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Sedimentological Studies of Nagavali-Vamsadhra Estuaries, East Coast of India, Andhra Pradesh

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Abstract: ***The importance of textural characteristics of estuarine sediments in the present study is useful in understanding the intensity of sediment transportation in the fluvial systems. The importance of grain size parameters of the sediments is well recognized in sedimentology and has been well established. The present study illustrates the detailed textural characterization of Nagavali and Vamsadhara estuarine sediments of East Coast of India, Srikakulam, Tamil Nadu. The textural studies reflect that the sediments have significant fractions of fine to medium sand, silt and clay, where fine sand is predominant in both the estuaries. The statistical sedimentary analysis for the samples says mean size, standard deviation, skewness and kurtosis is carried out. The sediment is dominantly fine sand with moderately sorted, nearly skewed in Nagavali estuary whereas the sand is very well sorted and nearly symmetrical in Vamsadhara estuarine sediments. The sediments of both are similar in size and show low variance. The present study suggesting that the sediments deposited in low energy conditions. The Nagavali estuary samples shows nearly symmetrical skewness and the Vamsadhara estuary samples shows nearly symmetrical to positive skewness. Negative Skewness was being correlated with high energy and winnowing action and positive Skewness with lower energy levels. The present study demarcates the sedimentation have no influence of nearshore tidal activity.***

Key words: ***Grain size distribution, Nagavali and Vamsadhara Estuaries, statistical parameters, very well sorted, Low energy levels.***

I. INTRODUCTION

The importance of textural characteristics of estuarine sediments in the present study is useful in understanding the intensity of sediment transportation in the fluvial systems. The importance of grain size parameters of the sediments is well recognized in sedimentology and has been well established. They are often used and helpful in interpreting the environments of sediment deposition of ancient as well as modern sediments. There have been many attempts (Mason and Folk 1958, Friedman 1961 and 1967) to differentiate the sediments from varying environments like beach and dune, dune beach and river, beach and river etc. based on grain size parameters. The main intention in these studies is centered on in establishing a tool with which the transportation and depositional history of ancient sediments can be deduced.

The estuarine sediments of the river systems, namely Nagavali and Vamsadhara have been studied for their textural parameters. For this purpose, samples have been collected and standard methodology is adopted as given by earlier workers. The results are presented further, thus sand fraction of the sediments from both Nagavali and Vamsadhara was mounted on a glass slide and mineralogical studies were carried out. The details are also incorporated in this part.

II. STUDY AREA

The study area covers the Vamsadhara and the Nagavali River systems that originates from Eastern Ghats of Andhra Pradesh and Odisha to meet the coastal tracts of the Srikakulam District, Andhra Pradesh. It comprises an area of 2285 km2 and lies between 18°40′N to 18°09′N latitude and 84°10′ E to 83°39′E longitude covering Vamsadhara and Nagavali estuarine systems along the Bay of Bengal. These two rivers flow from North West to the South Eastern direction in Srikakulam district.

Vamsadhara River originates in the border of Kalyansinghpur in Rayagada district and Thuamul Rampur in Kalahandi district of Odisha flowing for a length of 154 km in Odisha State and runs along the border of Odisha and Andhra Pradesh for a length of 29 km from Battili to Gotlabhadra village of Andhra Pradesh. The river flows for a length of 82 km in Andhra Pradesh before emptying into the Bay of Bengal at Kalingapatnam in Srikakulam District of Andhra Pradesh. The River Nagavali rises just south of the Belagad village in the undivided Phulbani district of Odisha at an elevation of about 600 m. The total length of the river is about 221 km, of which 125 km is in Odisha, 23 km is at the boundary between Odisha and Andhra Pradesh and 73 km is in Andhra Pradesh. Study area is shown in the following figure (Figure 1).

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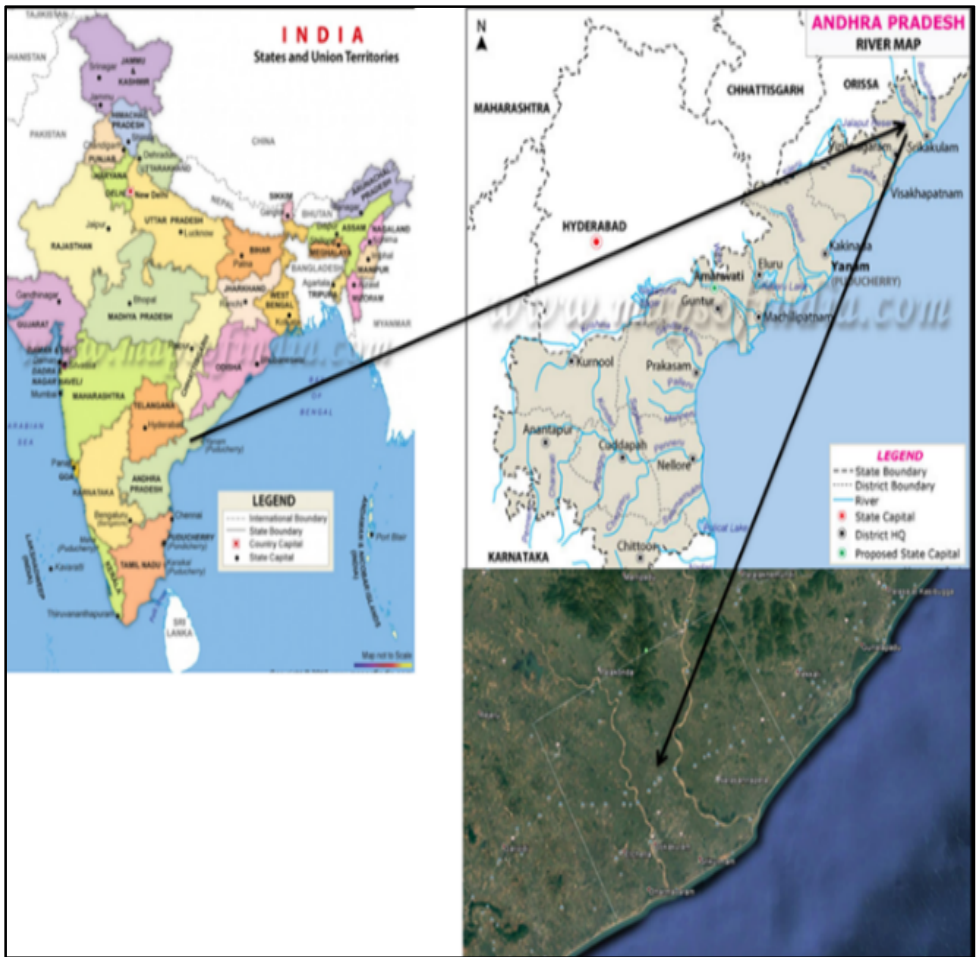


Fig. 1. Study area of Nagavali and Vamsadhara Estuarine Systems

III. GEOLOGY OF THE AREA

The main geological formations of the study area are Dharwars, peninsular granites, puranas, Gondwanas and Archaeans. The groundwater occurs under unconfined conditions in the joints, fissures and fractures extending to deeper levels beneath the weathered zone. The entire drainage basin consists of Eastern Ghats super group of rocks belonging to Archean age. These rocks are subjected to granulite facies of metamorphism and comprises of khondalite group, charnockite group, basic pyroxene granulites and granitic rocks.

The study area is characterized by widespread alluvial cover underlain mostly by granite gneisses. Except for the Eastern Ghats flanking the western boundary and isolated hillocks, the study area is essentially a plain with gentle slopes. The rich alluvial cover has facilitated agricultural activity in 90% of the region. The most abundant rock type is garnetiferous granite gneiss (Padmanabhayya, 1958; Suryanarayana, 1957). The pegmatites occur as veins in the area (Padmanabhayya, 1958; Rao, personal communication). The other rocks include acid, intermediate, basic and ultrabasic charnockites (pyroxene amphibolite) of charnockite series and calc-granulites, garnet-sillimanite gneiss and garnetiferous quartzites of the khonatlite series.

IV. MATERIALS AND METHODS

Fifteen sediment samples each from Nagavali and Vamsadhara estuaries (fig. 2 and fig. 3) were collected by pushing down a PVC tube (60mm dia) and Van Veen grab sampler. These samples were mixed homogenously for both the areas separately and a known quantity of sediment samples were prepared for further procedure. It includes treatment of these samples with dil. HCL and H_2O_2 for removal of shell fragments and organic matter. Further, these samples were then washed and dried at ~50˚C for further analysis. These samples were subjected to textural analysis. Mechanical analysis for determining grain size distribution of the sediments was conducted by the standard method of sieving described by Carver (1971) and their statistical analysis as mentioned by R.L Folk (1957) was carried out and discussed further.

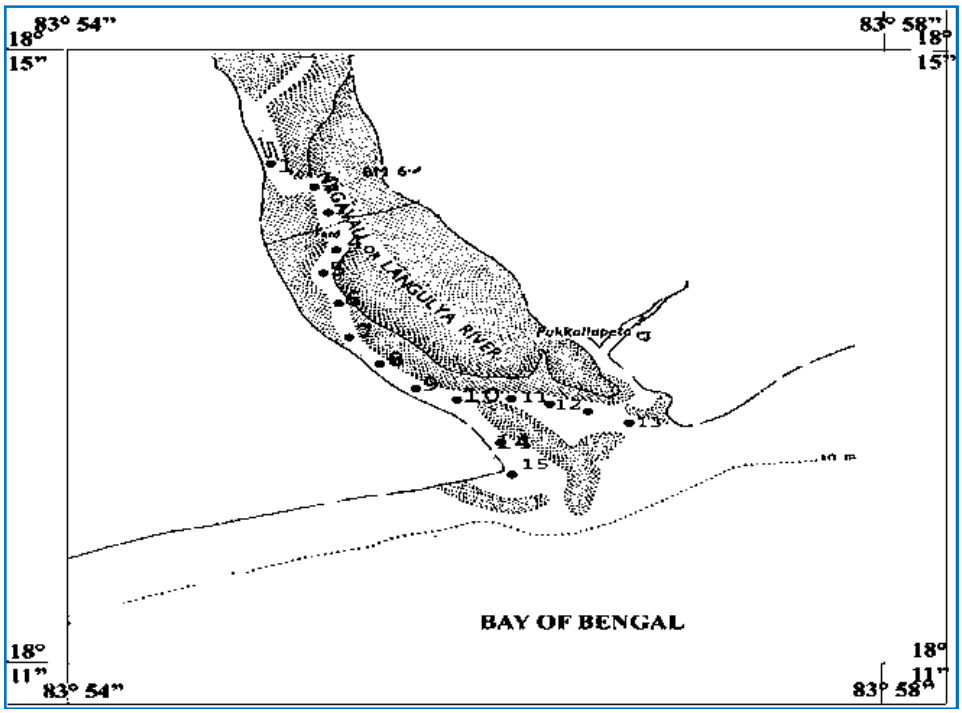


Fig. 2: Sample locations of Nagavali Estuary

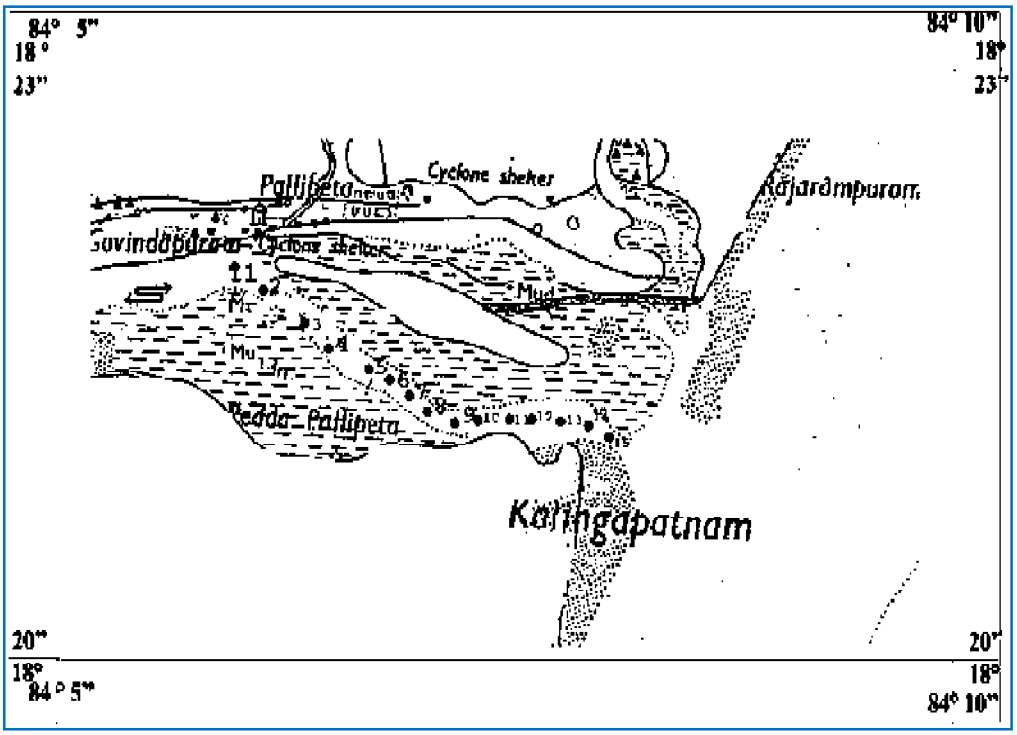


Fig. 3: Sample locations of Vamsadhara Estuary

V. RESULTS & DISCUSSIONS

The textural analysis for the sediments of the study area has been carried out to describe the spatial variation in the grain size characteristics of Nagavali and Vamsadhara estuaries and the results are shown in Table 1 and Table 2 respectively. These sediments are dominated by sand, silt and clay. Sand is of higher proportion and followed by silt and clay in minor proportions in both the locations.

A. Results and discussion of Nagavali River Estuary:

1) Mean Size (Mz):

The average grain size of the sediment distribution known as mean size is an important parameter to different the sedimentary trends. Nagavali estuary sediments having average value 2.23. The estuary sediments have maximum value is 2.80 and minimum value is 1.65. So the mean size varies from medium to Fine sand.

2) Standard Deviation (σI):

The sorting depends on at least three major factors.

(1) Size range, (2) Type of deposition, (3) Current character,

Standard deviation is a measure of the dispersion of the grain size distribution. It is an important parameter in sediment analysis because it reflects the energy condition of depositional environment but it does not necessarily measure the degree to which the sediment has been mixed (Spencer 1963) according to Levees (1973) it is debatable whether the much-skewed sand with (1957) is followed here to describe the nature of sorting.

Nagavali estuarine sediments have the average standard deviation value of 0.661. The maximum value is 0.96 and the minimum value is 0.35. It shows the grains are moderately sorted.

Table 1. Textural Characteristics and Statistical Textural Parameters of Sediments from Nagavali River estuary, Srikakulam District, Andhra Pradesh

Sample No.	Sand (%)	Silt (%)	Clay (%)	Mean Size(Mz)	Standard Deviation(σI)	Skewness (SK1)	Kurtosis (KG)	Remarks			
								Mean Size (Mz)	Standard Deviation (σI)	Skewness (Sk1)	Kurtosis (KG)
1.	90.5	7.31	2.1	1.98	0.88	-0.365	1.434	Medium Sand	Moderately Sorted	Negatively Skewed	Lyptokurtic
2.	-	-	-	2.11	0.405	0.425	0.9314	Fine Sand	Well Sorted	Very Positively Skewed	Mesokurtic
3.	87.2	10.11	2.6	2.5	0.899	-.03006	0.9562	Fine Sand	Moderately Sorted	Negatively Skewed	Mesokurtic
4.	-	-	-	2.8	0.4276	-0.725	1.4344	Fine Sand	Well Sorted	Very Positively Skewed	Lyptokurtic
5.	72.2	22.7	5.3	2	0.7136	0.05	0.8553	Fine Sand	Moderately Sorted	Nearly Symmetrical	Platykurtic
6.	-	-	-	2.55	0.7314	-0.0512	1.4207	Fine Sand	Moderately Sorted	Nearly Symmetrical	Lyptokurtic
7.	80.5	16.6	2.85	2.05	0.6455	0.06	0.9016	Fine Sand	Moderately Sorted	Nearly Symmetrical	Mesokurtic
8.	-	-	-	1.7	0.7738	0.0119	0.6731	Medium Sand	Moderately Sorted	Very Negatively Skewed	Platykurtic
9.	89.5	8.7	1.7	2.15	0.6359	0.0652	0.8977	Fine Sand	Moderately Sorted	Nearly Symmetrical	Platykurtic
10.	-	-	-	2.03	0.9621	0.1012	0.8334	Fine Sand	Moderately Sorted	Nearly Symmetrical	Platykurtic
11.	74	21.8	4.13	2.31	0.9541	0.054	0.7271	Fine Sand	Moderately Sorted	Nearly Symmetrical	Platykurtic
12.	-	-	-	1.65	0.8443	0.1099	0.8984	Fine Sand	Moderately Sorted	Nearly Symmetrical	Platykurtic

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13.	82.8	13.2	3.9	2.9	0.3568	0.2143	1.3115	Fine Sand	Well Sorted	Positively Skewed	lyptokurtic
14.	-	-	-	2.48	0.7962	-0.0078	0.8368	Fine Sand	Moderately Sorted	Nearly Symmetrical	Platykurtic
15.	-	-	-	2.25	0.485	0.0284	0.8355	Fine Sand	Well Sorted	Nearly Symmetrical	Platykurtic

3) Skewness (SKI):

Skewness measures the symmetry of the grain size distribution. A normal distribution being symmetrical has zero. Skewness if the distribution possess a coarse tail portion relative to the fine size relative to the coarse size the Skewness is positive. Skewness is proved to be valuable parameter in distinguishing among the environments.

Folk and Ward (1957), Friedman (1961, 1965 and 1967) and Chapel (1967) have been used Skewness to decipher different environment and it can be sensitive indicator of subpopulation mixing. Sign of the Skewness was related to the environment energy (Duane, 1964). Negative Skewness was being correlated with high energy and winnowing action and positive Skewness with lower energy levels.

The variation of the Skewness of the Nagavali River sediments is shown in the table 2. The Skewness of the river sediments individual stations very from different values in table. Based on the variable verbal classification of Folk and Ward (1957) the Skewness range values are –1.0 to –0.4 is very negatively skewed -0.4 to –0.1 is negatively skewed and –0.1 to 0.1 is nearly symmetrical and 0.1 to 0.3 is positively skewed greater than 0.3 is very positively skewed these values are explain the sediments variation in the beach sediments.

The average Skewness value of Nagavali estuary is 0.93 then the Skewness is nearly symmetric. The maximum value is 1.21 and minimum value is -0.03. Most of the samples shows nearly symmetrical skewness.

4) Kurtosis (Kg):

Kurtosis is measure of degree of peaked ness it indicates the ratio of the sorting in the extremes of the distribution along the beach. It is a sensitive and valuable measure in testing the normally of distribution.

The kurtosis range is value are 0-0.5 is very platy kurtic and 0.5- 0.9 is platy kurtic, 0.9-1.1 is Mesokurtic, 1.1 to 1.5 is leptokurtic 1.5 to 3.0 is Very leptokurtic and greater than 3 is extremely leptokurtic these values are explained in the Nagavali estuary sediments variation are shown in the table.

The maximum kurtosis value of estuary is 1.43 and minimum value is 0.83. The samples values show Platy, Meso and lypto kurtosis values.

B. Results and Discussion of Vamsadhara River Estuary:

1) Mean Size (Mz):

Vamsadhara Estuary sediments having average value 2.05. The estuary sediments have maximum value is 2.35 and minimum value is 1.75. Therefore, mean size varies from medium sand to fine sand.

2) Standard Deviation (σI):

Vamsadhara estuary sediments have the average standard deviation value of 0.346. The maximum value is 0.57 and the minimum value is 0.006. A maximum value shows Very well sorted grains.

Table 2. Textural Characteristics and Statistical Textural Parameters of Sediments from Vamsadhara River estuary, Srikakulam District, Andhra Pradesh

Sample No.	Sand (%)	Silt (%)	Clay (%)	Mean Size (Mz)	Standard Deviation (σI)	Skewness (Sk1)	Kurtosis (KG)	Remarks			
								Mean Size(Mz)	Standard Deviation (σI)	Skewness (Sk1)	Kurtosis (KG)
1.	89.7	8.4	1.9	2.35	0.0065	-0.0807	1.0139	Fine Sand	Very Well Sorted	Nearly Symmetrical	Mesokurtic

2.	-	-	-	1.98	0.0496	-0.1588	0.7787	Medium Sand	Very Well Sorted	Nearly Symmetrical	Platykurtic
3.	90.9	9	1.4	2.03	0.0193	0.8069	0.8607	Fine Sand	Very Well Sorted	Very Fine Skewed	Platykurtic
4.	-	-	-	1.9	0.022	-0.0346	2.0491	Medium Sand	Very Well Sorted	Nearly Symmetrical	Very Lyptokurtic
5.	92.7	7.6	0.8	2.05	0.0194	-0.055	0.9562	Fine Sand	Very Well Sorted	Nearly Symmetrical	Mesokurtic
6.	-	-	-	2.9	0.01	0.09	1.5028	Fine Sand	Very Well Sorted	Nearly Symmetrical	Very Lyptokurtic
7.	89	9	1.2	1.9	0.57	0.3	0.78	Medium Sand	Moderately Sorted	Poorly Skewed	Mesokurtic
8.	-	-	-	2.2	0.095	0.651	0.44	Fine Sand	Very Well Sorted	Poorly Skewed	Platykurtic
9.	97	2	1	2.26	0.014	-0.116	0.8569	Fine Sand	Very Well Sorted	Poorly Skewed	Platykurtic
10.	-	-	-	2.05	0.041	-0.0228	0.7214	Fine Sand	Very Well Sorted	Nearly Symmetrical	Platykurtic
11.	96	3	1	1.78	0.11	0.0848	1.035	Medium Sand	Very Well Sorted	Nearly Symmetrical	Lyptokurtic
12.	-	-	-	1.93	0.0367	-0.0183	0.8011	Medium Sand	Very Well Sorted	Nearly Symmetrical	Platykurtic
13.	95	4	1	1.81	0.0219	0.0174	0.9108	Medium Sand	Very Well Sorted	Nearly Symmetrical	Platykurtic
14.	-	-	-	1.9	0.024	0.0025	0.8812	Medium Sand	Very Well Sorted	Nearly Symmetrical	Platykurtic
15.	96.8	2.5	0.5	2.06	0.0163	0.0059	0.8033	Fine Sand	Very Well Sorted	Nearly Symmetrical	Platykurtic

3) Skewness (Ski):

The average Skewness value of Vamsadhara estuary is 0.93 then the skewness is nearly symmetric. The maximum value is 0.80 and minimum value is -0.01. The maximum values show nearly symmetrical to positively skewed.

4) Kurtosis (KG):

The maximum kurtosis value of estuary is 2.04 and minimum value is 0.44. The values shows platykuritic, mesokuritic and very lyptokuritic.

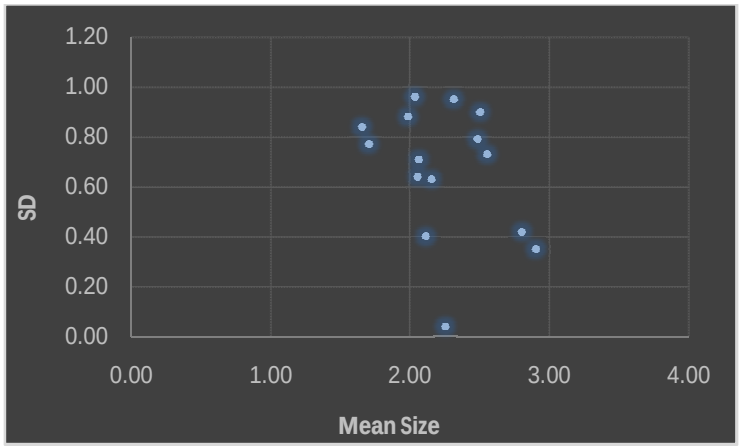
5) Scatter Plot Analysis:

Though the different statistical size measures arrived at by using the formula in theory are geometrically independent, several workers have noticed significant trends and interrelationship among the statistical parameters plotted against each other (Folk and Ward, 1957; Friedman, 1961, 1962 and Schlee, 1973). Inman (1949) and Griffiths (1951) are the earliest workers to notice in their experiments, these physical relationships between median diameter, Standard Deviation and Skewness measures. Folk and Ward (1957) described that these trends and interrelationship exhibited in the scatter plots might i.e. clues to the mode of deposition and in turn in identifying the environments. Although considerable attention is devoted to analyze the environmental significance of these scatter plots, a few investigators have not agreed on their sensitivity and utility. However Mason and Folk (1958), Friedman (1961), Moila and Weiser (1968) claimed differentiation between Aeolian, beach and river sediments based on these scatter plots. An attempt has been made here to utilize these scatter plots in the Vamsadhara and Nagavali estuary sands.

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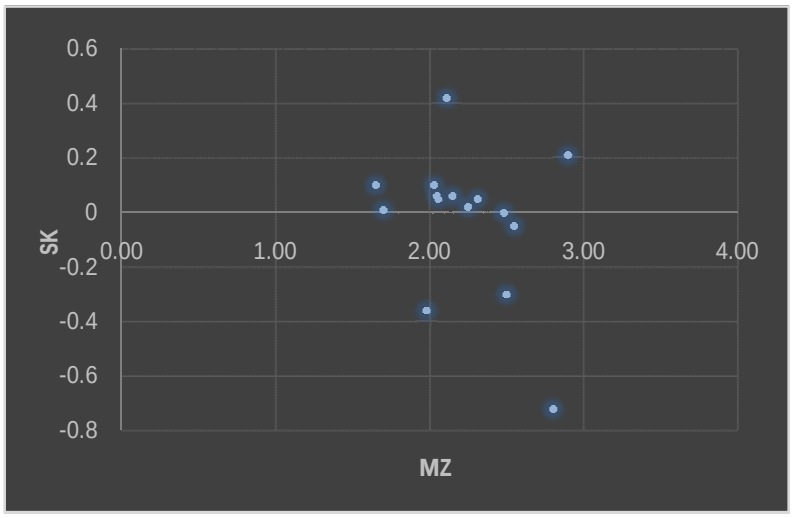
SCATTER PLOTS OF NAGAVALI RIVER ESTUARY

- Standard deviation vs Mean



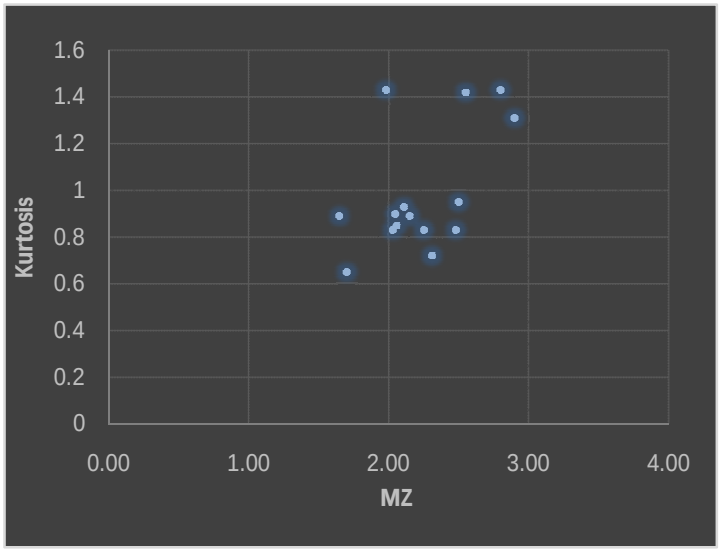
R=-0.35185

- Skewness vs Mean



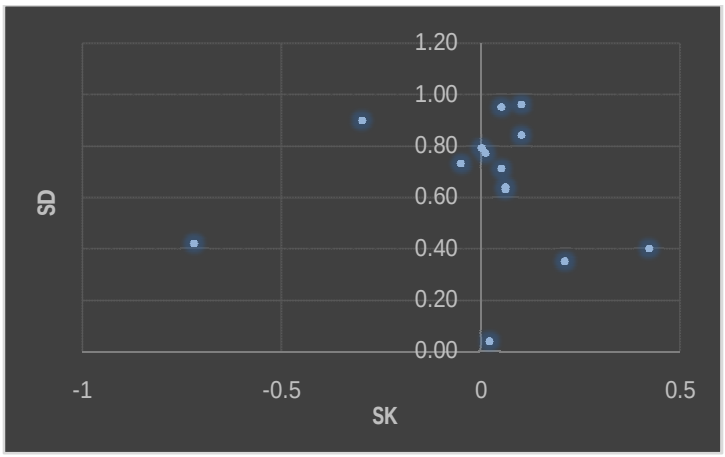
R= -0.31993

- Kurtosis vs Mean



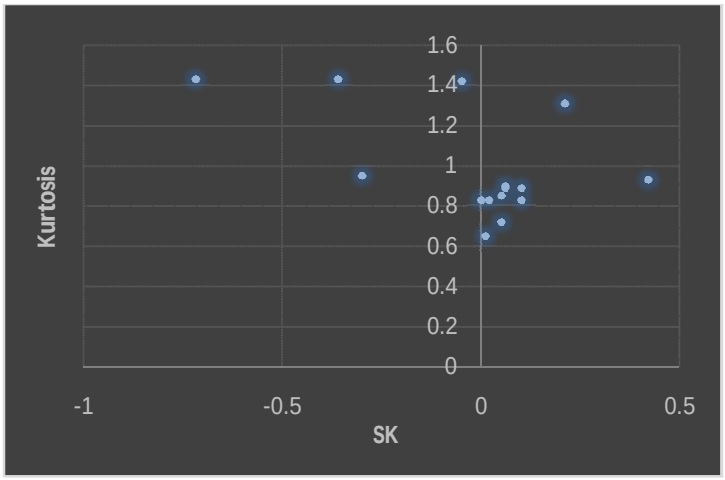
R= 0.552443

- Standard deviation vs Skewness



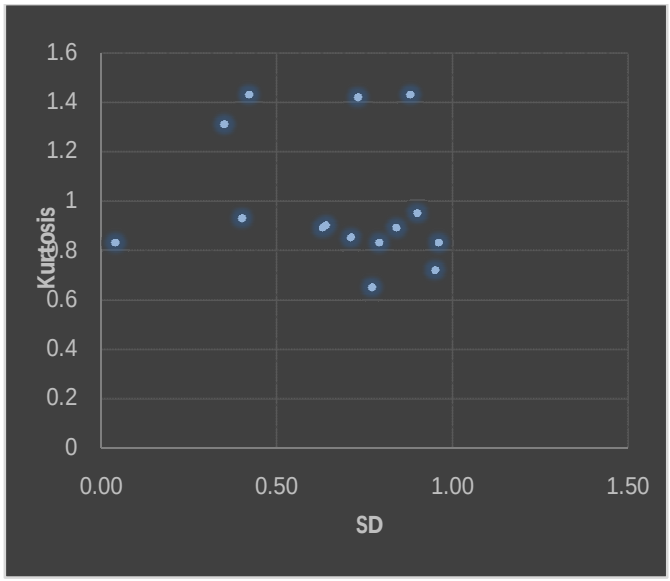
R= -0.02929

- Kurtosis vs Skewness



R= -0.51255

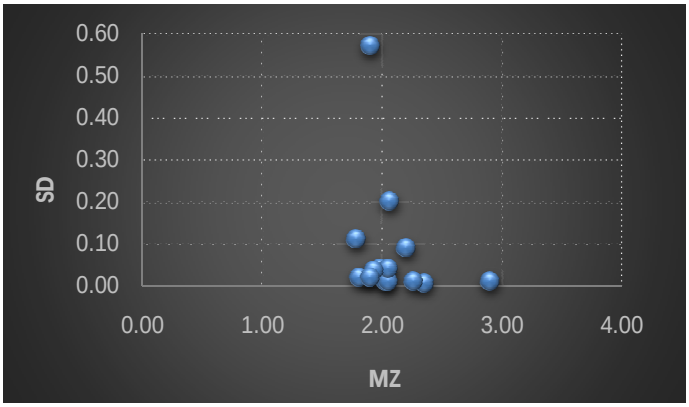
- Kurtosis vs Standard deviation



R= -0.11817

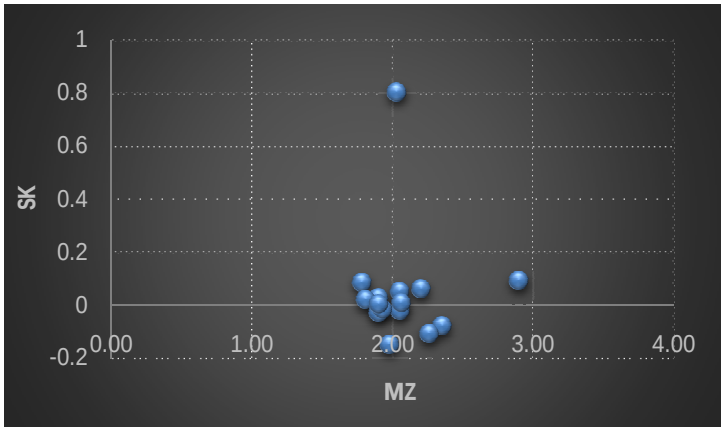
SCATTER PLOTS OF VAMSADHARA RIVER ESTUARY

- Standard deviation vs Mean



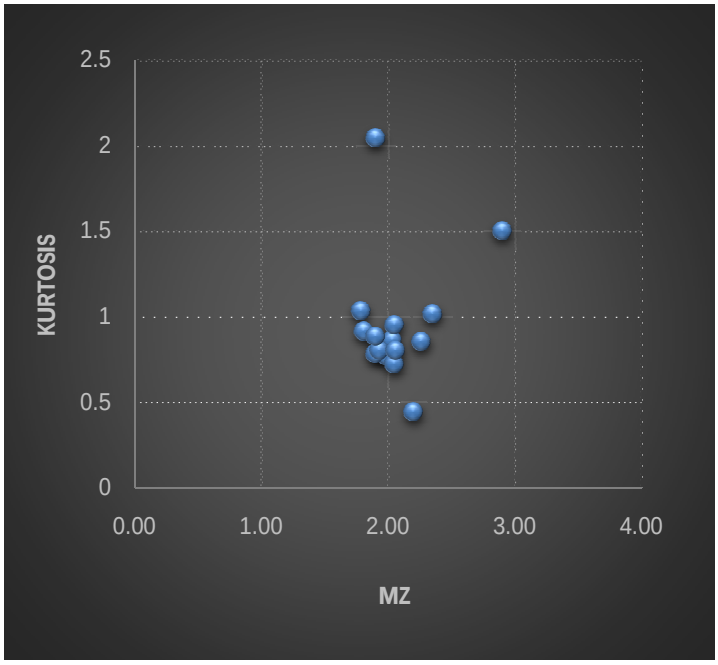
R=-0.35185

- Skewness vs Mean



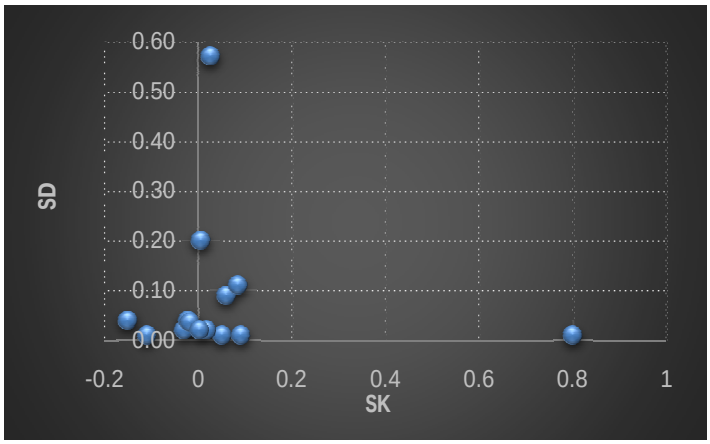
R=-0.0094

- Kurtosis vs Mean



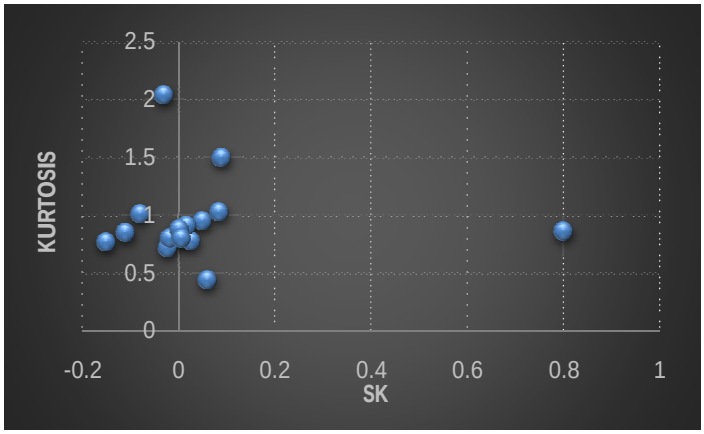
R=0.191572

- Standard deviation vs Skewness



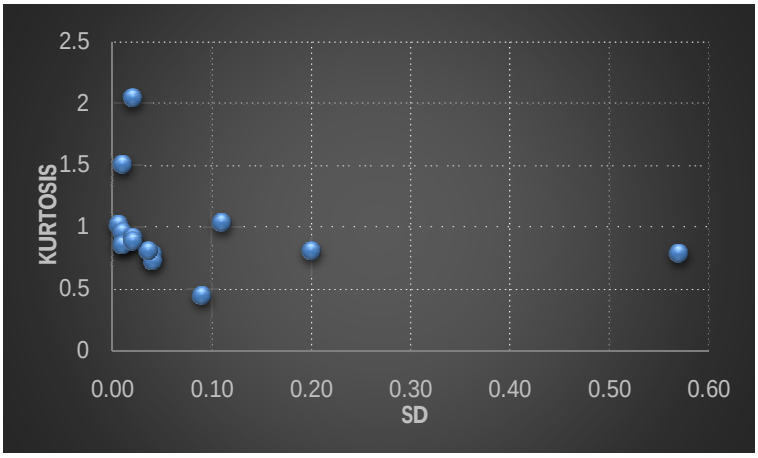
R=-0.08636

- Kurtosis vs Skewness



R=-0.04265

- Kurtosis vs Standard deviation



R=-0.11817

VI. CONCLUSION

From grain size distribution studies of Nagavali and Vamsadhara Estuarine systems it is shown that most of the sediments are medium to fine sand and silts. The sediment deposition has taken place during the slow river discharge. Bivariant plots such as standard deviation vs mean, skewness vs mean, standard deviation vs skewness presents the following comparative statistics between the two estuaries.

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Comparison of the Nagavali and Vamsadhara River Estuaries:

1) The graphic mean size value depicts the average particle size or a measure of central tendency. The mean size of the both estuaries having the medium sand to fine sandy nature. The avg. value of the estuaries is 2.23 Φ and 2.05 Φ. The average value shows the dominance of medium sand (MS) size sediments and the rest very smaller amounts of silt. The variations in Φ mean size reveals the differential energy conditions leads to their deposition of such sediments in different locations.

2) Standard deviation is a measure of the dispersion of the grain size distribution. It is an important parameter in sediment analysis because it reflects the energy condition of depositional environment. The Nagavali estuary sediments shows moderately sorted nature and Vamsadhara estuary sediments have Very well sorted nature. The present study suggesting that the sediments deposited in low energy conditions. The variations in the sorting values are likely due to continuous addition of finer/coarser materials in varying proportions.

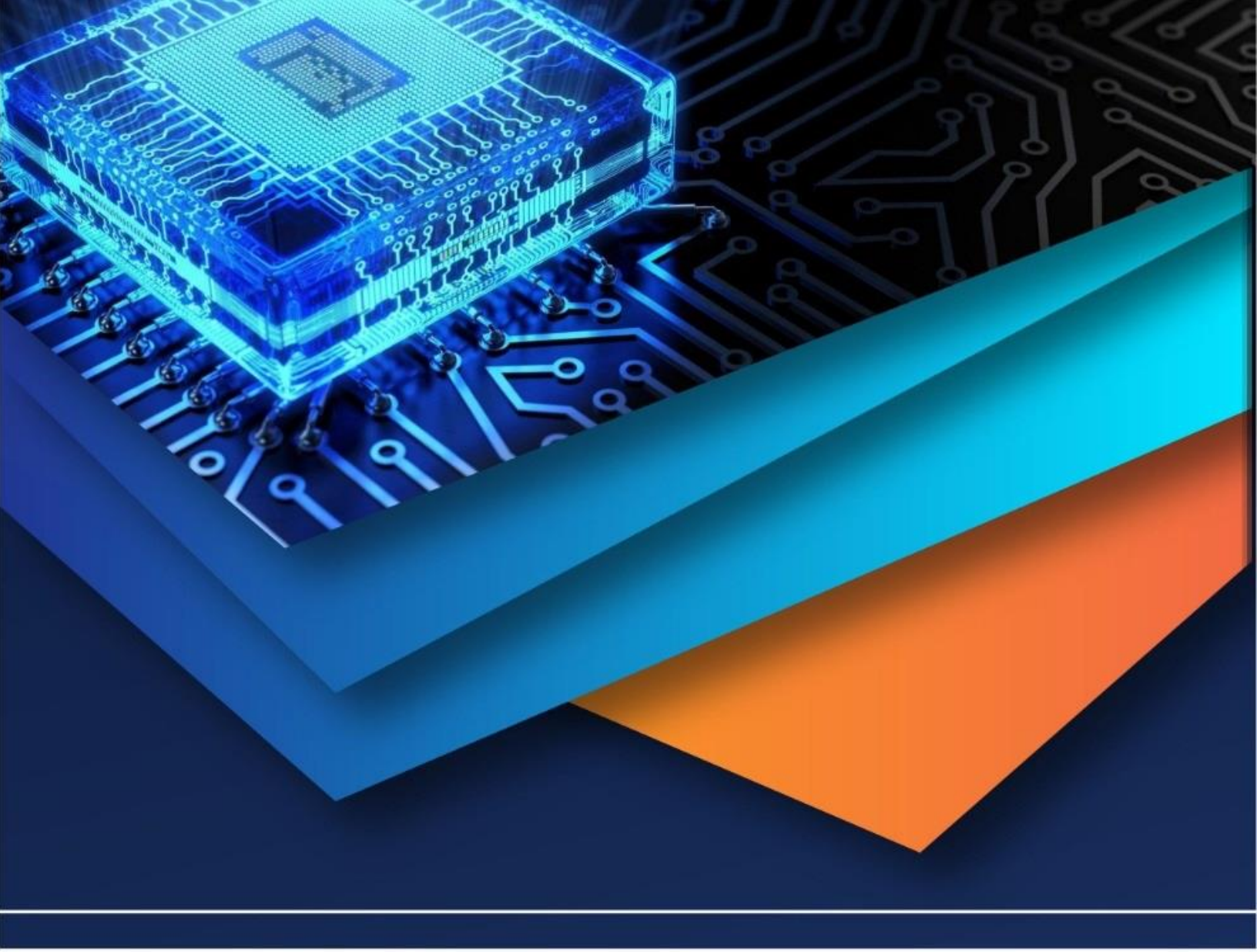
3) The graphic Skewness is the measure of symmetrical distribution, i.e. predominance of coarse or fine sediments. The Nagavali estuary samples shows nearly symmetrical skewness and the Vamsadhara estuary samples shows nearly symmetrical to positive skewness. Negative Skewness was being correlated with high energy and winnowing action and positive Skewness with lower energy levels.

4) Variations in the kurtosis values are a reflection of the flow characteristics of the depositing medium, the dominance of finer size of platy kurtic nature of sediments.

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