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RESEARCH ARTICLE

Studies on textural characteristics of sediments in Lower Gadilam River, Cuddalore District, Tamilnadu, India.

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Abstract

The present study was carried out in order to study the textural characteristics of sediments. The graphic mean distribution for these sediments ranging from 0.50 to 2.57 ϕ, indicative of fine to coarse grained sand. The standard deviation (sorting) shows a spread of 0.46 to 1.02 ϕ and a mean value of 0.70. Most of the samples are moderate to moderately well sorted with only a few being poorly sorted. The skewness values of the samples ranged from -0.11 to 0. 61, thus indicating the presence of symmetrical to very fine skewed and coarse fraction in the particle population. The kurtosis is between 0.58 and 1.63, Thus indicates kurtosis of the river estuary sediments are platykurtic to leptokurtic in nature (0.62 to 1.63 ϕ). The sample location 2, 4 and 7 bottom cores show very platykurtic with medium to coarse sand, moderately to poorly sorted nature. The kurtosis of the midstream sediments are platykurtic to mesokurtic in nature (0.59 to 1.37 ϕ). Based on the CM pattern the river estuary sediment falls in bottom suspension and rolling while midstream sediments show bottom suspension and rolling whereas channel bar sediments show depositions by rolling mechanism.

Introduction:-

Estuaries are in a state of constant flux and their dynamic nature provides many ecological niches for diverse biota. The health status and biological diversity of Indian estuarine ecosystems are deteriorating day by day through multifarious man-made activities. The dumping of enormous quantities of sewage and industrial effluents into estuaries has resulted in a drastic reduction of shallow water fish populations, increased pollution and ecological imbalance resulting in the large-scale disappearance of numerous flora and fauna (Rajendran et al. 2004).

Learning of the textural qualities of the estuarine sediments is of extraordinary significance in differentiating different depositional small scale situations. Sediment transport system in the Vellar estuary, east coast of India was done in point of interest by Mohan (2000). Texture and composition of sediments of Hooghly estuary and close shore environment has been studied by Sesamal et al., (1986). Few authors have studied the textural qualities of sediments from various situations of the east coast, (Seetharamaswamy, 1970; Jagannadha Rao and Krishna Rao, 1984; Dhanunjaya Rao et al., 1989; Krishana Rao et al., 1990; Ramesh and Subramanian, 1992; Vaithiyanathan et al., 1992; Seetharamaiah and Swamy, 1994; Bragadeeswaran et al., 2007; Rajasekhara Reddy et al., 2008; Ramanathan et al., 2009; Rajani Kumari and Mrutyunjaya Rao, 2009; Venkatramanan et al., 2010; Anithamary Irudhayanathan et al., 2011). Thinks about on Clay mineralogy of the riverine estuaries, east shore of India were done by a few authors (Subba Rao, 1963; Satyakumar and Subba Rao, 1987; Raman et al., 1995; Ramamurty and Shrivastava, 1979; Reddy and Rao, 1996; Rao, 1991; Mohan and Damodaran, 1992). In the present investigation the grain size parameters are used to interpret sediment movement in Gadilam River.

Study Area:-

The present study area (Gadilam river) lies between 79°40' and 79°45' East longitude; and between 11°40 and 11°45' North latitude. It lies in the toposheet No. 58M of survey of India. The river originates near Sankarapuram and flows through the Cuddalore Villupuram districts and drains at Bay of Bengal at Cuddalore, the area coverage of Gadilam River is about 181.315 Sq. Km. (Figure: 1& 2).

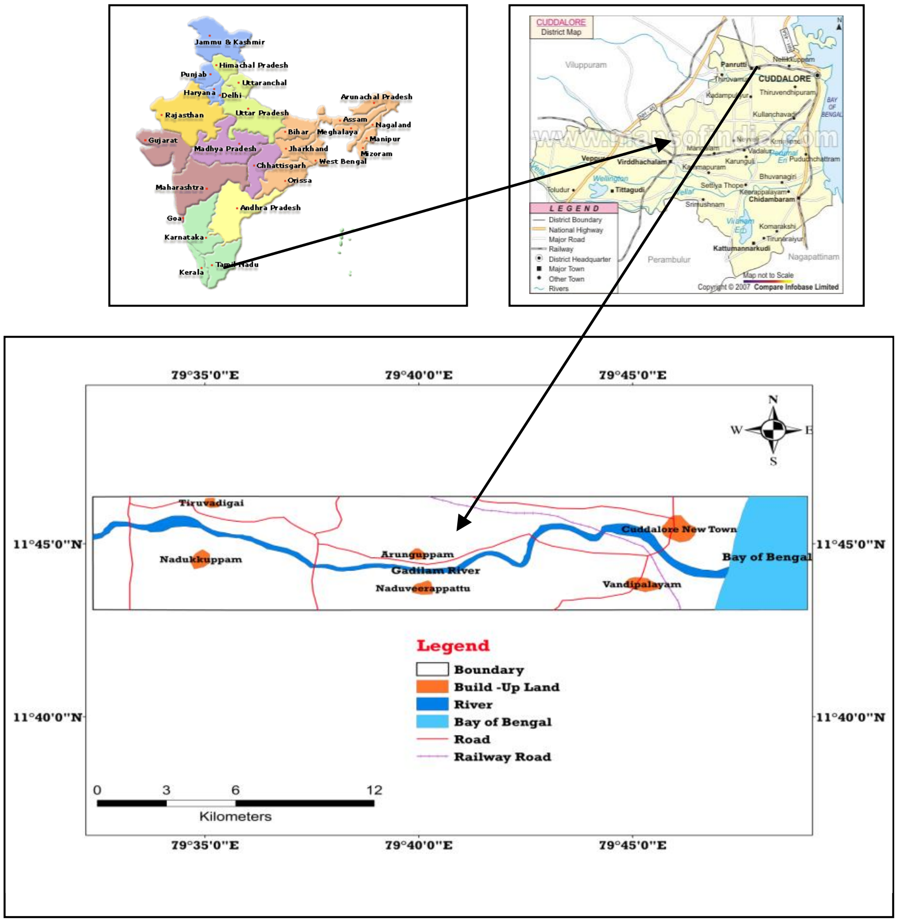


Figure: 1 Study area Base map

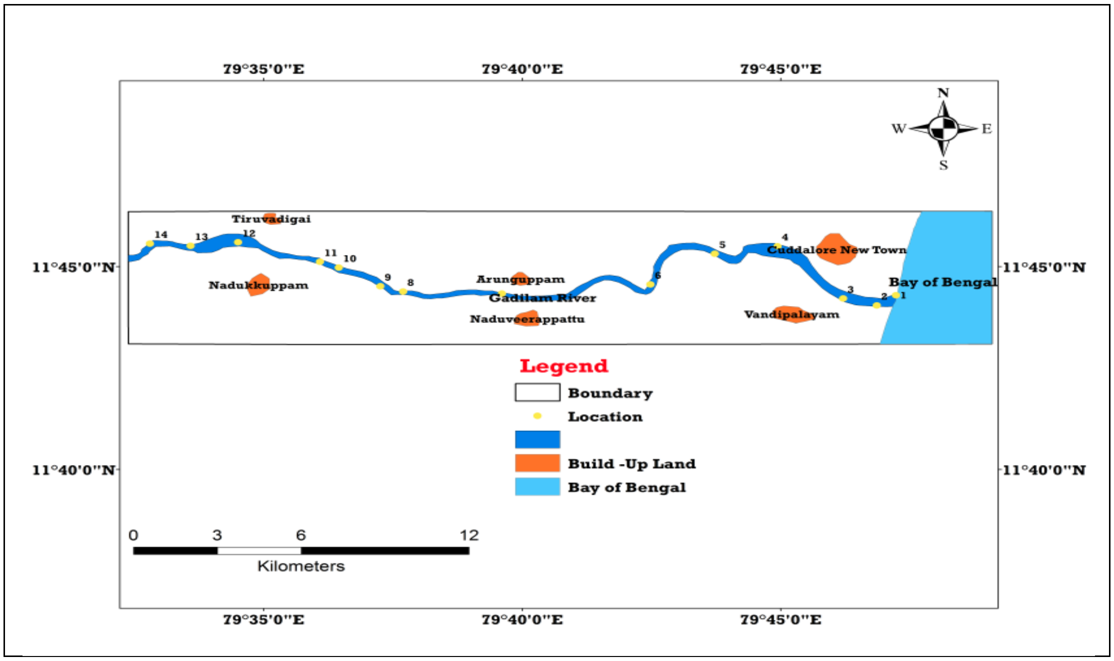


Figure: 2 Location map

Materials and methods:-

Sampling and Textural Analysis

The parameters used to describe the particle size distribution fell into four primary groups: those are the mean, standard deviation (sorting), Skewness and kurtosis. These parameters can be easily acquired by mathematical or graphical methods. The mathematical 'method of moments' (Krumbein and Pettijohn, 1938; Friedman and Johnson, 1982) is the most accurate, since it represented the entire sample population. However, consequently the statistics are greatly affected by outliers in the tails of the distribution and this form of analysis should not be used unless the size distribution is known (Mcmanus, 1988). Fourteen stations in the river basin have been visited and it has been divided into fourteen cores sediment samples were collected randomly including river mouth, downstream (7) and upstream (7) of the Gadilam River. The samples were carried out by 1m PVC pipes and then all samples divided into three sections like, Top, Middle and Bottom. After divided the samples in the laboratory, dead shells were separated from sediments and the mixed saline content was removed from the grains by washing with water. The grain size distribution was carried out by using eight sieves ranges varies from sizes 75µm, 125µm, 180µm, 250µm, 355µm, 500µm, 1000µmand 2000µm.

Results and Discussion:-

The results has been carried out with consists of grain size parameters of downstream and upstream sediments which is detailed in Table.1 & 2 respectively. There is no major variations of grain size parameters viz. mean size, standard deviation, Skewness and kurtosis in downstream and upstream sediments of Gadilam River along the profile as shown in Figures.3, 4, 5 & 6.

Table: 1 Grain size parameters of Gadilam Downstream core sediment samples

Loc. No	Division	Mean	Sorting	Skewness	Kurtosis	Remarks			
1	Top	2.52	0.47	0.26	1.00	FS	WSO	FSK	MKU
	Middle	2.27	0.60	-0.01	1.40	FS	MWSO	SM	LKU
	Bottom	2.36	0.62	-0.08	1.19	FS	MWSO	SM	LKU
2	Top	2.42	0.56	0.15	1.09	FS	MWSO	FSK	MKU
	Middle	2.57	0.51	-0.05	1.34	FS	MWSO	SM	LKU
	Bottom	2.24	0.56	0.09	1.64	FS	MWSO	SM	VLKU
3	Top	1.31	0.87	0.22	0.99	MS	MSO	FSK	MKU
	Middle	0.95	0.84	0.40	0.87	CS	MSO	VFSK	PKU
	Bottom	1.04	0.99	0.53	1.01	MS	MSO	VFSK	MKU
4	Top	1.17	0.92	0.39	1.00	MS	MSO	VFSK	MKU
	Middle	0.96	0.81	0.43	0.77	CS	MSO	VFSK	PKU
	Bottom	2.09	1.02	0.08	1.01	FS	PSO	SM	MKU
5	Top	1.87	0.81	-0.08	1.58	MS	MSO	SM	VLKU
	Middle	0.80	0.66	0.43	0.74	CS	MWSO	VFSK	PKU
	Bottom	0.70	0.60	0.51	0.84	CS	MWSO	VFSK	PKU
6	Top	0.88	0.72	0.37	0.88	CS	MSO	VFSK	PKU
	Middle	1.14	0.69	-0.12	0.84	MS	MSO	CSK	PKU
	Bottom	0.89	0.69	0.33	0.67	CS	MWSO	VFSK	VPKU
7	Top	0.81	0.68	0.47	0.68	CS	MWSO	VFSK	PKU
	Middle	1.07	0.76	0.08	0.73	MS	MSO	SM	PKU
	Bottom	0.89	0.72	0.39	0.63	CS	MSO	VFSK	VPKU

Table: 2 Grain size parameters of Gadilam river Upstream core sediment samples

Loc. No	Division	Mean	Sorting	Skewness	Kurtosis	Remarks			
8	Top	2.04	1.01	0.26	1.09	FS	PSO	FSK	MKU
	Middle	1.20	0.56	-0.13	0.78	MS	MWSO	CSK	PKU
	Bottom	1.16	0.59	-0.06	0.75	MS	MWSO	SM	PKU
9	Top	0.87	0.63	0.32	0.73	CS	MWSO	VFSK	PKU
	Middle	0.73	0.64	0.56	0.78	CS	MWSO	VFSK	PKU
	Bottom	0.93	0.65	0.11	0.77	CS	MWSO	FSK	PKU
10	Top	0.85	0.66	0.36	0.77	CS	MWSO	VFSK	PKU
	Middle	0.94	0.68	0.17	0.66	CS	MWSO	FSK	VPKU
	Bottom	0.74	0.65	0.57	0.73	CS	MWSO	VFSK	PKU
11	Top	1.00	0.82	0.38	0.74	MS	MSO	VFSK	PKU
	Middle	0.93	0.73	0.30	0.68	CS	MSO	VFSK	PKU
	Bottom	0.96	0.74	0.27	0.68	CS	MSO	FSK	PKU
12	Top	0.98	0.91	0.49	0.98	CS	MSO	VFSK	MKU
	Middle	1.01	0.89	0.41	1.05	MS	MSO	VFSK	MKU
	Bottom	1.07	0.91	0.29	0.98	MS	MSO	FSK	MKU
13	Top	0.71	0.71	0.62	1.15	CS	MSO	VFSK	LKU
	Middle	0.50	0.51	0.50	1.37	CS	MWSO	VFSK	LKU
	Bottom	0.57	0.57	0.55	1.22	CS	MWSO	VFSK	LKU
14	Top	0.87	0.70	0.40	0.59	CS	MWSO	VFSK	VPKU
	Middle	0.79	0.66	0.51	0.68	CS	MWSO	VFSK	PKU
	Bottom	0.89	0.71	0.34	0.63	CS	MSO	VFSK	VPKU

Note: FS-Fine Sand, CS-Coarse Sand, MS-Medium Sand, MSO-Medium Sorted, MWSO-Moderately Well Sorted, PSO-Poorly Sorted, SM-Symmetrical, FSK-Fine Skewed, VFSK-Very Fine Skewed, CSK-Coarse Skewed, MKU-Mesokurtic, PKU-Platykurtic, VPKU-Very Platykurtic, LKU-Leptokurtic, VLKU-Very Leptokurtic.

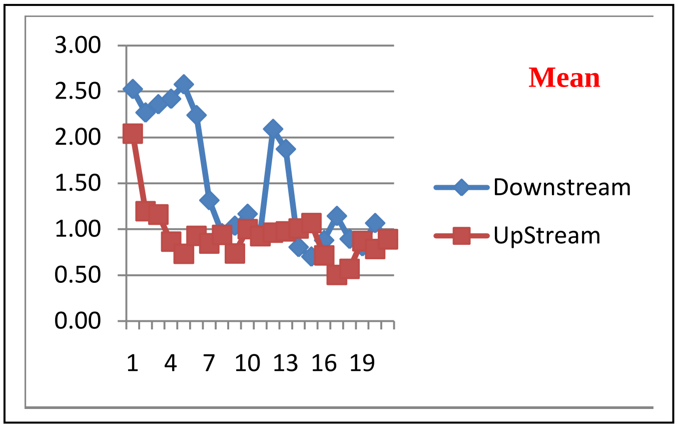


Figure: 3

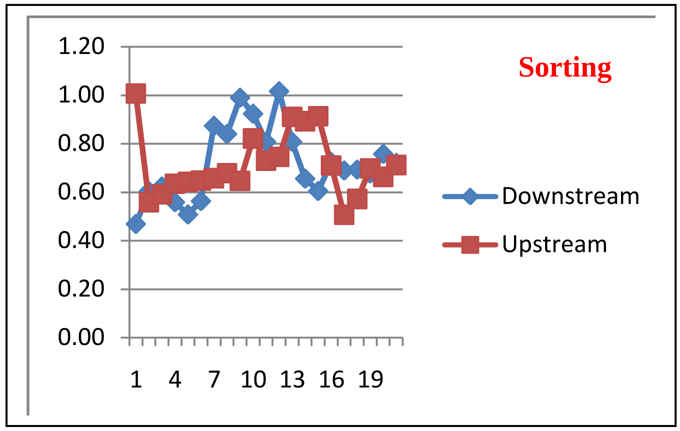
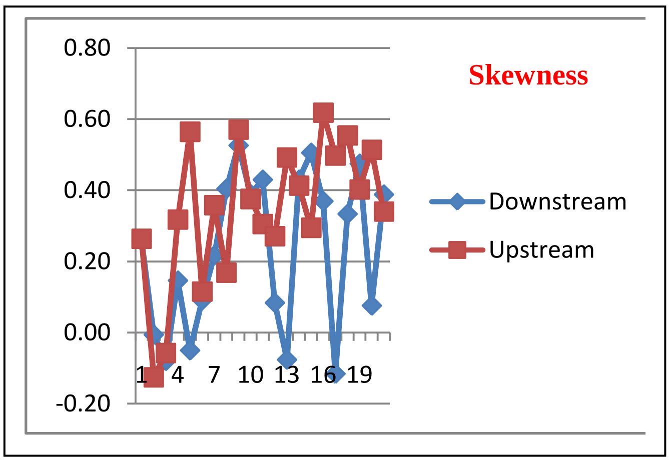


Figure: 4



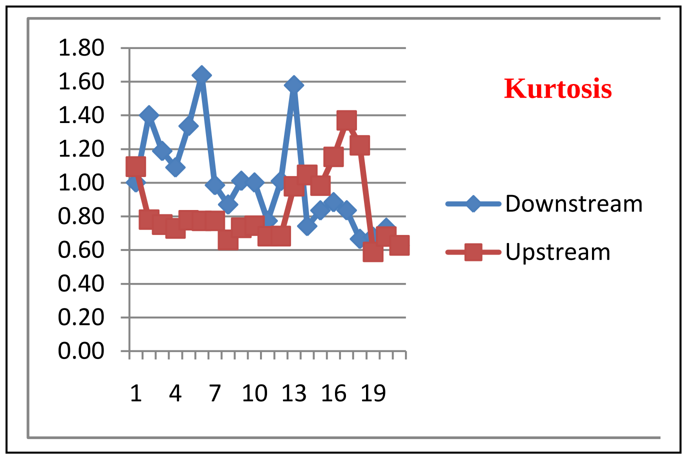


Figure: 5

Figure: 6

Mean size:- The graphic mean size is the average size of the sediments represented by ϕ mean size and mainly is an index of energy conditions. The mean grain size of the Gadilam river downstream and upstream sediments varies from fine to coarse sand and medium sand to coarse sand and its ϕ size ranges from (0.70 to 2.57 ϕ) and (0.50 ϕ to 2.04 ϕ) respectively. The variations in ϕ mean size reveals the differential energy conditions resulting their deposition (Karuna et.al., 2013). Most of the sediments are measured as fine sand to coarse sand. The range of mean (i.e., fine to coarse) and moderately sorting indicate only proximity to source and hence limited transport of sediments (Joseph, et.al., 1997).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 (Sahu, 1964).

Standard deviation (Sorting):-
The graphic Standard deviation indicates the difference in kinetic energy associated with mode of deposition or uniformity of particle size distribution. It is an important parameter in sediment analysis because it reflects the energy conditions of depositional environment but it does not necessarily measure the degree to which the sediment has been mixed (Spencer, 1963). The standard deviation of the Gadilam river downstream sediments varies from moderately sorted to moderately well sorted (0.47 to 1.02). The downstream sediments show fine sand and well sorted nature in the location 1in top core. The standard deviation of the upstream sediments is also differing from moderately sorted to moderately well sorted (0.51 to 1.01). The variations in the sorting values are likely due to continuous addition of finer or coarser materials in differential proportions.

Skewness:-

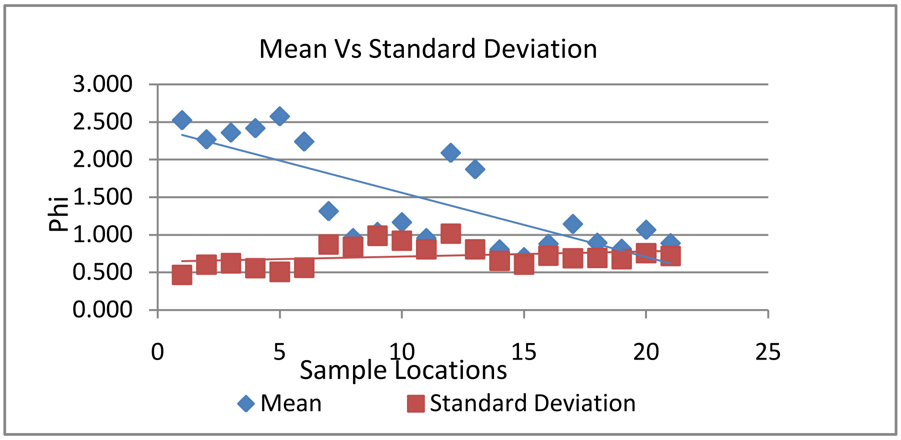
The graphic Skewness measures the symmetrical distribution, i.e. predominance of coarse or fine-sediments. The negative value denotes coarser material in coarser-tail i.e., coarse skewed, whereas, the positive value represents more fine material in the fine tail i.e., fine-skewed. The skewness of the downstream sediments are very symmetrical skewed to very finely skewed (-0.12 to 0.53) whereas the upstream sediments fine skewed to very fine skewed (-0.13 to 0.62). The upstream sediments are medium sand, moderately well sorted with very coarse skewed are shown from location 1in top portion of the core. The other stations show coarse to medium sand, moderately sorted; coarsely to finely skewed. Very finely skewed to finely skewed sediments generally imply the introduction of fine material and very finely skewed nature of sediments indicates excessive riverine input.

Kurtosis:- The graphic kurtosis is a quantitative measure used to describe the departure from normality of distribution. It is a ratio between the sorting in 'tails' and central portion of the curve. If the tails are better sorted than the central portion, then it is termed as leptokurtic, whereas, it is platykurtic in opposite case, or mesokurtic if sorting is uniform both in tails and central portion. The kurtosis of the Gadilam river downstream sediments are platykurtic to leptokurtic in nature (0.62 to 1.63 ϕ). The sample location 2, 4 and 7 bottom cores show very platykurtic with medium to coarse sand, moderately to poorly sorted nature. The kurtosis of the upstream sediments are platykurtic to mesokurtic in nature (0.59 to 1.37 ϕ). Friedman (1967) suggested that extreme high or low values of kurtosis truth that part of the sediment achieved its sorting elsewhere in a high energy environment. The variation in the kurtosis values is a reflection of the flow characteristics of the depositing medium (Seralathan and Padmalal, 1994; Baruah et.al., 1997).

Mean size Vs. Standard deviation:-

The Scatter plot (Figure: 7) between mean grain size and standard deviation of the Gadilam river estuary sediments in upper stream varies from fine to coarse sand. The higher energy level permits deposition of coarser sediments as well as transportation of a much wider range of fine sediments (Brayant, 1982). The downstream of estuary sediments clearly bring out that sorting increase with decrease in the size of the sediments from fine sand to coarse sand. Similar observations are also reported by Reddy et.al, (2008) and Karuna et.al, (2013) in sandy sediments of Mahanadi River.

Downstream



Upstream

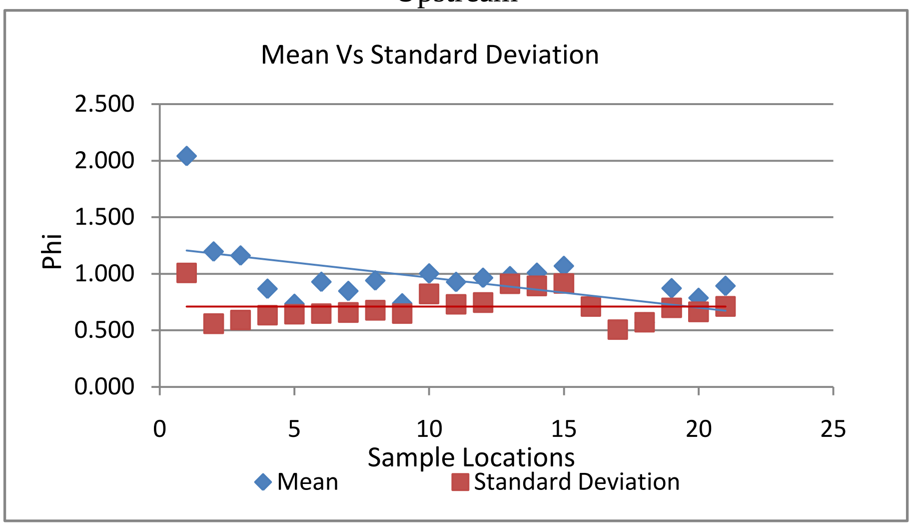


Figure: 7 Mean Vs Standard Deviation

Mean size Vs. Skewness:- The scatter plot between mean and skewness (Figure: 8) of the Gadilam river estuary sediments in upper stream differ from medium sand to coarse with positive to negative skewness. The positive skewness of contribution in finer Aeolian sediments transported from the winds (Chauhan, 1986). The negative skewed indicates excess of coarser tail depicts the depletion of the finer sediments indicates a depositional tendency (Duane, 1964). The lower stream sediments of negative skewness occur in high energy environments while; sediments with positive skewness lie in low energy environments.

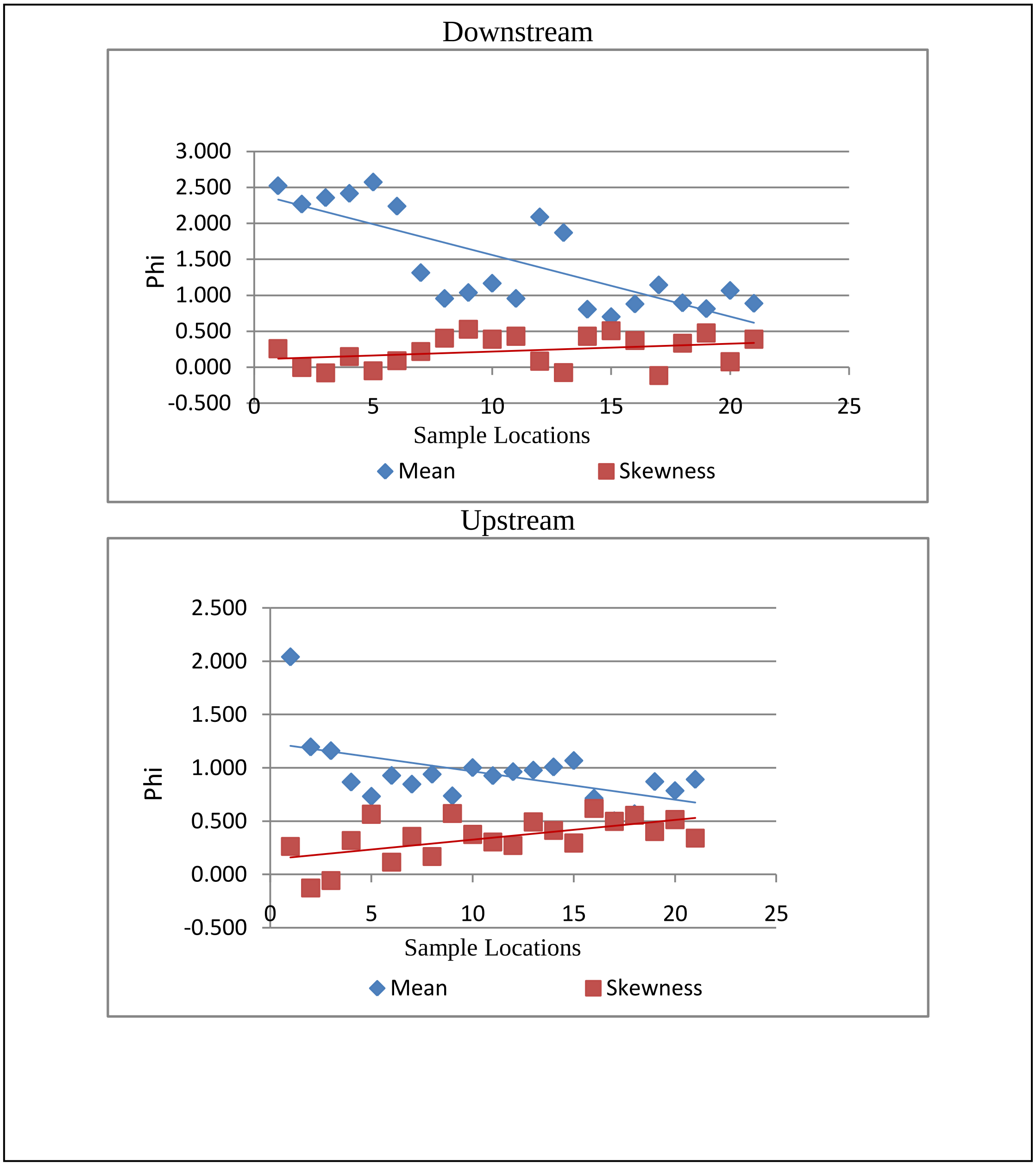


Figure: 8 Mean Vs Skewness

Skewness Vs. Kurtosis:-

The plot between Skewness and Kurtosis (Figure: 9) sediments samples are observed that the sediments were negative (coarse) skewed (Hegde et al, 2006). The percentage of positive skewed samples were relatively less, where negatively skewed were relatively more, which indicates that the beach were undergoing erosion or non-position. (Duane, 1964). Along the shoreline all the samples varied in between very platykurtic to very leptokurtic. Mostly dominance of platykurtic is noticed. Friedman (1962) suggested that extreme high or low values of kurtosis imply that part of the sediments achieved its sorting elsewhere in a high energy environment. The above result shows that the skewness was highly influenced by wave action.

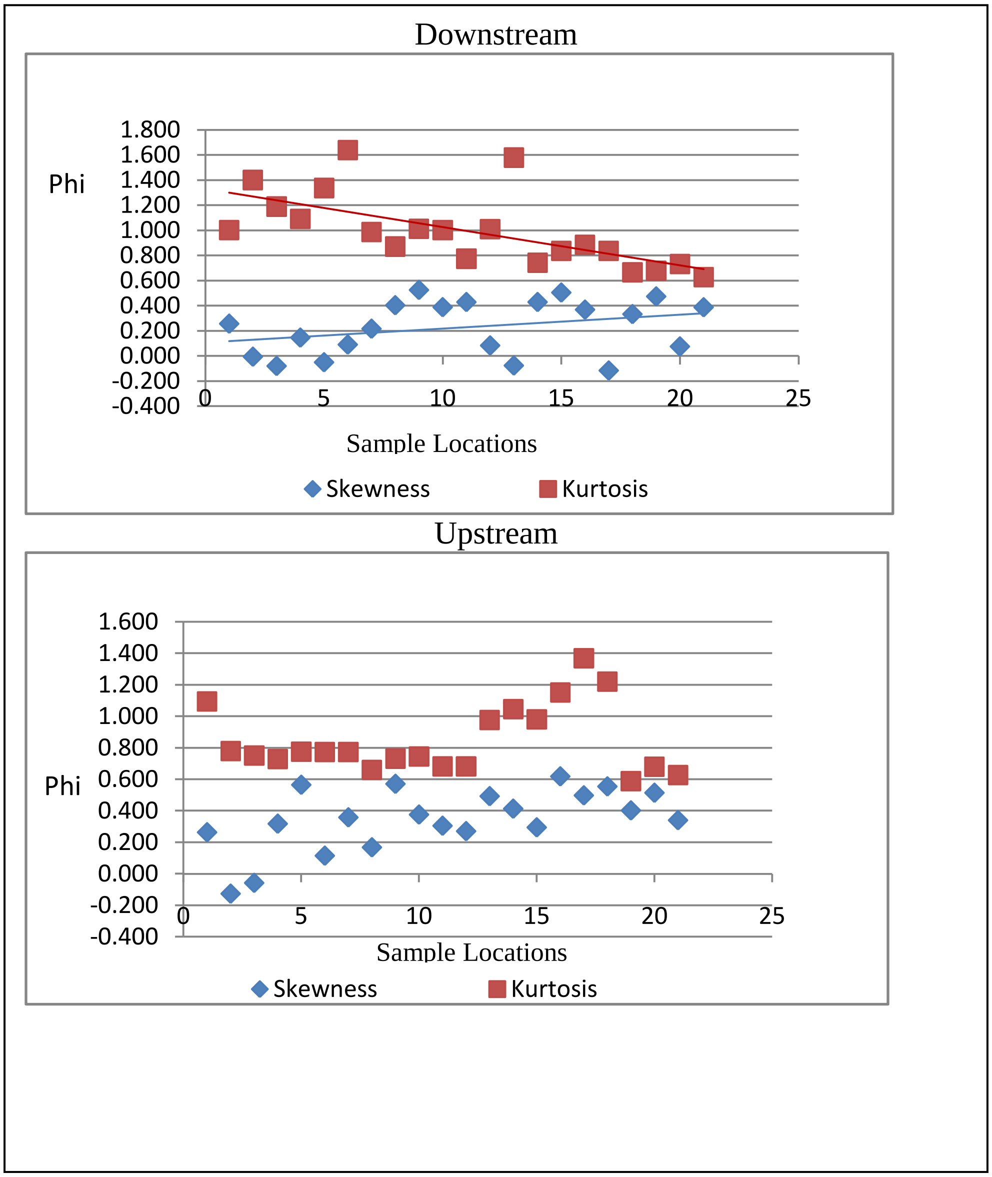


Figure: 9 Standard Deviation Vs Skewness

C M diagram:-

The CM pattern of the sedimentary environment are action of analyzing transportation mechanism, depositional environment with respect to size, range and energy level of transportation and also its determining process and characteristic agents that are responsible for the formation of clastic deposits. In the present study an attempt has been made to identify the modes of deposition of sediments in Gadilam River by CM patterns. The present interpretation is based on Passega (1957, 1964) and Passega and Byramjee (1969). Passega (1957) explained 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 (1969) explained the log normal sub populations within the total grain size spreaded curve as representing suspension, saltation and surface creep or rolling modes of transportational mechanisms. 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 accuracy to control of sedimentation by bottom turbulence. The CM plot (Figure 10 & 11) shows that most of the samples formed by two different depositional conditions. This field represents the most of tractive current deposition and these sediments are deposited by bottom suspension and rolling in downstream sediments. While the sediments of upstream sediments shows bottom suspension and rolling whereas channel bar sediments show depositions by rolling mechanism.

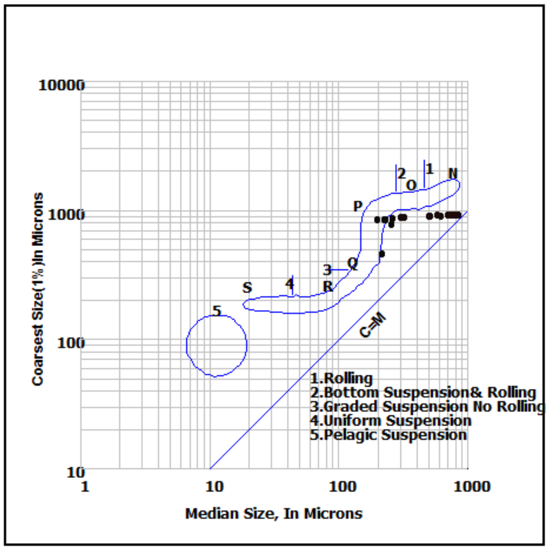


Figure: 10 Downstream Sediments

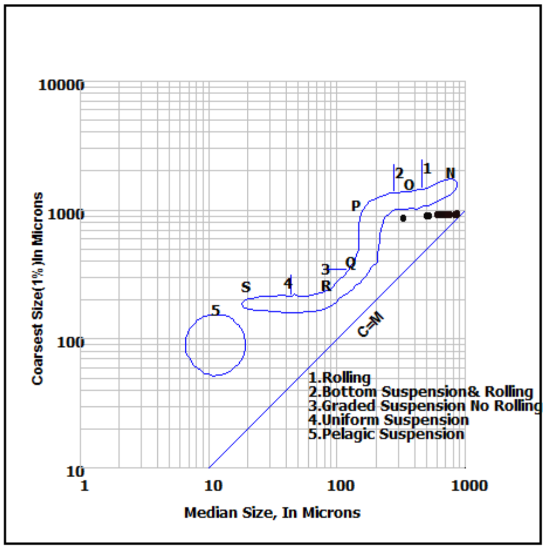


Figure: 11Upstream Sediments

Summary and conclusions:-

The various plots discussed above suggest that the estuary river sediment and mid-stream sediment are mixed with fine grained sediments which are evidence from the positive skewness. This is in turn an indication that the river is seasonal and only flows during flood leaving its fine grained sediments unwashed in each flow cycle. Also some ambiguities are observable in the plots above which indicates the mixing of variously grained sediments by associated drainage channels joining the main stream of Gadilam river. It is therefore the coarser sediments are appearing in the graph showing rather gradational pattern of sediments so analyzed along the river profile.

The most important conclusions are,

The textural parameters indicate that the estuary river sediments and mid-stream sediments are of granule to medium sand; moderately sorted to poorly sorted; very coarsely skewed to very finely skewed; very platykurtic to very leptokurtic in nature.

The river sediments are deposited under high to low energy conditions with dominant bottom suspension and rolling mechanisms. The sediments from sediment bar were deposited under sheltered, low energy conditions while the channel bar sediments deposited under high energy conditions. The variations in mean size indicate differential energy conditions at different locations. Whereas, the variations in sorting values indicate continuous addition of finer to coarser material in varying proportions at different locations.

Frequency Distribution Curves (FDC) clearly suggest that the river sediments are unimodal and composed of mainly medium sand. While, the sediments which are bimodal are composed mainly of very coarse sand. The sediment bar shows medium sand and channel bar shows coarse sand with unimodal nature in both the cases.

The CM plot of river sediment samples indicates two different depositional conditions, viz. bottom suspension and rolling. While the sediments from sediment bar show bottom suspension and rolling and channel bar sediments show depositions by rolling.

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