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Textural characteristics of Sediments of the lower reaches of the Vellar River, Cuddalore District, Tamilnadu, India

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Abstract: The rivers are the most significant geomorphological agents, which show a fantastic diversity in their form and behaviour, reflecting the wide range of environments in which they are found and are highly dynamic. River channels adjust and evolve over time from seconds to tens of thousands of years. Despite the complex environment, the textural analysis and interpretation of the same provide insight into the prevailing deposition environment. The two-year sedimentological analysis indicates that most of the locations' sediments are well-sorted to moderately sorted, with mean sizes ranging from 1.02 to 1.94φ. The skewness value ranged from -0.09 to 0.39, indicating the sediments are well-sorted to moderately sorted. The kurtosis varies from 0.12 to 1.51 as very leptokurtic to mesokurtic nature. The seasonal variations within the station are more visible with respect mean size. The variation in the mean size has a very limited influence on the other statistical parameters like standard deviation, skewness, and kurtosis. The variations in the other parameters are slightly conspicuous. Both the textural classification of the sectioned core sample and the detailed grain size analysis of each core as a single unit indicate that the monsoon rainfall in this region controls sediment distribution patterns along the river course.
Keywords: River sediments, grain size characteristics, sediment texture, Vellar river.

Introduction

The river plays a significant role in the lives of people. Rivers erode mountains and create land. Biodiversity depends on the existence of the river to a large extent. Rivers are found in many different climatic zones, ranging from humid to arid and equatorial to arctic. Rivers provide a livelihood to many people in fishing and agriculture. The main inputs to the system are water and sediment derived from the breakdown of the underlying rocks. Additional inputs include biological material and solutes derived from atmospheric inputs, rock weathering, and the breakdown of organic material. The nature of the rivers' sediment distribution pattern details the active hydrodynamic process in that region. Despite the complexity of the hydraulic process in an aquatic environment, the textural pattern of sediments, which mostly approaches dynamic equilibrium after high water flow, waves, and tidal activities, are a good indicator of energy variations. Numerous authors have used grain size characteristics as an indicator for identifying the hydrodynamic condition of the river, estuary, and beach environments (Harsha sunder et al. (2010); Liu et al. (2010); Anithamary et al. (2011); Venkataramanan et al. (2011); Ramesh et al. (2015): Jasmine Sheeba et al. (2016). Determination of sedimentary environments of recent times using sediment grain size parameters in Thailand has been done successfully by Chengatao wang et al. (2020). Considering the significance of the sediment deposition pattern, the present investigation was made to understand the hydrodynamic condition of this river environment.

Vellar River

The Vellar River basin is one of the seventeen river basins of Tamil Nadu. The Vellar River has its origin from three rivers (i) Anaimaduvu river originates from Velanguttu hills at an altitude of 1122m and flows from west to southeast direction in Salem district, (ii) Thumbal river originates from Thumbal hills at an altitude of 772m. It gains its name as Kallar river at Idayapatti [Long 78˚29'29" E, Lat 11˚45'6" N] and confluences with Anaimaduvu river at Ramanatham village [Long 78˚25'49" E, Lat 11˚41'35" N] in Salem district, (iii) Singipuram river originates from Tengal hills, Jambuttu hills and Perumal hills of Atturtaluk of Salem district, and joins the confluence river of Kallar and Anaimaduvu at Vaittikavundanpudur[Long 78˚26'47" E, Lat 11˚39'31" N] and travels as Vasistanadhi upto Kalpaganur[Long 78˚32'26" E, Lat 11˚37'57" N] and after that the river is called as Vellar river. Vellar river originating from Velliyur village [Long 78˚46'36" E, Lat 11˚28'45" N] at an elevation of 160m joins Vellar river near Mettur village [Long 78˚54'25" E, Lat 11˚27'45" N]. The tributaries, viz., Swethanadhi, Chinnar river, Anaivariodai, Gomukhi river, Manimuktha river, and Periyaodai with Vellar river and the river flows through Dharmapuri, Salem, Namakkal, Trichy, Perambalur, Ariyalur, Villupuram, Cuddalore districts and finally confluences with the Bay of Bengal. The Vellar River Basin consists of 7 Sub basins: Upper Vellar, Swethanadhi, Chinnar, Anaivariodai, Gomukhinadhi, Manimukthanadhi and Lower Vellar. The Basin has a total geographical area of 7504.346 sq. km covering 22 taluks, 40 blocks falling in parts of 8 districts, namely, Dharmapuri, Salem, Namakkal, Trichy, Perambalur, Ariyalur, Villupuram, and Cuddalore districts of TamilNadu. The main tributaries of the Vellar river are Vasistanadhi, Swethanadhi, Manimukthanadhi and Gomuki, Chinnar and Anaivariodai. Both Vasistanadhi and Swethanadhi originate in Salem district and drain from ChitteriPachaimalai, Kollimalai, and Kalrayan hill areas. The maximum of elevation is +1266m (a peak) near Batumalai at longitude 78° 28' and latitude 11° 52' in the southern slope of Kalrayan hills, where Vasista Nadhi originates. The last tributary to join Vellar is Manimukthanadhi. This tributary very often meanders in its course with about +20m to +40m elevations at B-Udaiyur and Bhuvanagiriarea in Chidambaram taluk, and finally, it empties into the Bay of Bengal at Parangipettai in Chidambaram taluk.

Description of the Study Area

The study area comes under Bhuvanagiri Block, Cuddalore district, Tamil Nadu, India. The Vellar River basin falls in 22 Survey of India (SOI) Toposheets (1:50,000) 58/I/2,3,5,6,7,9,10,11,12,13,14,15,16 and 58/M/1,2,3,4,6,7,10,11,15. The Vellar estuary is one of the prominent estuaries along the Southeast Coast of India. The details of the sampling locations are shown in Table 1 and the study area boundary with sampling locations is in Figure 1.

Table 1. Details of the Sampling locations in the Vellar river.

S. No.	Location	Sample	Latitude	Longitude
1.	Ayipettai	1	$11^{o}25'22"$	$79^{o}36'08"$
2.	Boothangudi Dam	2	$11^{o}25'50"$	$79^{o}32'37"$
3.	Mudikandanallur	3	$11^{o}26'11"$	$79^{o}29'05"$
4.	Mudikandanallur	4	$11^{o}25'24"$	$79^{o}26'58'$
5.	Ambujavallipettai	5	$11^{o}25'19"$	$79^{o}26'20"$
6.	Kallippadi	6	$11^{o}25'09"$	$79^{o}23'19"$

The drainage pattern of the area is shown in Figure 2. The junction of the rivers, Vasishtanadi and Swetanadi, which rise in the Salem district, forms the Vellar River. The Vasishtanadi enters the then South Arcot district through Attur, passes just south of the Kalvarayan and Tiruchirapalli for 16 miles, it joins the Swetanadi.

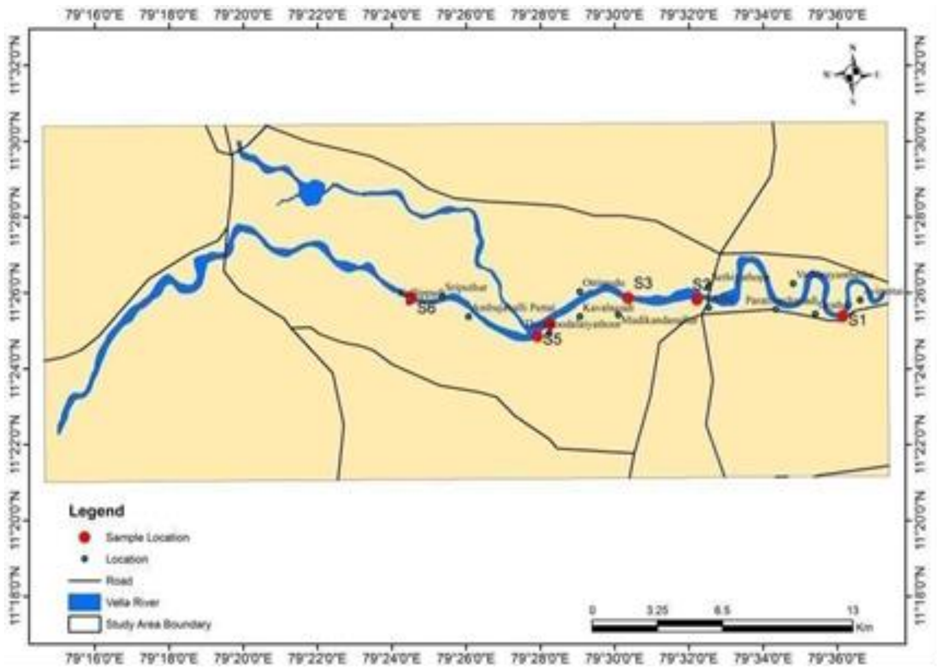

Fig. 1. Study area and Boundary with Sampling Locations.

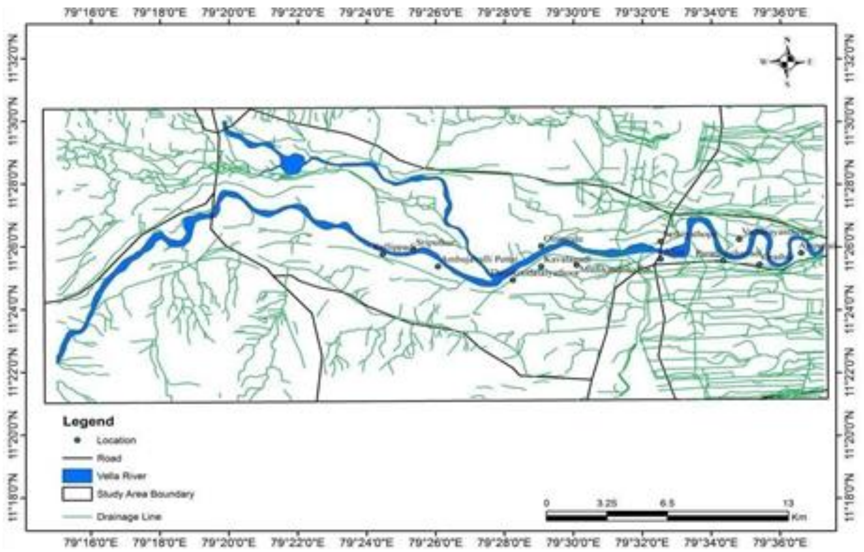

Fig. 2. Drainage pattern of the study area.

The united streams still follow the boundary and the river flows for another 20 miles, gathering the waters of Manimuktanadi, Gomukhanadi, and Mayuratnadi which drain the eastern slopes of the Kalrayan. The river then passes through Chidambaram taluk and joins the Bay of Bengal near Parangipettai. There are backwaters on the seacoast caused by the seawater breaking into the watercourse of streams and rivers. One such backwater is found near Cuddalore.

Geology

This district is characterized by a different age range of rocks, from the oldest Archean rocks to recent sediments. The geology of the district (Fig. 3) comprises sandstone, clay, alluvium, and laterite soils of the Tertiary and Quaternary ages (Wadia, 1975). The major composition is sedimentary rock 90% and Hard Rock 10%. The geological formation includes sandstone, conglomerate, gneiss, charnockite, Marine deposits, and alluvium.

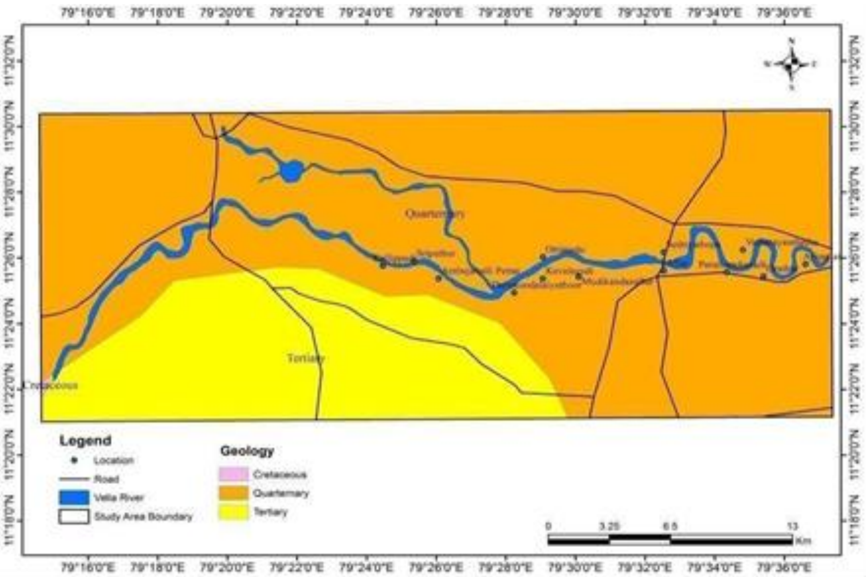

Fig. 3. Geology of the study area.

The Archean is exposed outside the Neyveli region in the west and northwest. The tertiary formations are composed of sandstone, grit sands, and clays. The Ariyalur formations comprise calcareous sandstones; siliceous limestone, fossiliferous limestone, etc. and are found around Patti and Parur villages. Eocene exposures are also seen at a few locations in the northeast of Virudhachalam.

Geomorphology

The entire Cuddalore district is broadly divided into three zones - Western pediplains of the entire area covered by Mangalur and Nallur blocks. This area is occupied by denudational landforms like shallow-buried pediments and deep-buried pediments. The central part of the district is mainly characterized by sedimentary high grounds, with an elevation >80 m of Cuddalore sandstone of Tertiary age. This zone occupies part of Virudhachalam, Kammapuram, Kurinjipadi, Cuddalore, and Kattumannarkoil taluks. The rest of the area in the district is covered by the eastern coastal plain, which is predominantly occupied by the flood plain of fluvial origin formed under the influence of Penniyar, Vellar, and Coleroon river systems (Charlton., 2008; Nethaji et al., 2017). Marine sedimentary plain is noted all along the eastern coastal region. Consists between the marine sedimentary plain and fluvial flood plains, fluvio-marine deposits are noted, which consists between the marine sedimentary plain and fluvial flood plains, fluvio-marine deposits are noted, consisting of sand dunes, and back swamp areas. The region is much under the influence of the northeast monsoon. Based on this, four seasons were identified as post-monsoon (January- March), summer (April-June), pre-monsoon (July-September), and monsoon (October–December).

Materials and Methods

Sampling

The sediment samples were collected from selected locations (Fig.1) in the Vellar river of the Cuddalore district using a PVC core sampler at six locations for two years 2018 and 2019, covering four seasons each year. These stations were located at an interval of 4 km. By using a core sampler, six samples were collected. The collected core samples were transferred into an airtight zip-lock packet for further analytical work. The sediments were dried in room temperature to remove the moisture before the laboratory analysis. The core samples were sectioned at a 2cm interval to determine the sand, silt, and clay percentages. The total grain size distribution of each core sample was done using the subsample, and statistical parameters like mean, standard deviation, skewness, and kurtosis were determined using the formula of Folk and Ward (1957).

Determination of pH

To determine sediment pH, 10 grams of sediment sample was added with 10ml of double distilled water in the ratio 1:1.Then the suspension was stirred and shaken in a mechanical shaker for an hour. Then the pH was measured by inserting a pH pen (eco tester pH). The salinity of the sediments was determined by the method described by Jackson (1973) where an amount of sediment samples was moistured with double distilled water up to the moisture saturation level of the sediment. Then the volume of saturation level was doubled, again the water was added and mechanically shaken for 15 minutes. Through a filter paper, the water with salt was filtered, and the salinity was measured using a hand refractometer.

Particle Size Analysis

A laser beam particle size analyzer (Horiba LA 300) was used to determine the grain size. The first 10g sediment sample was sieved in the 1.41mm and 1mm mesh in a digital sieve shaker (Ritch Tech) from that one gram of the sediment sample was taken for further grain size analysis using laser-beam particle size analyzer. In the first instance the analyzer chamber was filled with double distilled water and the precirculation was made. Then the chamber was filled with distilled water. One gram of sediment was added to the distilled water in the chamber, the circulation was maintained till the entire circulation of water was completed. The grain size distributions in the sample are recorded in microns with percentages. Cumulative frequency curves were drawn using log probability sheet and percentiles were read off from the graph to calculate statistical parameters.

Results and Discussion

The pH value of the river sediment samples varied from 6.9 to 7.9 during the study period. The maximum pH value was recorded in station 1 and the lowest in station-4. The pH of sediments mainly depends upon the amount of Carbon Dioxide, the influence of floodwater, and the decomposition of organic matter (Calace et al., 2005).

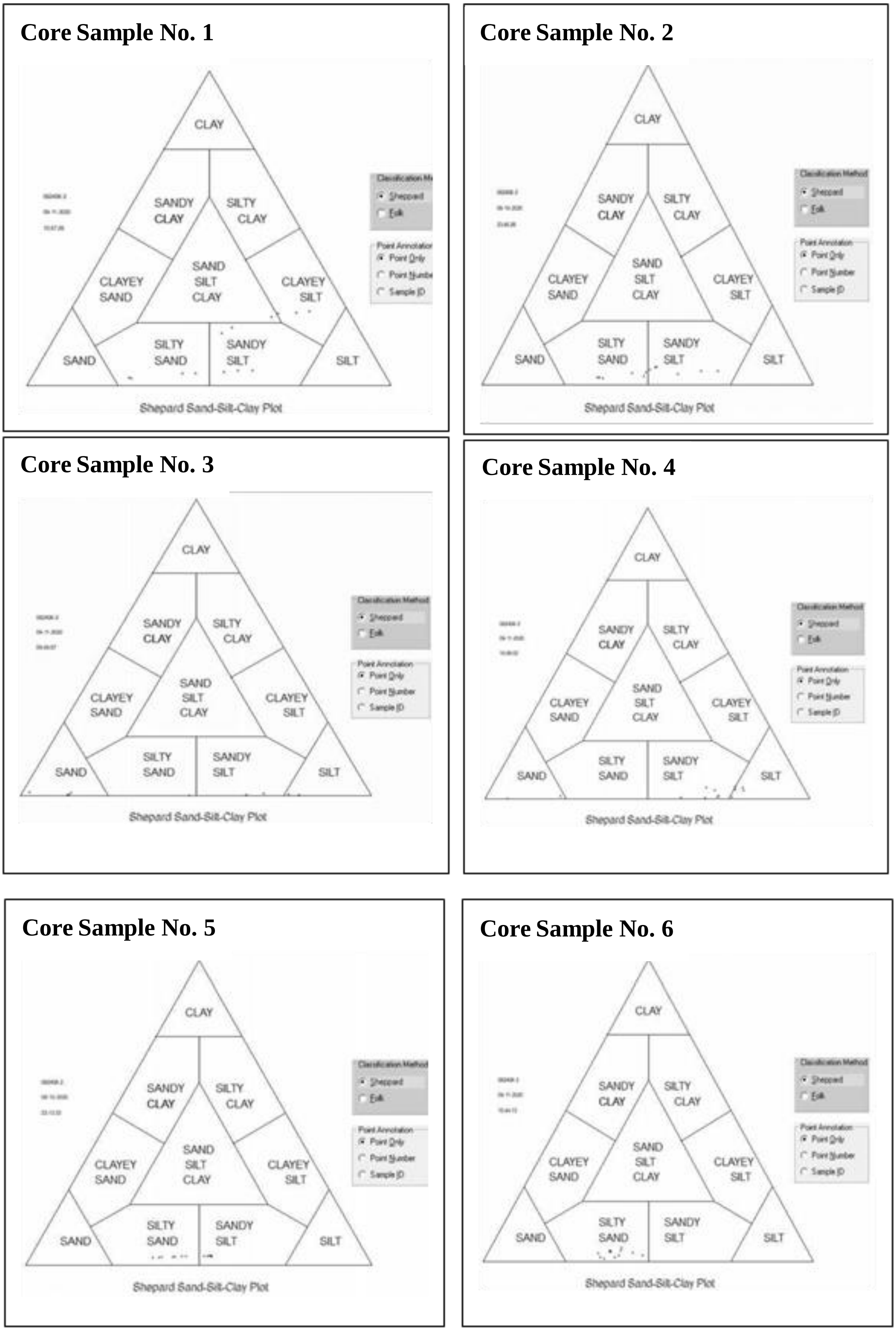

Fig. 4. Textural Classification of Sediments (after Shepard, 1954).

Salinity

The concentration of dissolved salt in a given volume of dissolved salt concentration in a given sample is called salinity. It is expressed in terms of grams of salt per kilogram of water or in parts per thousand (ppt). The salinity mainly depends upon factors like temperature, rainfall, location of the sampling stations, and difference in the freshwater flow. During the study period, the highest salinity value of 5 ppt was recorded at station-1 whereas the minimum value (2ppt) was recorded at station-4.

Textural Analysis

The study of textural characteristics provides valuable information to understand the source of evolution for sediments in the river environment. It indicates the environmental condition of transporting and deposition in the river. Generally, during sediment transport, the edges and surface become during sediment transport the edges and surface become rounded and reduced in the down current down directions. Downstream of the river, the sediments are mainly fine, composed of fine sediments when compared to the upstream. The percentage of distribution of sand, silt, and clay (Shepard, 1954) in the different sections of the core samples are given in Tables 2 to 7, and classification in Figure 4.

Sand Percentage

Sand size particle belongs to size ranging from 2.0 mm to 63µm. The percentage of sand in the first core ranged from 35.54% to 70.6%. In 2nd core, the sand percentage ranged from 26.728% to 63.986%. In the case of 3rd core the values ranged between 23.327% and 96.633%. In 4th core minimum and maximum sand percentages are 18.707% and 92.772%. In the 5th core the sand percentage ranged from 44.696% to 62.029%. In the 6th core the percentage ranges between 50.623% and 63.847%.

Silt Percentage

Sediment sizes ranging from 63µm to3.9µm are termed as silt. The percentage of silt in the 1st core ranged from 26.854% to 59.653%. In 2nd core, the silt percentage ranged from 33.689% to 68.949%. In 3rd core, the silt percentage ranged from 2.108% to 79.267%. The 4th core sample showed a maximum silt percentage ranging from 7% to 78%. In 5th core, the percentage ranged from 35.402%to 52.229%. In 6th core, the silt percentage ranged between 33.627% and 47.413%.

Clay Percentage

Sediment sizes less than 3.9µm are termed as clay. The percentage of clay in the 1st core ranged from 2.302% to 5.185%. In the case of 2ndcore, the clay percentage ranged from 2.11% to 5.689%. For the 3rd core it ranged between 0.129% and 2.001%. The clay percentage of the 4th core ranged between 0.198% and 4.012%. In the 5th core the percentage ranged from 2.469% to 3.151%. For the 6th core the percentage ranged between 1.052% and 6.396%.

Discussions

Analysis of textural parameters to delineate transport mechanisms and depositional environments are widely employed in studying modern sedimentary provinces. Significant advances have been made in the comprehension of the interactions existing comprehending the interactions between sediment transport and environmental energy. Attempts made by many have been found successful in delineating distinct depositional environments using different combinations of textural parameters. Studies by Folk and Ward (1957), Masson and Folk (1958), Friedman (1961; 1967), Visher (1969), Allen (1971) demonstrated that distinct environments leave a definite imprint on the grain size and sorting indices of sand populations. These techniques have been effectively used by Qiao et al. (2010), Pan et al. (2015), Rajkumar et al. (2016), and Arun et al. (2019).

Table 2. Percentage of sand, silt, clay and textural classification (Shepard) CORE SAMPLE-1.

Section No.	Depth	Sand %	Silt %	Clay %	Texture
1	0-2	51.78	44.3	3.92	silty sand
2	2-4	52.35	43.55	4.1	silty sand
3	4-6	54.03	41.12	4.85	silty sand
4	6-8	50.35	45.32	4.33	silty sand

5	8-10	51.21	44.56	4.23	sandy silt
6	10-12	48.96	47.321	3.72	silty sand
7	12-14	51.21	45.243	3.56	silty sand
8	14-16	55.381	40.674	3.945	silty sand
9	16-18	51.644	44.42	3.935	silty sand
10	18-20	42.26	52.556	5.185	sandy silt
11	20-22	43.528	52.091	4.38	sandy silt
12	22-24	70.61	26.854	2.547	silty sand
13	24-26	62.465	34.637	2.899	silty sand
14	26-28	39.619	55.719	4.663	sandy silt
15	28-30	35.54	59.653	4.81	sandy silt
16	30-32	70.17	27.528	2.302	silty sand

Table 3. Percentage of sand, silt, clay and textural classification (Shepard) CORE SAMPLE-2.

Section No.	Depth	Sand %	Silt %	Clay %	Texture
1	0-2	63.986	33.689	2.325	silty sand
2	2-4	63.437	34.313	2.25	silty sand
3	4-6	62.524	35.425	2.11	silty sand
4	6-8	49.759	47.618	2.623	silty sand
5	8-10	48.548	47.521	3.935	silty sand
6	10-12	44.372	49.938	5.689	sandy silt
7	12-14	45.016	49.635	5.349	sandy silt
8	14-16	46.848	48.364	4.787	sandy silt
9	16-18	52.875	43.475	3.651	silty sand
10	18-20	39.09	57.445	3.464	sandy silt
11	20-22	27.987	67.991	4.024	sandy silt
12	22-24	26.728	68.949	4.324	sandy silt
13	24-26	31.622	64.144	4.234	sandy silt

Table 4. Percentage of sand, silt, clay and textural classification (Shepard) CORE SAMPLE-3.

Section No.	Depth	Sand %	Silt %	Clay %	Texture
1	0-2	23.327	76.076	0.597	Silt
2	2-4	96.633	2.108	1.259	Sand
3	4-6	20.494	79.267	0.239	Silt
4	6-8	86. 334	13.367	0.299	Sand
5	8-10	81.02	18.11	2.001	Sand
6	10-12	30.224	69.006	0.77	sandy silt
7	12-14	85.056	14.023	0.921	Sand
8	14-16	51.802	48.069	0.129	silty sand
9	16-18	35.507	64.262	0.231	sandy silt
10	18-20	85.995	13.68	0.325	Sand

Table 5. Percentage of sand, silt, clay and textural classification (Shepard) CORE SAMPLE-4.

Section No.	Depth	Sand %	Silt %	Clay %	Texture
1	0-2	39.328	60.143	0.529	sandy silt

2	2-4	32.143	67.56	0.297	sandy silt
3	4-6	28.072	71.199	0.729	sandy silt
4	6-8	76.143	22.928	0.929	Sand
5	8-10	27.612	69.406	2.982	sandy silt
6	10-12	29.903	66.172	3.925	sandy silt
7	12-14	21.11	75.101	4.012	Silt
8	14-16	92.772	7.031	0.198	Sand
9	16-18	18.707	77.416	3.877	Silt
10	18-20	18.846	78.173	2.981	Silt
11	20-22	21.422	75.353	3.225	Silt
12	22-24	23.652	75.679	0.689	Silt
13	24-26	27.432	71.631	0.937	sandy silt

Table 6. Percentage of sand, silt, clay and textural classification (Shepard) CORE SAMPLE-5.

Section No.	Depth	Sand %	Silt %	Clay %	Texture
1	0-2	45.867	50.9869	2.964	sandy silt
2	2-4	44.696	52.229	3.074	sandy silt
3	4-6	44.793	52.124	3.083	sandy silt
4	6-8	44.924	51.982	3.094	sandy silt
5	8-10	45.226	51.623	3.151	sandy silt
6	10-12	46.921	49.998	3.078	sandy silt
7	12-14	53.534	43.61	2.856	silty sand
8	14-16	62.029	35.402	2.572	silty sand
9	16-18	60.324	37.205	2.469	silty sand
10	18-20	59.266	38.065	2.668	silty sand
11	20-22	52.154	44.834	3.012	silty sand
12	22-24	55.57	41.792	2.639	silty sand
13	24-26	56.256	41.089	2.696	silty sand

Table 7. Percentage of sand, silt, clay and textural classification (Shepard) CORE SAMPLE-6.

Section No.	Depth	Sand %	Silt %	Clay %	Texture
1	0-2	63.847	34.698	1.455	silty sand
2	2-4	63.652	33.627	2.721	silty sand
3	4-6	62.735	36.213	1.052	silty sand
4	6-8	59.526	39.143	1.331	sandy silt
5	8-10	56.432	39.945	3.623	sandy silt
6	10-12	50.623	47.413	1.964	sandy silt
7	12-14	57.923	40.152	1.925	sandy silt
8	14-16	53.256	43.787	2.957	sandy silt
9	16-18	59.845	36.64	3.515	Silt
10	18-20	55.946	39.652	4.402	Silt
11	20-22	58.757	34.847	6.396	silty sand

12	22-24	59.677	36.956	3.369	silty sand
13	24-26	59.824	36.92	3.259	silty sand

Table 8. Grain Size Statistical Parameter of the Vellar River Sediments.

Year	2009				2010			
Mean Size								
Station/Seasons	**Monsoon**	**Post Monsoon**	**Summer**	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Summer**	**Pre Monsoon**
1	1.71	1.89	1.86	1.81	1.67	1.91	1.92	1.82
2	1.62	1.67	1.82	1.67	1.7	1.87	1.89	1.89
3	1.17	1.41	1.36	1.49	1.34	1.52	1.47	1.59
4	1.02	1.14	1.17	1.61	1.19	1.59	1.41	1.32
5	1.29	1.61	1.79	1.94	1.38	1.12	1.69	1.03
6	1.31	1.59	1.69	1.87	1.17	1.34	1.82	1.21
Standard Deviation								
1	0.67	0.81	0.98	0.97	0.74	0.89	0.98	0.91
2	0.61	0.84	0.91	0.91	0.79	0.97	1.08	0.98
3	0.77	0.82	0.74	0.81	0.69	0.82	0.67	0.88
4	0.61	0.74	0.89	0.92	0.41	0.59	0.67	0.79
5	0.57	0.71	0.94	0.97	0.37	0.69	0.64	0.98
6	0.59	0.79	0.84	0.97	0.39	0.74	0.69	0.89
Skewness								
1	-0.07	-0.02	0.14	-0.02	-0.09	0.23	0.14	-0.08
2	-0.13	-0.36	-0.09	-0.14	-0.17	-0.12	-0.09	-0.21
3	0.11	0.09	-0.21	-0.19	-0.07	-0.08	0.64	-0.17
4	0.27	-0.21	-0.17	-0.1	-0.09	-0.09	-0.87	-0.14
5	0.29	-0.11	-0.13	0.11	-0.08	-0.12	-0.07	-0.16
6	0.34	-0.29	-0.28	0.39	-0.1	-0.14	-0.17	-0.18
Kurtosis								
1	1.01	1.21	1.13	1.21	1.13	1.37	1.17	1.19
2	1.29	1.07	1.14	0.97	0.31	1.27	1.24	0.99
3	1.11	1.21	1.29	1.14	1.51	1.41	1.13	1.14
4	1.04	1.12	1.07	1.07	0.91	1.27	1.17	1.24
5	0.67	1.09	0.94	1.11	0.94	1.19	1.38	1.24
6	0.97	0.9	0.94	0.12	0.89	0.21	0.49	0.27

The grain size data indicates that silt is the dominant fraction in all samples, followed by sand and clay. The majority of the samples fall under the silty sand nature. In the core one the percentage of sand is 52%, silt is 44% and clay is 4%. In core two the percentage of sand, silt and clay are 46%, 50% and 4%. In 3rd core the percentage of sand is dominant by 56%, silt with 43% and clay 1%. In 4^{th} core the percentage of silt is dominant with 63%, followed by sand 35% and clay 2%. In the 5th core the percentage of sand, silt and clay are 52%, 45% and 3%. In 6th core the percentage of sand is dominant with 59%, silt is 38% and clay is 3%, respectively. In this present study, it is observed that sand and slit are the dominating fractions of the sediments.

The statistical parameters of the grain size distribution of the samples for the two years are shown in Table 8. The observed reduction in the standard deviation values during monsoon indicates the removal of finer, materials leading to a better sorting of sediments. This was similar to the observations made by Anithamary et al. (2011), Venkararamanan et al. (2011), Ramesh et al. (2015), Melini et al. (2015), Manivel et al. (2016) and KarunaKaradu et al. (2018) recorded reduction in standard deviation values due to the removal of fines.

The sediments attain the maximum sorting value, any further fall in the competency of water flow results in the increase of fine particles and results in poor sorting. Similar observations were recorded by Rao et al. (1988) in the Krishna delta. Folk and ward (1957; Cardigan, 1961) also pointed out that a small change in the primary mode within the sand mode would affect the sorting values. Skewness, a measure of the degree of symmetry, describes the tendency of the data to spread preferentially on one side of the average. It is an essential parameter in grain size studies since it is a sensitive indicator of sub-population mixing. The skewness values (Table 6) reveal that most of the sediments during 2018 and 2019 are three of them skewed, and three are finely skewed. This indicates that a considerable amount of finer particles in the system makes the right-hand side of the curve more distinct which influences the skewness value. This is similar to the observation of Sathyanarayana et al. (1993) in the coastal sediments of Visakhapatnam. These phenomena have also been reported by Folk and Ward (1957), and Allen (1965), which have been further explained by Friedman (1961) and Martin (1965). The existence of negatively skewed sediments indicates that these stations are comparatively high energy zone as the movement of the water is relatively faster due to a gradient where fine sediments are removed and coarse sediments are slowly concentrated together may probably be the reason. Kurtosis measures the sorting ratio in the extreme of the grain size spectrum compared with sorting in the central portion. All stations exhibit a wide range of values from platykurtic to leptokurtic nature. The majority of the sediments are leptokurtic during the two years of study. Folk and Ward (1957) and Cadigan (1961) classified kurtosis as leptokurtic if the central part of the grain size distribution is relatively better sorted than the average in tails, whereas the converse is true in the case of platykurtic. The highest and lowest kurtosis values were associated with very poorly sorted sediments. This is parallel to the observation of Folk and Ward (1957). The observations made by Anithamary et al. (2011), Ramesh et al. (2015) and KarunaKaradu et al. (2018) was also similar to the present observation.

Conclusions

The seasonal variations in the mean water discharge and the flow velocity related to the mean discharge together would have thus influenced the differential transport mechanism of sediments. Hence the change in the mean discharge of water may be accounted for by the above-said differences. A relatively high phi mean size was observed during the monsoon month could mainly be due to the constant inflow of freshwater from the upstream regions along with the relatively high flow velocity of the water which prevents the settling of fines leaving the coarser material resulting in the decrease of phi mean size. The degree of sorting improvement was noticed in the intermediate class rather than very well-sorted nature. Thus, as such sorting class variations within the study area were due to the influence of hydrodynamic environmental conditions. The wide range of occurrences of sorting (from well-sorted to very poorly sorted) nature indicates the existence of hydraulic energy and its influence over the sorting character of the sediments. The polymodal nature of the sediments and variations in the mode of populations coupled with the hydraulic conditions would have thus influenced the skewness value in the study area. In the comparison of the skewness versus kurtosis, the symmetrically skewed sediments exhibit a platykurtic to leptokurtic nature with the majority in the leptokurtic class. Likewise, the well-sorted sediments exhibit a mesokurtic to leptokurtic nature. The occurrence of a wide range of kurtosis values in the study area. The occurrence of a wide range of kurtosis values in the study area. Indicates the mixing of two or more populations. This is especially prominent in the case of stations 4, 5, and 6 where the station exhibits polymodal nature. The present investigation reveals that the sediment distribution nature in the study area varied concerning seasonal changes and variations were observed in the monsoon season. The nature of variations observed between the stations is limited even though the mean size of the sediments is varying with respect to different seasons. This type of distribution of sediments along the river course suggests the existence of the prevailing hydrodynamic condition of the study area as the significant influencing parameter coupled with monsoon rainfall in this region.

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