POST TSUNAMI REBUILDING OF BEACHES AND THE
TEXTURE OF SEDIMENTS

V.J. Loveson¹, A.R. Gujar², G.V. Rajamanickam, N. Chandrasekar³,
D. Soosai Manickaraj, R. Chandrasekaran, S.K. Chaturvedi, R. Mahesh,
P.J. Josephine, Vinita Deepa, V. Sudha and D. Sunderasen

Department of Disaster Management, SAstra University,
Thanjavur
¹Central Mining Research Institute,
Dhanbad
²Geological Oceanography Division, National Institute of Oceanography,
Dona Paula, Goa
³Centre for Geotechnology, Manonmaniam Sundaranar University,
Abishekapatti, Tirunelveli

ABSTRACT
Under CSIR-CMRI Network Programme of Coastal Placer Mining beach sand samples have
been collected along the Poompuhar-Nagoor beaches of Central Tamil Nadu, India. Representative
samples of 2003, 2005 and 2006 have been analysed for grain size and textural
statistic studies. In view of the presence tsunami in between, the beach sand composition and
texture have been drastically changed, the studies on beach re-building effort has been initiated
by continuing the beach sand sample collection to 2006 at regular intervals. The textural
statistics have clearly shown the shift in the mean, standard deviation, skewness and kurtosis
for both low-tide and high-tide samples. The binary plots have distinctly placed each group of
samples according to the period of collection such as pre-tsunami, immediately after tsunami
and post-tsunami. Even after giving lapse of one year, the transformed sands though slowly
ebbing to reach the 2003 stage of distribution, reaching to the pre-tsunami conditions could not
be achieved by the sands. CM pattern also reflects similar condition. However, it shows that the
2003 and 2006 sands have reached similar pattern of distribution, but the grain size is coarser
in 2006 when compared to 2003. Probably, in the next 2 to 3 years, it may reach the pre-tsunami
condition.

1. INTRODUCTION
Grain size studies are being utilized as the primary factor in understanding the nature of sediments. In coastal
mining, as there is scraping of the upper surface sands, the nature of the sands is likely to be transformed
subsequently. This type of transformation in the form of sediment texture is being applied to infer the nature
of denudational processes taken place the tsunami affected beaches. Many of the earlier workers have
successfully demonstrated the sediment texture and its application to understand the previous history of the
The sediment texture has been successfully used by many authors in the Indian coast, river and offshore to interpret the depositional environment, erosion and accretion, provenance and energy distribution during transportation (Rajamanickam and Gujar, 1984, 1988, 1985, 1993, 1997; Rajamanickam and Muthukrishnan, 1995; Mohan and Rajamanickam, 1996, 1998; Udayaganesan and Rajamanickam, 1996; Chandrasekar and Rajamanickam, 2000).

The grain size data has also been effectively related to the wave refraction pattern (Rajamanickam et al., 1986; Chandrasekar et al., 1996; Angusamy et al., 1998). Grain size characters in many places have been used by the different authors to appreciate the re-building of the beaches once the stability of the beaches are disturbed for both sedimentary character and landforms (Kahn, 1986; Dingler and Reiss, 1995; Risi et al., 1995; Shaozong et al., 1995; Guntherpergen et al., 1995; Tedesco et al., 1995; Stone et al., 1997; Desrosiers et al., 2001; Jaffe and Gelfenbaum, 2002; Gelfenbaum and Jaffe, 2003; Morton and Sallenger Jr., 2003; Dougherty et al., 2004; Hill, 2004; Hussain et al., 2006; Moore et al., 2006; Srinivasalu et al., 2006).

Under CSIR-CMRI network programme, in order to evaluate the volume of sediment budget, fortnightly sampling from December 2003 to December 2004 has been taken up in a straight beach having length of 35 km, dispositioned between Poompuhar and Nagoor in the Central part of the Tamil Nadu, India (Fig.1). The studies have been carried out on the distribution of the sediments for one year and the results have already been published (Angusamy et al., 2005; Chandrasekaran et al., 2005; Loveson et al., 2005; Soosai Manickaraj et al., 2005) on those sediments collected between 2003 and 2004. The surprise attack of 26th December 2004 tsunami has brought a drastic change in the sedimentary characters. For example, in Poompuhar not even a single grain of earlier sand has been left after tsunami (Plate 1). In such cases, every bit of sand brought forward after tsunami is expected to have a new character admixed with Aeolian source. After tsunami, these beaches have shown not only lithological changes but also in heavy mineral enrichment and sediment texture. Whatever the estimation completed on reserves of the heavy minerals, different landforms under geomorphological mapping and the sediment characteristics can not be carried over further for any other purposes because of complete change in characterization not only in the composition of the sediments but also in the significant changes of sediment texture and assemblages of different sizes of sands and biogenic products. Sediment texture being an important parameter in assessing the value of heavy mineral, environmental effect out of mining and assessing the denudational processes, etc., the continuous collection of sands and observations from December 2004 at a regular interval upto 2006 have been carried out. In this paper, the results of representative the low-tide, high tide samples of each stations. These stations are being positioned after triangulation survey, sand samples could have been collected in the same position both in pre-tsunami and post-tsunami of 2003, 2005 and 2006. The results are presented in this paper (Table 1-3, Fig.1-5 and Plate 1).
### Table 1: Textural Parameters for December 2003

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Distribution Curve</th>
<th>Mean</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Mean</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poonpurah - High tide</td>
<td>Bimodal</td>
<td>1.854</td>
<td>1.934</td>
<td>0.362</td>
<td>0.27</td>
<td>1.60</td>
<td>1.826</td>
<td>0.859</td>
<td>1.37</td>
</tr>
<tr>
<td>Poonpurah - Low tide</td>
<td>Bimodal</td>
<td>2.344</td>
<td>2.78</td>
<td>0.663</td>
<td>0.09</td>
<td>2.403</td>
<td>2.750</td>
<td>0.593</td>
<td>0.004</td>
</tr>
<tr>
<td>Chinamanjiveli - High tide</td>
<td>Bimodal</td>
<td>1.977</td>
<td>2.537</td>
<td>0.712</td>
<td>0.15</td>
<td>2.783</td>
<td>2.708</td>
<td>0.73</td>
<td>0.177</td>
</tr>
<tr>
<td>Chinamanjiveli - Low tide</td>
<td>Bimodal</td>
<td>2.383</td>
<td>2.607</td>
<td>0.72</td>
<td>0.15</td>
<td>2.453</td>
<td>2.175</td>
<td>0.748</td>
<td>0.165</td>
</tr>
</tbody>
</table>

### Table 2: Textural Parameters for January 2005

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Distribution Curve</th>
<th>Mean</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Mean</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poonpurah - High tide</td>
<td>Trinomial</td>
<td>1.16</td>
<td>1.40</td>
<td>0.243</td>
<td>0.27</td>
<td>2.978</td>
<td>2.178</td>
<td>0.951</td>
<td>0.109</td>
</tr>
<tr>
<td>Poonpurah - Low tide</td>
<td>Trinomial</td>
<td>2.206</td>
<td>2.68</td>
<td>0.509</td>
<td>0.526</td>
<td>2.645</td>
<td>2.821</td>
<td>0.676</td>
<td>0.239</td>
</tr>
<tr>
<td>Chinamanjiveli - High tide</td>
<td>Tri modal</td>
<td>2.722</td>
<td>2.723</td>
<td>0.252</td>
<td>0.026</td>
<td>3.352</td>
<td>2.765</td>
<td>0.490</td>
<td>0.013</td>
</tr>
<tr>
<td>Chinamanjiveli - Low tide</td>
<td>Tri modal</td>
<td>1.873</td>
<td>1.925</td>
<td>0.515</td>
<td>0.65</td>
<td>3.346</td>
<td>1.893</td>
<td>0.948</td>
<td>0.014</td>
</tr>
</tbody>
</table>

### Table 3: Textural Parameters for January 2006

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Distribution Curve</th>
<th>Mean</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Mean</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poonpurah - High tide</td>
<td>Trinomial</td>
<td>1.675</td>
<td>1.734</td>
<td>0.578</td>
<td>0.043</td>
<td>3.625</td>
<td>1.859</td>
<td>0.576</td>
<td>0.217</td>
</tr>
<tr>
<td>Poonpurah - Low tide</td>
<td>Trinomial</td>
<td>2.344</td>
<td>2.78</td>
<td>0.663</td>
<td>0.09</td>
<td>2.403</td>
<td>2.750</td>
<td>0.593</td>
<td>0.004</td>
</tr>
<tr>
<td>Chinamanjiveli - High tide</td>
<td>Bimodal</td>
<td>1.977</td>
<td>2.537</td>
<td>0.712</td>
<td>0.15</td>
<td>2.783</td>
<td>2.708</td>
<td>0.73</td>
<td>0.177</td>
</tr>
<tr>
<td>Chinamanjiveli - Low tide</td>
<td>Bimodal</td>
<td>2.383</td>
<td>2.607</td>
<td>0.72</td>
<td>0.15</td>
<td>2.453</td>
<td>2.175</td>
<td>0.748</td>
<td>0.165</td>
</tr>
</tbody>
</table>

---

*Post Tsunami Rebuilding of Beaches and the Texture of Sediments*
Figure 2: Base Map of the Study Area
Fig. 3(a): Mean, Standard deviation, Skewness and Kurtosis trends in the High tide region for December 2003, January 2005 and January 2006
Fig. 3 (b): Mean, Standard deviation, Skewness and Kurtosis trends in the Low tide region for December 2003, January 2005 and January 2006
Fig. 4 (a): Scatter plots in the High tide region for December 2003, January 2005 and January 2006
Fig. 4 (b): Scatter plots in the High tide region for December 2003, January 2005 and January 2006
Fig. 5: CM Diagram for December 2003, January 2005 and January 2006
2. STUDY AREA

The present study is located in the central coast of Tamil Nadu. For the present study, the region from Poompuhar to Nagoor is chosen (Fig.2). Coastline of the study region trends in N-S direction. Poompuhar region is drained by the river Cauvery while the Chinnankudi region is discharged by the river Ambanar. The shelf is very narrow at Poompuhar region where 20 m depth contours at 6 km from the shore and 100 m at 24 km from the shore. At Kuttiyandiyur, 20 m contour is located at 12 km distance whereas 100 m is dispositioned at 33 km from the shore. At Nagoor, 20 m contour is located at 12 km distance whereas 100 m contour is located at 39 km from the shore. Current velocity is 1 – 2 knots southerly in October – December whereas in February, the current velocity is reduced to 0.5 knots in northerly direction.
3. METHODOLOGY

The 35 km stretch of the study area has been (Toposheet No: 58 M/13 and 58 N/13) surveyed for detailed sample collections. Using a hand auger, sediment samples have been collected at 10 km interval between the sampling station upto 33 cm depth in the year of Dec. 2003, Jan. 2005 and Jan. 2006. Since the baseline data was available for the pre-tsunami period, systematic grain size studies were undertaken for the post-tsunami samples. Sample geographic positions were fixed using hand held GPS. Post-tsunami field changes have been noted and marked in the base map itself.

In the laboratory, samples were dried in the oven at 60°C and stirred with a mechanical stirrer for 10 minutes to remove clay and silt content. The weight loss was weighed. Using H₂O₂, organic matter content was estimated. The dried samples were treated with 10% HCl to estimate the carbonate content of the samples. Then, it was oven dried. After weighing, it was sieved at 1/4 f intervals in ASTM sieve sets stacked from +7 to +230 mesh sizes. It was shaken using a mechanical shaker for 10 minutes and then the samples retained in the individual mesh sizes were weighed. Using Folk and Ward (1957) formula, textural parameters of the sediments were estimated.

4. RESULTS AND DISCUSSION

The different values of textural statistics obtained by both graphic and moment measures for the periods 2003, 2005 and 2006 are given in Table 1 to 3. The textural statistics of Mean, Sorting, Skewness and Kurtosis clearly establish a characteristic shift in their values. In order to appreciate the changes effected in the texture after tsunami and the extent of normalization the respective textural parameters’ values are shown in a graphic pattern (Fig.3a, b). In the figures, one can easily observe the approach of 2006 sediment to the vicinity of 2003. The drastic shift seen in those samples collected immediately after tsunami during 2005 is seen in all the stations, whether the station has faced high order of impact or less order of impact. In the low tide, the northern four stations have shown a systematic order of distribution. Here, in the low tide particularly skewness displays a more or less close distribution with minimum change. The standard deviation of low tide as well as high tide shows strong difference between pre- and post-tsunami sands. Among the stations, Kuttiyandiyur sediments show ebbing of normalcy in the distribution of sediments.

However, when the binary plots of the textures of these three periods are compared in standard deviation Vs skewness plot, it shows the presence of the sands from December 2003 and January 2006 in one zone. Similarly, mean Vs skewness first moment to second moment, standard deviation to kurtosis display similar trend for high tide whereas the distribution of the low tide in this area is not yet normalized. All the plots show the Dec. 2003 and Jan. 2006 are separated by Jan. 2005 sample segregations. From this, it clearly depicts that high tide samples are reaching the previous status fastly than the low tide (Fig.4a, b).

With the view to understand the energy level of deposition during this period, the year 2003 high tide samples show their presence in the PQ sector reflecting the dominance of rolling and suspension. In the same, Jan. 2005 is dominantly present in the higher turbulent energy zone of NOP, reflecting the deposition in turbulent condition.

Jan. 2006 high tide samples are segregated in NOP sector but with less energy, the coarseness remains to be of 100 microns whereas 2005 has reflected a turbulent level bringing particles of 1000 microns. The 2003 high tide samples are in the PQ rolling sector or a graded suspension. Till 2006, the sediments have not reached the level of 2003. In low tide, the 2003 samples characterize a similar condition of high tide but Jan. 2005 reflects a very scattered irregular mix-up of the sediments. It can be surmised that the low tide sediments do not represent onward push of tsunami waves-brought sediments. Probably, low tide sands are expected to
have been dominated by the under-tow or the receding current situation. 2006 sands are once again reflecting the condition of high turbulence in the zone of NOP but to a low energy turbulence of 100 microns levels. Low tide and high tide on the basis of CM pattern reflect a strong diversity among the sands of those three periods (Fig.5). Though 2006 emphatically indicates presence of low energy condition, it has also reached the graded suspension stage, but with the higher coarser particles. In due course of time, there is a possibility of those sands retaining the PQ distribution. In short, it can be surmised that the disturbance created by the tsunami waves to the sands in the beaches are rebuilt, the pre-tsunami condition of the graded suspension character is normally seen in all beaches of Quaternary sediments.

5. CONCLUSION

The sediment character and textural characteristics have been obtained for the representative samples of three years 2003, 2005 and 2006. They have been analysed for grain size characteristics and the statistical textural parameters have been estimated using both graphic and moment measures. The graphical presentation of the textural characteristic in addition to the binary plot, CM pattern clearly bring out the existing sands have not yet reached the pre-tsunami level of 2003.

6. ACKNOWLEDGEMENT

The authors are thankful to the Vice-Chancellor of SASTRA University for encouraging the research under the network project. The authors are grateful to the Director Central Mining Research Institute (CMRI), Dhanbad for having chosen SASTRA to work jointly in network program. The authors are also thankful to ESS division of Department of Science and Technology for partial financial support in under taking the heavy mineral studies in detail. The kind support of all the staff of CARISM particularly Ms. A. Rajarajeswari, Ms. K. Muthumeena, and Ms. R. Sivagama Sundari and other SASTRA administrative staff are highly acknowledged in completing this work successfully.

REFERENCES


