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THE PATTERN OF SEASONAL SEDIMENT TRANSPORT MECHANISMS AROUND ARICHAIMUNAI BY SEDIMENT TREND MATRIX (STM)

Rajagopalan V.[1], Usha Natesan[2] and G. Venkatesan[3]

Abstract: *The coast is a zone of intense energy input. This energy, transported by waves arrives at the coast which set the processes of sediment transport in motion and driven by forces such as waves, tides and wind that causes morphological change. Sedimentary coastlines have an attraction to many human beings. The study on the pattern of seasonal sediment transport mechanism around Arichamunai will provide a management tool for rapid assessment of natural hazard risk potential and it is important for such activities as economics, development, tourisms, planning research, science and education etc. This study was analyzed using toposheets and beach samples characteristics. From beach samples characteristics, Grain size analysis followed by the computation of Sediment Trend Matrix (STM) helps to understand the sediment movement from various stations and points out the sediment sources and sinks around Arichamunai and also showed that predominant direction of the sediment transport during the premonsoon and monsoon is from south to north and reversed during post monsoon season.*

Keywords: *coast; sediment; grain size; sources and sinks.*

INTRODUCTION

The coast is a zone of intense energy input. This energy, transported by waves arrives at the coast which set the processes of sediment transport in motion and driven by forces such as waves, tides and wind that causes morphological change. Sedimentary coastlines have an attraction to many human beings. (Benedet et al., 2004). For many of them it is a place to relax, for others it is a way to earn a living either on the dry part or from the regions offshore, consequently coast lines have become densely populated areas. These reasons make the presence and quality of a sandy coastline a valuable asset.

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Coastal sediment management is an issue that has attracted the attention of coastal manager, engineers, planners and the like. (Chang et al., 2001).The study on the pattern of seasonal sediment transport mechanisms around Arichaimunai will provide a management tool for rapid assessment of natural hazard risk potential and it is important for such activities as economics, development, tourisms, planning research, science and education etc. Around 6 km coastal stretch of Dhanushkodi – 3 km on either side of Arichamunai, lying between 9° 11' N - 9° 9' N latitude and 79° 26' E - 79° 24' E longitudes was considered as study area. This study is very much essential because this area is one of the vulnerable sites affected by cyclone in 1964, which cause great damage due to flooding and siltation (Nayak S 2002).

MATERIALS AND METHODS

The Base map of Dhanushkodi was prepared from Survey of India toposheets of 1977 in 1:25000 by tracing the shoreline and then digitized using ARCGIS (Ramaswamy et al., 2004). Beach samples were collected from seven locations around Archamunai, Dhanushkodi, during different seasons - premonsoon, monsoon, postmonsoon. The sampling locations were identified with a hand held GPS and placed in the base map is shown in Figure 1. At each sampling location about 150-200 g of unconsolidated wet sand was collected with a scoop from topmost layers approximately 3~5 mm thick. The samples were packed in polythene covers and grain size analysis was carried out. In grain size analysis, the moisture content from collected samples was removed by oven drying. Then these dried samples were weighed for finding initial weight and then sieve process had been carried out in a single stack through 10 sieves for 20 minutes using Ro-Tap sieve shaker. The sand retained on each sieve was carefully removed and again weighted which was converted into cumulative weight percentage retained. (Falco et al., 2003).

The textural parameters of grain size are dependent upon the environment in which is located such as deserts, rivers, beaches, etc (Weber et al. 2003). Further, within a given environment, these characteristics differ spatially with response to various sediment transport process. Statistical measures such as mean, sorting and skewness help to differentiate the distribution of sand genetically meaningful. These statistical measures of the grain size parameters as proposed by Folk and Ward (1957) were adopted in the present study. The formulae used to calculate the statistical parameters and their range are given in Table 1 and Table 2 respectively.

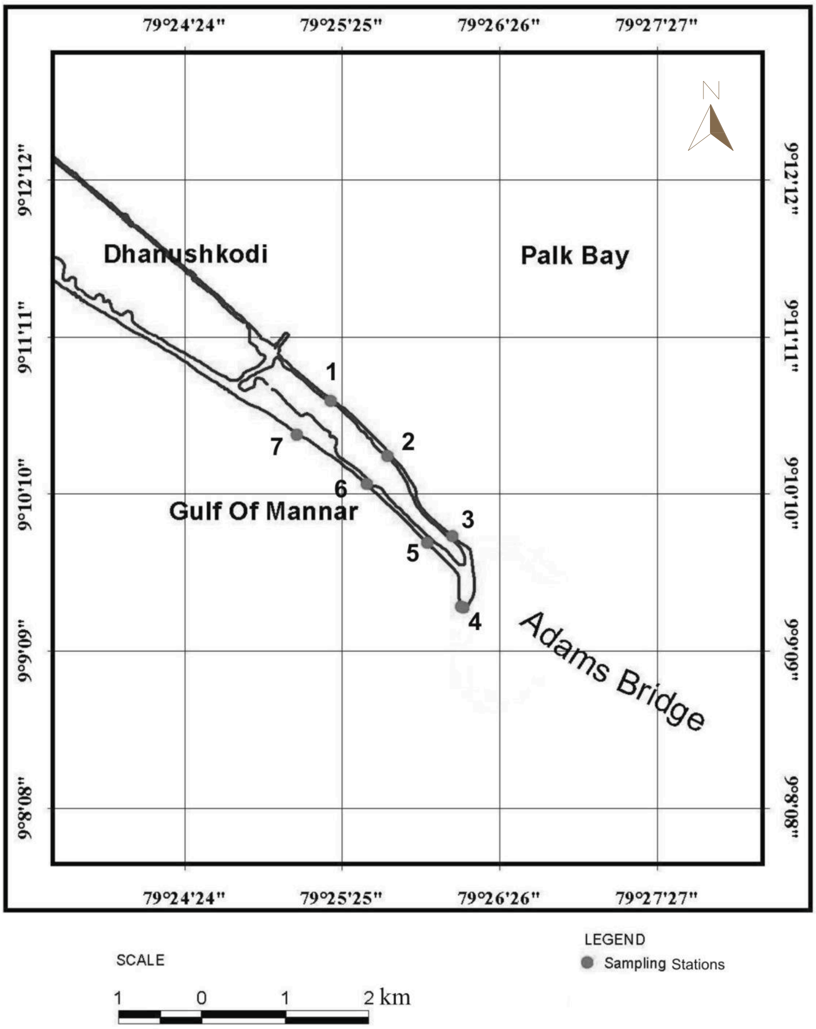

Fig.1. Base map with sampling stations

Table 1. Statistical for Size - Frequency Distribution

Sl.No.	Name of the Statistical Parameter	Formulation
1	Mean	$Mz = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$
2	Standard Deviation or Sorting	$\sigma_1 = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$
3	Skewness	$Sk_1 = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2(\phi_{84} - \phi_{16})} + \frac{\phi_5 + \phi_{95} - 2\phi_{50}}{2(\phi_{95} - \phi_5)}$

Table 2. Range of Statistical Parameters

A) Classification of Grain Size Based on Mean

Sl.No.	Mean M_z (Φ)	
1	Pebbles	-3 to -2 Φ
2	Gravel	-2 to -1 Φ
3	Very Coarse sand	-1 to 0 Φ
4	Coarse sand	0 to +1 Φ
5	Medium sand	+1 to +2 Φ
6	Fine sand	+2 to +3 Φ
7	Very fine sand	+3 to +4 Φ
8	Coarse silt	+4 to +5 Φ

B) Classification of Grain Size Based on Sorting and

Sl. No.	Sorting (σ1)		Skewness (Sk_I)	
1	Very well sorted	< 0.35	Very fine skewed	+0.3 to 1.0
2	Well sorted	0.35 – 0.50	Fine skewed	+0.1 to 0.3
3	Moderately well sorted	0.50 – 0.70	Symmetrical	+0.1 to –0.1
4	Moderately sorted	0.70 – 1.00	Coarse skewed	-0.1 to –0.3
5	Poorly sorted	1.00 – 2.00	Very coarse skewed	-0.3 to –1.0
6	Very poorly sorted	2.00 – 4.00		
7	Extremely poorly sorted	> 4.00		

GRADISTAT, a statistical program developed by Blott (2000), was used to calculate the mean, sorting, skewness from the grain size fractions. A tool was developed using C language to derive the STM from statistical parameters. This tool compares the statistical parameters between two stations to derive the STM. The following conditions were used in the comparison:

IF,

Mean[1] = Mean[2]	S	Same
Mean[1] < Mean[2]	F	Fine
Mean[1] > Mean[2]	C	Coarse
Sorting[1] = Sorting[2]	S	Same
Sorting[1] < Sorting[2]	P	Poor
Sorting[1] > Sorting[2]	B	Better
Skewness[1] = Skewness[2]	S	Same
Skewness[1] < Skewness[2]	+	Positively skewed
Skewness[1] > Skewness[2]	-	Negatively skewed

The procedure adopted in the STM analysis using statistical parameters is explained along with a typical example – location No.1 as follows:

i. The cumulative percentage finer from sieve analysis were calculated. Typical sieve analysis data for location No.1 for pre-monsoon period is given in Table 3.

ii. Cumulative percentage finer was plotted on log - probability scale.

iii. To Φ - values corresponding to the percentage of exceedance were taken from log – probability plots and statistical parameters were calculated using the formulae given by Folk and Ward (1957) and for location No.1, M_Z =1.986, σ =0.498 and Sk = 0.203

iv. In the similar way, statistical parameters were determined for all the samples for different periods and finally STM was drawn.

v. The results of the STM were represented in the pictorial form called Sediment Transport Path (STP) (*Roux* et al., 2002).

Table 3. Sieve Analysis – Sample 1

ASTM Mesh No.	Aperture in mm	Equivalent diameter (Φ) mm	Weight (g)	Weight % retained	Cumulative % retained
18	1.000	0.00	0.1	0.04	0.04
25	0.707	0.50	00	00	0.04
35	0.500	1.00	2.6	1.04	1.08
45	0.354	1.50	26.3	10.52	11.6
60	0.250	2.00	119.4	47.76	59.36
80	0.177	2.50	58.2	23.28	82.64
120	0.125	3.00	42.0	16.8	99.44
170	0.088	3.50	1.2	0.48	99.92
230	0.062	4.00	0.2	0.08	100.00
375	0.044	4.50	0	0	100.00
Pan	_	_	0	0	100.00

RESULTS AND DISCUSSION

The Statistical parameters are computed along the coast of Dhanushkodi for premonsoon, monsoon and postmonsoon seasons. The Sample Statistical parameters for premonsoon season along with inferences is given in Table 5. The statistical parameters were compared by considering each location as a source and other locations as possible deposits and then tabulated. This is called Sediment Trend Matrix. The sediment movement trends were drawn based on the results of STM. If the deposit is finer, better sorted and more negatively skewed it shows case I trend (Total deposition). If the deposit is finer or coarse but better sorted and positively skewed it shows case III (Partially deposition in transport) McLaren (1981). The Sample STM of the premonsoon is given in Tables 4. Then major source and sink locations for each period are observed from the trend maps, the sample trend map is in Figure 2, and tabulated in Table 6.

Table 4. Sediment Trend Matrix - Premonsoon (19.08.2005)

Location		**Sediment Source**							**Parameter**	**Inferences**
		P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**		
SEDIMENT DEPOSIT	**P1**		F	F	C	F	F	F	Mean	P1 → P2, P4
			P	B	P	B	P	P	Sorting	
			-	+	-	-	+	+	Skewness	
	P2	C		F	C	F	F	F	Mean	P2 → P4
		B		B	P	B	P	P	Sorting	
		+		+	-	-	+	+	Skewness	
	P3	C	C		C	F	C	F	Mean	P3 → P1, P2, P4, P6, P7
		P	P		P	P	P	P	Sorting	
		-	-		-	+	-	-	Skewness	
	P4	F	F	F		F	F	F	Mean	---------
		B	B	B		B	P	P	Sorting	
		+	+	+		+	+	+	Skewness	
	P5	C	C	F	C		F	F	Mean	P5 → P1, P2, P4
		P	P	P	P		P	P	Sorting	
		+	+	+	-		+	+	Skewness	
	P6	C	C	F	C	C		F	Mean	--------------
		B	B	B	B	B		B	Sorting	
		-	-	+	-	-		+	Skewness	
	P7	C	C	C	C	C	C		Mean	P7 → P6
		B	B	B	B	B	P		Sorting	
		-	-	+	-	-	-		Skewness	

Table 5. Statistical Parameters

Location	Premonsoon (19.08.2005)		
	Mean (mm)	Sorting (mm)	Skewness (mm)
P1	1.986	0.498	0.203
P2	1.854	0.430	0.211
P3	1.537	0.542	-0.071
P4	2.054	0.426	0.273
P5	1.844	0.610	0.227
P6	1.566	0.367	-0.032
P7	1.402	0.420	-0.039
Inference	Medium sand	Well Sorted	Fine Skewed to Symmetrical

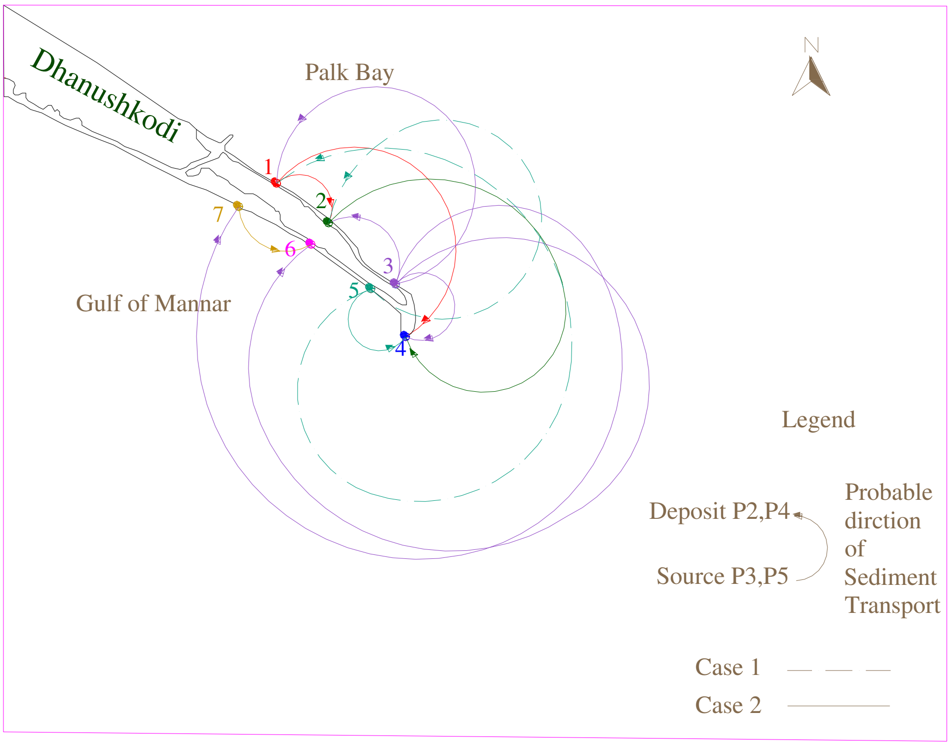

Fig.2. Sediment Trend Paths – Premonsoon (19.08.2005)

Table 6. Source and Sink locations

Sl.No	Period	Major Source	Major Sink
1	August 2005	P3, P5	P2, P4
2	October 2005	P3	P1, P2
3	December 2005	P2, P3, P4,	P1, P5, P6, P7
4	February 2006	P3, P7	P2, P5, P6

The result of this trend show that predominant direction of the sediment transport during the premonsoon and monsoon (16.10.2005) is from south to north and reversed during monsoon (25.12.2005) and postmonsoon seasons. From the Table 6, P2 (along Palk Bay) and P5, P6 are observed to be major sink locations and P3 (along Palk Bay) is to be major source for sediment.

CONCLUSIONS

Sediment dynamics of the area was analyzed from the beach samples collected at seven stations along the shoreline during different seasons. Grain size analysis was done and statistical parameters such as Mean, Sorting and Skewness of the grain size were computed. Sediment Trend Analysis was done using McLaren (1981) one dimensional model. Sediment Trend Matrix was prepared to determine the probable source and sink for the sediment. Sediment transport paths for the premonsoon, monsoon and postmonsoon seasons were then determined with the help of STM. The direction of sediment transport in premonsoon and monsoon period is reversed in comparison with the postmonsoon. The sediment movement trends show that P2 (along Palk Bay) and P5, P6 (along Gulf of Mannar) are the major sink locations and P3 (near Arichamunai) is the major source for sediment.

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