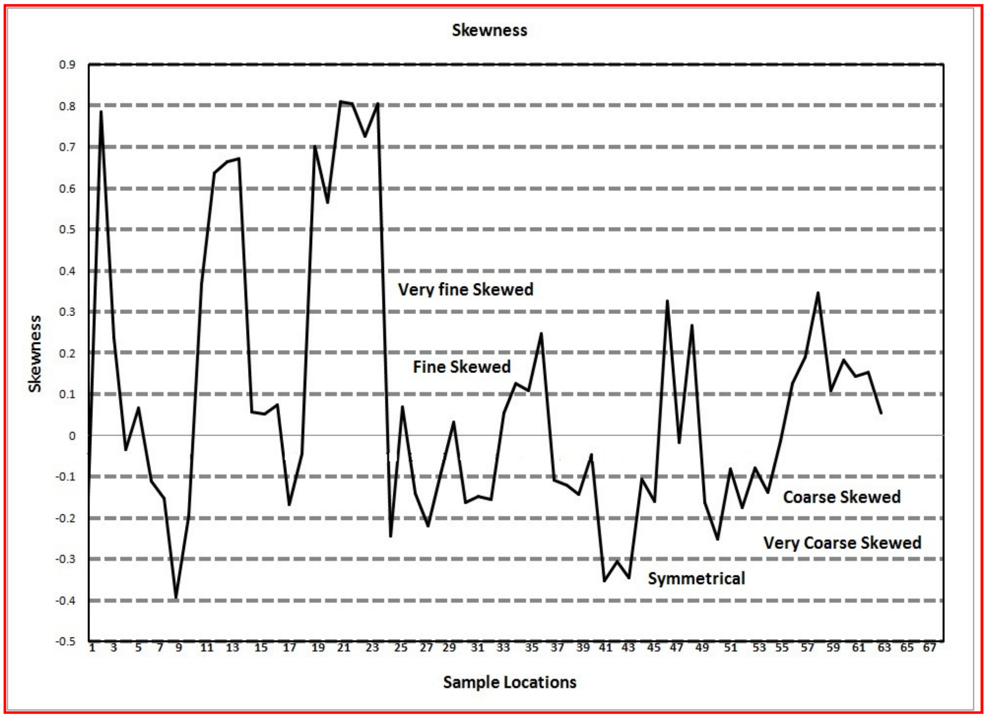

Figure-5
Variogram for Textural Parameter-Skewness

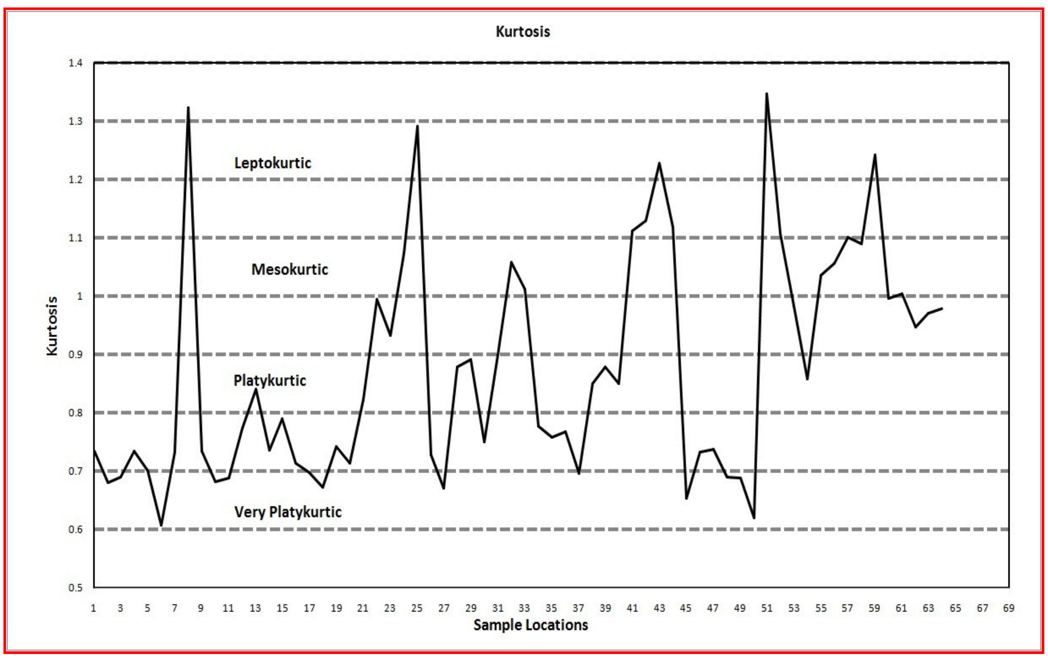

Figure-6
Variogram for Textural Parameter-Kurtosis

C-M Diagram: The CM diagram is an important plot used in sedimentlogy for the analysis of sedimentary environment. The CM Pattern of the sedimentary environment is means of analyzing transportation mechanism, depositional environment with respect to size, range and energy level of transpiration and also is determining the processes and characteristic agents that are responsible for the formation of clastic deposits. It is also observed that in several environments the coarse fraction of sediment almost invariably is more representative of the depositional agent than the fine fraction. The two parameters used in the plot from the grain size distribution are of particular significant ‘C’, the one percentile value represents the maximum grain size and indicates the competency of the transporting agent and the medium diameter 'M', expressed median grain-size of sediment transported[20]. The present interpretation is based on Passega and Byramjee. Passega 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, Visher explained the log normal sub populations within the total grain size distribution curve as representing suspension, saltation and surface creep or rolling modes of transportational mechanisms[21]. 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. The CM diagram (figure-7) shows that most of the samples formed by two different depositional conditions. This field represents the most of the sediments are deposited by bottom suspension and rolling in river sediments. Other the sediments are deposited by graded suspension and rolling.

Scatter Plots: Scatter plots between certain parameters are also helpful to interpret the energy conditions, medium of transportation, mode of deposition etc. Passeg, Visher, Folk, Ward 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. An attempt has been made here to utilize these bivariate plots in the Kolakkudi Lake sediments. Scatter plots between certain parameters are also helpful to interpret the energy conditions, medium of transportation, mode of deposition etc. Passega,Visher, Folk and Ward and others described that these trends and interrelationship exhibited in the scatter plots might indicate the mode of deposition and in turn aid in identifying the environments. Scatter plots are useful for understanding the geological significance of the grain size parameters. Inman and Griffiths are the earliest workers to notice in their experiments, the physical relationship between median diameter, standard deviation and skewness measures. Folk and Ward, Mason and Folk, Friedman, Moiola and Weiser have used the values of graphic mean, inclusive graphic standard deviation, graphic skewness and graphic kurtosis etc., to demarcate the fields of beach, river and dune sands[22]. Scatter plots viz. mean size vs. Standard deviation, mean versus Skewness and standard deviation vs. skewness were drawn to understand the relationship between different size parameters. An attempt has been made here to utilize these scatter plots in the Kolakkudi lake sediments.

Mean Vs Standard deviation: The plot between Mean size Vs. Standard deviation shows (figure-8) sorting increase with decrease in the size of the sediments from Medium sand to fine sand.

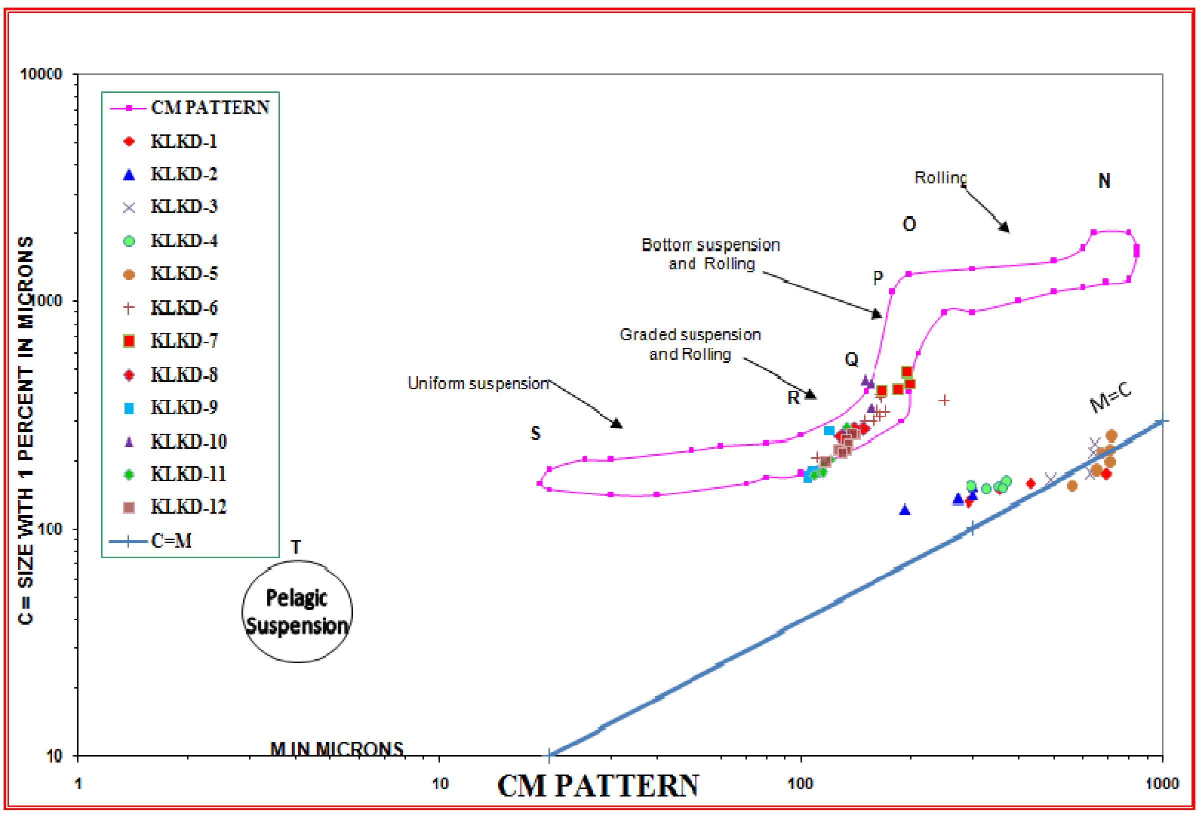

Figure-7
CM pattern of the sediments of Kolakkudi Lake

Mean Vs Skewness: The plot between Mean size Vs. Skewness shows the (figure-9) shows the decrease in grain size from coarse sand to very fine sand with positive skewness. The sediments of positive skewness occur in high energy environments.

Standard Deviation Vs Skewness: The plot between standard deviation and skewness (figure-10) shows well sorted sediments are positively skewed whereas the moderately well sorted sediments are negatively skewed with decrease in sorting.

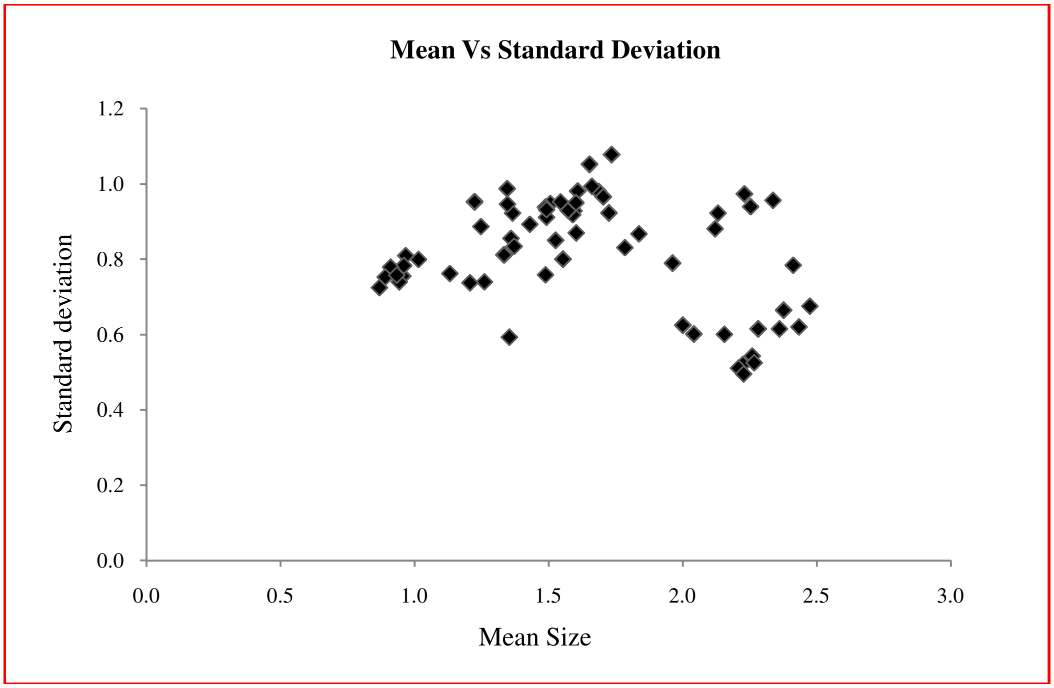

Figure-8
Scatter plot between Mean size and Standard deviation of Kolakkudi Lake sediments

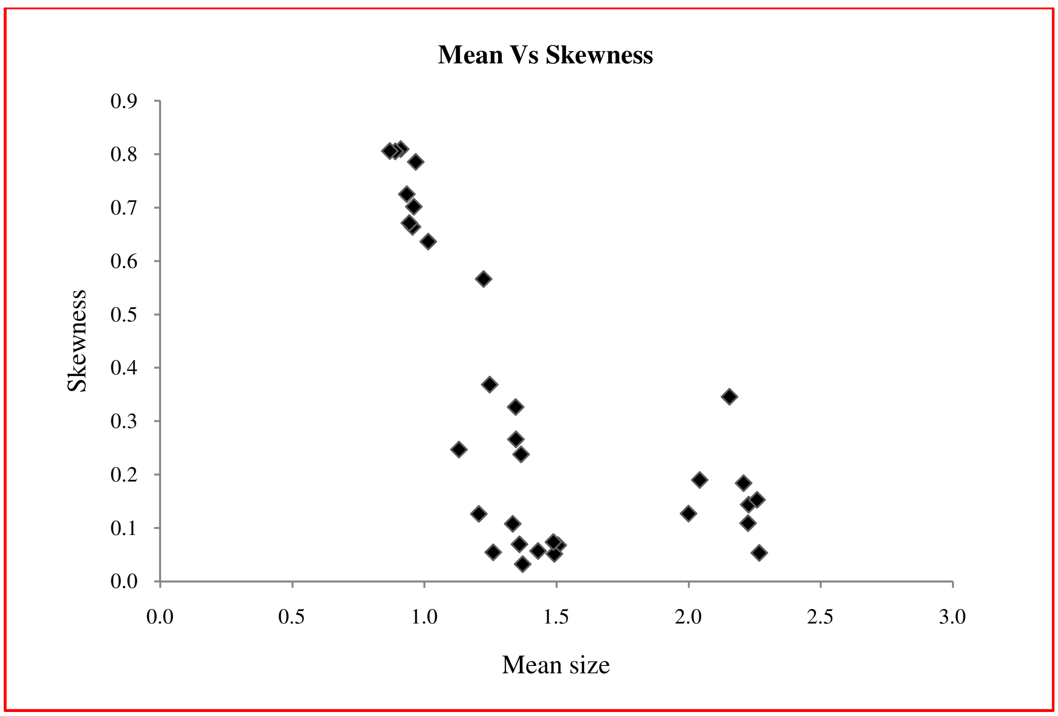

Figure-9
Scatter plot between Mean size and Skewness of Kolakkudi Lake sediments

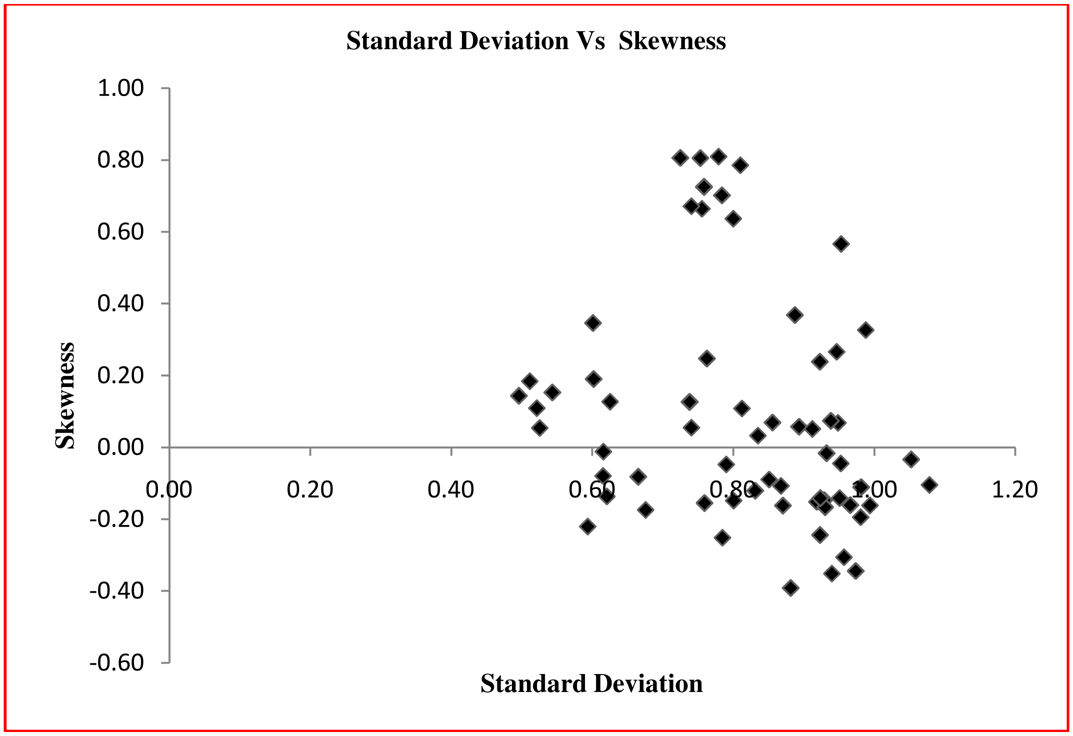

Figure-10
Scatter plot between Standard Deviation and Skewness of Kolakkudi Lake sediments

Conclusion

Textural analysis carried out for the sediments of the Kolakkudi Lake reveals that inlet part is dominated by fine sand. Central part is dominated by medium sand and outlet part is dominated by coarse sand. The grain size parameters viz., Mean size (MZ) standard deviation (σ_1) Skewness (Ski) and kurtosis (KG) of percentile values derived from the cumulative curves following Folk and Ward and the moment technique based upon grouped data are most widely used. Mean size is the average size of the sediments represented by ф mean size and mainly an index of energy conditions. The mean grain size is important tool for interpretations of sediment data in relation to bottom dynamics. The grain size diagram to spatially highly distribute in the very fine sand. The standard deviation is the measure of sorting sediments and indicates the fluctuations in kinetic energy of the depositioning agent about its average velocity. The Lake Kolakkudi it is observed that all the samples were falls in the poorly sorted to well sorted nature. Skewness measures asymmetry of frequency distribution and marks the position of mean with respect to median. The fine skewed nature of the sediments clearly exhibits sediment input from various sources of tributaries. The finely skewed nature is also implies a low velocity than normal. This skewness data indicate that in the sediments finer than the median class of the sediments dominate almost throughout their distribution. Kurtosis is a quantitative measure used to describe the departure from normality of distribution. It is seen that the entire Kolakkudi lake sediments are floored mainly by medium sand to fine sand. The CM pattern divulges that the sediments are transported mainly by suspension and rolling as well as graded suspension. Textural diversity in the sediments of the Kolakkudi Lake is due to the working and reworking of the fluvial processes.

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