CHAPTER 5
SEDIMENT TRANSPORT ALONG THE PONDICHERRY COAST

5.1 GENERAL
In this chapter, the various methods adopted to estimate the longshore sediment transport rates; the field measurement adopted to determine the actual rates are described and the results obtained compared and are discussed.

5.2 ALONG-SHORE TRANSPORT
5.2.1 Process and Importance
Coastal zone is the most dynamic zone since it experiences by erosion, accretion and sea level rise etc. Various natural and man-made activities are the prime response for an unstable coastal zone. Beaches, which is the formation of sandy shore are one of the most dynamic systems in nature, they show visible changes over hours, days, months and years.

The important factor that governs the beach erosion is the long shore sediment transport, which is mainly controlled by wave characteristics and near shore topography. Waves generated in the deep ocean propagate into the near shore and expend their energy on the coast causing lifting of sediments, generating long-shore currents and producing littoral sediment transport. Onshore - Offshore transport is initiated by the high and short period waves resulting from a storm removing the sand from the beach and transporting it into the sea to form offshore sandbar. During the ensuing fair weather period, the sediments formed as offshore bar tend to migrate onshore and build up the beach. Long-shore sediment transport is more dominant than onshore - offshore transport and of greater significance to coastal engineers who are interested in annual changes rather than seasonal variation. The longshore sediment transport rate enters into most coastal engineering designs. The longshore current generated by obliquely incident breaking waves plays an important role in transporting sediment in the surf zone.

The waves approaching the coastline have varying heights and periods due to spectral nature of incident waves and as a result, successive waves break at different locations with respect to prevalent still water level. This, therefore, results in the wide surf zone and the bed material on the beach is subjected to suspension and to on shore-offshore movement with up rush and down rush of the water mass. Due to some obliquity of the crests of the

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with up rush and down rush of the water mass. Due to some obliquity of the crests of the breaking waves with the shoreline, there is a net component of momentum and energy in the direction along the beach. This causes a net alongshore transport of beach sand. Littoral drift, (i.e. along-shore transport) rates and distribution are functions of wave and beach parameters. These littoral currents also get influenced by beach forms, and rip currents. The strong currents caused by breaking of waves and associated drift move in a band extending from the beach to a short distance beyond the breaker line or surf zone and there is net transport of sediments depending on the wave climate.

5.2.2 Modes of Littoral Transport
Littoral drift occurs in two modes, namely (a) bed load transport - the motion of grains rolled over the bottom by the shear of water moving above the sediment bed and (b) suspended-load transport of grains by currents after the grains has been lifted from the bed by turbulence. Both modes of transport are usually present at the same time, but it is hard to distinguish where bed-load transport ends and suspended-load transport begins. In either zone, net sediment transport is the product of two processes: the periodic wave-induced fluid motion that initiates sediment motion and the superimposed currents, which transport the sediment set in motion.

5.2.3 Gross and Net Sediment Transport
Littoral movement is the sediment moved in the littoral zone under action of waves and currents. The rate at which littoral drift is moved parallel to the shoreline is the long-shore transport rate 'Q'. Since this movement is parallel to the shoreline, there are two possible direction of motion, right to left, relative to an observer standing on the shore looking out to sea. Gross long-shore transport rate, \( Q_s \), is the sum of the amounts of littoral drift transported to the right and to the left, past at a point on the shore-line in a given time period.

\[
Q_s = Q_r + Q_L
\]  

(5.1)

Net long-shore transport, \( Q_n \), is defined as the difference between the amounts of littoral drift transported to the right and to the left, past at a point on the shore-line in a given time period.

\[
Q_n = Q_r - Q_L
\]  

(5.2)
Long-shore transport rates are usually given in units of volume per time i.e. (m³/year). At present there are four basic methods to use for the prediction of long-shore transport rate. The best way to predict long-shore transport at a site is to adopt the best-known rate from a nearby site, with modifications based on local conditions.

1. If the sediment transport rate from nearby sites are unknown, the next best way to predict transport rates at a site is to compute them from data showing historical changes in the topography of the littoral zone.

2. Long-shore transport rate can be calculated by a long-shore component of “wave energy flux” which is related to an empirical curve to long-shore transport rate.

3. An empirical method is available to estimate gross long-shore transport rate from mean annual near-shore breaker height.

5.2.4 Factors Affecting Littoral Drift

The littoral drift at a shoreline depends on the offshore wave climate, caused by prevailing winds and storms and on the bottom topography that modifies the waves as they travel shoreward.

(A) Offshore Wave Climate
Wave climate is the temporal distribution of wave conditions averaged over the years. A wave condition is the particular combination of wave heights, wave period, and wave direction at a given time. The variations in offshore wave climate affect the amount of littoral wave energy availability and the directions from which it comes.

(B) Effect of Bottom Topography
As storm waves travel from deep water into shallow water, they generally lose energy even before breaking. They also change height and direction in most cases. The changes may be attributed to refraction, shoaling, bottom friction, percolation and non-linear deformation of the wave profile. Offshore island, shoals, and other variation in hydrograph also shelter parts of the shore. In general, bottom topography has the greatest influence on waves traveling long distances in shallow water. Due to the effects of bottom hydrography near-shore, waves generally have different characteristics than they had in deep water offshore.
(C) **Winds and Storms**

The orientation of a shoreline to the seasonal distribution of winds and to storm tracks is a major factor in determining the wave energy available for littoral transport and the resulting effect of storms. A storm near the coastline will influence wave climate owing to storm surge and high seas; a storm offshore will influence coastal wave climate only by swell. The probability that a given section of coast will experience storm waves on its ocean exposure, its location in relation to storm tracks, and the shelf bathymetry.

(D) **Geologic Factors**

The geology of a coastal region affects the supply of sediment on the beaches and the total coastal morphology, thus geology determines the initial conditions for littoral processes; but geologic factors are not usually active processes affecting coastal engineering.

(E) **Other Factors**

The works of man, construction activities, the resulting structures, activities of organisms native to the particular littoral zone, biological activity, reef development, through vegetation etc. are the other factors which affect littoral drift.

### 5.3 METHODS OF ESTIMATING LONG-SHORE SEDIMENT TRANSPORT

CTR.C. Kamphuis and Queen's formulae, (Eqn (5.3) , (5.4)and (5.4d), respectively are the very widely used formulae for estimating the bulk longshore sediment transport rate.

\[
Q_m = 330 H_b \sin^2 \alpha_b (m^3/hr) \quad \ldots\ldots(5.3)
\]

where, \( H_b \) near-shore breaking waves (m); \( \alpha_b \) - breaker angle. It can be seen that \( Q_m \) is a function of \( 'H' \) and \( '\alpha' \) only.

\[
Q = 7.3 H_b^2 T_c^2 m_b^{-0.75} \sin^{0.01} 2\alpha_b (m^3/hr) \quad \ldots\ldots(5.4)
\]

where,

- \( m_b \) - beach slope in the breaking zone:
- \( D \) - median grain size (mm)

It is to be noted that Eqn. (5.3) is applicable for sediment size in the range of 0.2-0.6mm.

Kamphuis and Sayao (1982) have shown that there is a strong dependence of the dimensionless littoral transport rate on the surf similarity parameter and gave the following expression [ i.e., Eqn. (5.4 a)]

\[
n Q_s = K Q_s \quad \ldots(5.4a)
\]

where, \( Q_s \) - dimensionless sediment transport rate.
\( K \) - suspended load coefficient and

\[ \chi = \text{surf similarity parameter}. \]

Eqn. (5.4a) can be written as in Eqn. (5.4b),

\[ \rho_c (1-p) Q / \rho (H_b)^* \sin (2\theta) = K \chi \]

where \( \rho_c \) is sediment density and \( K \) is given by Eqn. (5.4c)

\[ K = 0.002 (H_b/D_{100}) \]

Substituting Eqn. (5.4c),( 5.4b) onto (5.4a) and transposing

\[ Q = (4 \times 10^{-3}) [m^2 / (1-p) \rho_c \rho^*] * g [H_b^{-1} D_{100}] \sin (2\theta) \]

Eqn. (5.4d) is called the Queen's formula, which is an improvement over Kamphuis formula. Eqns.(5.4a to 5.4d) are as given by Sayao, (1994).

According to Shore protection Manual (1984), the evaluation of longshore energy flux at breaking requires approximation since the wave breaking is outside the linear wave theory. The equation for longshore energy flux at surf zone is given by:

\[ P_K = \left( \frac{(pg)}{16} H_b^2 C_k \sin 2\theta \right) \]

where,

- \( P_K \) = longshore energy flux in watts/m:
- \( H_b \) = significant wave height at breaking:
- \( C_k \) = velocity at breaking:
- \( \theta \) = breaker wave angle w.r.t. shore-line
- \( \rho \) = fluid density

The generalized relationship for estimating the actual sediment transport rate using energy flux relation is (CERC 1984):

\[ Q = K P_K \]

Eqn. (5.6) is based on the assumption that the longshore sediment transport rate (Q) depends on the longshore component of wave energy flux(\( P_K \)) in the surf zone. 'k' is generally treated as a constant equal to 0.39. However, the effects of the sediment hydraulic properties and the fluid transporting medium are not included in a constant value of \( k \). But a number of studies carried out by several investigators (CETN, 1985) have suggested that 'k' is not a constant, but, rather a variable dependent on sediment size and density, which may be represented by fall velocity. The suggested relationship for \( k \) (where \( k \) is a dimensionless and consistent with SPM methods for calculating \( P_K \)), using the dimensionless parameter \((gH_b/\rho_c^2)\) is given by Eqn.(5.7). It takes into account the breaker
height and fall velocity of the sediment. The fall velocity accounts for the effects of viscosity and density of water, as well as, sediment density, size and shape characteristics. The expression for \( k \) as suggested in CETN (1985) is:

\[
K = 0.1637 \log \left( \frac{gH_b w_f^2}{\rho_f} \right) - 0.0773
\]

where,

\( K \) = dimensionless constant of SPM equation; 
\( \log \) = logarithmic function to the base 10; 
\( g \) = gravitational constant; 
\( H_b \) = breaking wave height; 
\( w_f \) = fall velocity of sediment.

The fall velocity, \( w_f \), can be estimated using the following equations (CETN, 1981); wherein, consistent units may be used.

\[
A = \frac{(\rho_s - \rho) g M_d^2}{\rho_f^2}
\]

where, \( A \) = grain buoyancy; \( \rho_s \) = sediment density; \( \rho \) = fluid density; \( M_d \) = sediment median grain diameter; \( v \) = fluid kinematic viscosity.

The fall velocity equations and their ranges of applicability are:

\[
w_f = \frac{(\rho_s - \rho) g M_d^2}{18 \rho v} \quad \text{for } A < 39
\]

\[
w_f = \left( \frac{(\rho_s - \rho) g}{\rho} \right)^{0.7} M_d^{1.1} \quad \text{for } 39 < A < 10^4
\]

\[
w_f = \left[ \frac{(\rho_s - \rho) g M_d}{0.91 \rho} \right]^{1/2} \quad \text{for } A > 10^4
\]

The above relationships [i.e. Eqns. (5.9) to (5.11)] have been used to compute the value of \( k \) for the Pondicherry coast, and for estimating the longshore sediment rate using the energy-flux method, as mentioned in section 5.4.3.
5.4 ESTIMATION OF SEDIMENT TRANSPORT RATE FOR THE PONDICHERRY COAST

5.4.1 Methods Used
CERC, Kamphuis and Queen's formulae were used to estimate the bulk sediment transport rates. Further, the actual quantity of sediment transport rate was measured using a "sand trap" specially fabricated and erected in the study area. Apart from the above methods, a numerical approach was adopted, where in, the equations as proposed by Ebersole (1985) were solved to obtain $H_b$ and $q$, for the present coast and were used to compute the longshore sediment rate using the energy flux method.

5.4.2 Field Measurement of Sediment Transport Rate for the Coast

(A) Method Used
A sand trap was developed for measuring the sediment transport rate in the surf zone. The trap was designed in such a way that it is very easy to handle; durable to withstand maximum current and also capable of measuring transport rates of sand-sized particles moving in any uni-direction fluid flow.

(B) Location of instrument
The instrument was fixed in the old harbor at a distance of about 20m from the shoreline, to collect the sediment samples Fig. 5.1. The samples were collected in the breaker zone and was analyzed for full stretch under consideration. The samples were collected once in a day (i.e., every 24hrs.) for a period of two months i.e., during February and March of 2005, just for comparing the actual values with the computed sediment transport rates.

(c) Description of the Sand Trap System Used
For trapping the suspended sediments in the breaker zone, a "sand trap" was indigenously designed and fabricated, consisting of : (1) sampler bottle (1.5 liters capacity); (2) sampler holder (sliding type); (3) hollow sliding type frame. The sampler bottle was selected such that the shape is narrow at the neck and has a volume of 1.5 liters capacity. The narrow head portion prevents the washing away of the collected sample from the sampler bottle. They can be easily fixed in the sampler holder in position, which is not washed away easily. The sampler holder holds the sampler bottle in proper position and orientation without any disturbance. There are 3 numbers of sampler holders fixed at 50 cm c/c in height at an angle of 45° to the water level. The inclination of the sampler facilitates...
maximum quantity of sediments to be collected in it. The three sampler holders are connected to a sliding rod, which slides through a hollow holding frame. With the help of a pulley at the top, the sampler holder is lowered into the sea easily and raised up along with the samples every 24 hours. This main holding frame plays an important role in holding the total setup in position, which overcomes the tidal energy disturbance. It is a hollow MS pipe of class B. The sampler holder slides into the sea by holding this pipe with rings. For stability, the main pipe is fixed to the jetty structures handrail at top and tie beam at the near sea level. Fig. 5.1 shows the schematic view of the setup and Fig. 5.2 (a) and (b) shows the top and side views as erected in the field.

(D) Actual Measurement

The jetty structure was selected for hoisting the sediment trap. Sampling was taken at five meters interval across the surf zone. The samplers were arranged in such a way that the mouth of the sampler faces the longshore current. After a few initial trails, it was found that an inclination of 45 degree was best suited for collection of sediment samples. After a sample run was complete, the sampler bottle was detached from the instrument and carried to the laboratory for analysis.

The trap was deployed across the surf zone for one hour and three samples were collected each day, during the sampling period. The samples were taken directly without disturbing the sampler bottle and taken to the laboratory for analysis. Every time a new sampler was attached to the system for the collection of samples. The sediment collected was weighed and the sediment transport rate achieved per unit width of surf zone per unit time was calculated and tabulated.

Soil samples were also collected along the study area at 20 m intervals on the surf zone, each week of the month during the year 2005. Based on the above, K values were estimated for this coastal stretch for each month for the above year.

5.4.3 Theoretical Quantity of Sediment Transport Rate for the Coast

Using the CERC formula [Eqn.(5.3)] and the breaking wave height and angle obtained by the wave ray method (as outlined in chapter 4), monthly values of bulk sediment transport rate were computed for three years (2002 - 2005). In order to use Kamphuis formula, grain size analysis was carried out and the median grain size was determined by standard procedure i.e., sieve analysis as per IS : 2720 (Part4)- 1985. Based on bathymetry studies carriedout (for limited period) the average slope (1/30.3) was arrived at and used Fig.5.3. Other parameters used were same as the one used in CERC formula. However, Kamphuis and Queen's formula (Eqn.5.4, 5.4d) were used to assess the sediment transport rate for
one year (i.e., 2005) only. $H_n$, obtained using the numerical solutions of refraction equation (as outlined in chapter 4) was also used to estimate the monthly sediment rate for one year, using the energy - flux method (Eqn.5.6).

5.5 RESULTS AND DISCUSSION

The estimated values of $K$ ranges from 0.41 - 0.55 with an average of 0.48. Comparing with the various values reported in the literature, it is found to be within the reported maximum value (i.e.,0.77).

Monthly estimated sediment transport rate by CERC formula along with the direction for three years (2003 - 2005) are given in Tables 5.1(a) - (c) and the variation is also shown in Fig. 5.4 (a - l) to (5.6 (a - l). Based on the above the estimated net sediment transport rates for the three years are: (i) $2.5 \times 10^4 \text{ m}^3/\text{hr}$ in the Northerly direction during 2003, (ii) $4.1 \times 10^5 \text{ m}^3/\text{hr}$ in the Northerly direction during 2004 and (iii) $0.95 \times 10^7 \text{ m}^3/\text{hr}$ in the Northerly direction during 2005. Sediment transport rates by CERC, Kamphuis and Queen's formulae have been compared (for one year) and are given in Table 5.2 and shown in Fig. 5.7. In general, CERC formula 'over predicts' the sediment transport rate, when compared to the results from the other two methods used. Daily values of actual sediment transport rate (i.e., by the sand trap method) and the computed rate by Kamphuis and Queen's formulae (for two months in 2005) are given in Tables 5.3(a) (b) and the variation is also shown in Figs. 5.8 (a - b). Comparing the above values, it is found that the actual values are in very close agreement with the $Q_n$ obtained by the Queen's formula. This indicates the 'sand trap' method adopted for this study for assessing the actual values is fairly reliable and can be used with confidence.

Sediment transport rates computed using the numerical model where compared with results of Kamphuis and Queen's formulae for one year (i.e., 2005) and the variation is also shown in Fig. 5.9. It is found that the results from the numerical model is always higher than the results from the other two methods. This may be due to the approximations involved in the numerical model.

5.6 SUMMARY

Bulk sediment transport rates have been estimated by CERC, Kamphuis and Queen's formulae. The results were compared with that of actual field measurements carried out by a 'sand trap' specially fabricated for the present study and also with the results from the numerical model. It was found that the 'actual' and 'estimated' values (by Queen's formula) are comparable.
### Table 5.1 (a) Estimated Sediment Transport Rates (by CERC method) - 2003

<table>
<thead>
<tr>
<th>S.I. No</th>
<th>Month</th>
<th>Sediment transport rate (X $10^4$ m$^3$/month)</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>January</td>
<td>19</td>
<td>Southerly</td>
</tr>
<tr>
<td>2</td>
<td>February</td>
<td>12</td>
<td>Southerly</td>
</tr>
<tr>
<td>3</td>
<td>March</td>
<td>8</td>
<td>Northerly</td>
</tr>
<tr>
<td>4</td>
<td>April</td>
<td>1</td>
<td>Northerly</td>
</tr>
<tr>
<td>5</td>
<td>May</td>
<td>11</td>
<td>Northerly</td>
</tr>
<tr>
<td>6</td>
<td>June</td>
<td>24</td>
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</tr>
<tr>
<td>7</td>
<td>July</td>
<td>1.1</td>
<td>Northerly</td>
</tr>
<tr>
<td>8</td>
<td>August</td>
<td>13</td>
<td>Northernly</td>
</tr>
<tr>
<td>9</td>
<td>September</td>
<td>1</td>
<td>Northerly</td>
</tr>
<tr>
<td>10</td>
<td>October</td>
<td>8</td>
<td>Northerly</td>
</tr>
<tr>
<td>11</td>
<td>November</td>
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</tr>
<tr>
<td>12</td>
<td>December</td>
<td>17</td>
<td>Southerly</td>
</tr>
</tbody>
</table>

**Note:**

(i) **Total:** Northerly – $9.5 \times 10^4$ m$^3$/yr  
    Southerly – $7.0 \times 10^4$ m$^3$/yr  
    **Net:** $2.5 \times 10^4$ m$^3$/yr (Northerly)

(ii) $H_n$ is obtained by wave ray method and used in CERC formula for computing 'Q'.

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### Table: Estimated Sediment Transport Rates (by CERC method) - 2004

<table>
<thead>
<tr>
<th>S.I. No</th>
<th>Month</th>
<th>Sediment transport rate ( \times 10^4 \text{ m}^3/\text{month} )</th>
<th>Direction</th>
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<tr>
<td>1</td>
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<td>5</td>
<td>May</td>
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<td>Northerly</td>
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<td>2.1</td>
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</tr>
</tbody>
</table>

**Note:**

(i) Total: Northerly \( 9.4 \times 10^4 \text{ m}^3/\text{yr} \)  
Southerly \( 5.2 \times 10^4 \text{ m}^3/\text{yr} \)  
Net: \( 4.1 \times 10^4 \text{ m}^3/\text{yr} \) (Northerly)

(ii) \( H_s \) is obtained by wave ray method and used in CERC formula for computing 'Q'
Table: 5.1 (c) Estimated Sediment Transport Rates (by CERC method) - 2005

<table>
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<td>Southerly</td>
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<td>November</td>
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<tr>
<td>12</td>
<td>December</td>
<td>1.9</td>
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</table>

Note:

(i) Total: Northerly - $7.8 \times 10^3$ m$^3$/yr
   Southerly - $6.9 \times 10^3$ m$^3$/yr
   Net: $0.95 \times 10^3$ m$^3$/yr (Northerly)

(ii) $H_s$ is obtained by wave ray method and used in CERC formula for computing 'Q'
Table 5.2 Comparison of Estimated Sediment Transport Rates by CERC, Kamphuis and Queen’s formula (for 2005)

<table>
<thead>
<tr>
<th>S.L No</th>
<th>Month</th>
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<th>( \alpha_b )</th>
<th>( D )</th>
<th>( Q(m^3/\text{month}) )</th>
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<td>0.37</td>
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<td>12913.9</td>
</tr>
</tbody>
</table>

Note:

1. \( H_b \) is obtained by ‘wave ray method’ and used in CERC formula for computing ‘Q’
2. ‘m’ and ‘D’ are obtained by field measurements and used in Kamphuis and Queen’s formula.
3. Comparison is done only for one year i.e., 2005, as the field data for ‘m’ (bed slope) and ‘D’ (i.e., \( D_{we} \)) are available for that period only.
Table 5.3(a) Comparison of Sediment Transport Rates by Sand Trap, Kamphuis and Queen’s formula (Daily values – Feb. 2005)

<table>
<thead>
<tr>
<th>Month/Date</th>
<th>Sand Trap $Q_{act}$</th>
<th>Kamphuis $Q_{th}$ % Error</th>
<th>Kamphuis $Q_{th}$</th>
<th>Queen’s Formula $Q_{th}$ % Error</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>18.9</td>
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Note:

1. $Q_{act}$ – is the actual sediment transport rate realized in the field by the sand trap method.
2. $Q_{the}$ – is the estimated sediment transport rate based on Kamphuis and Queen’s formula and % error is calculated between $Q_{act}$ and $Q_{the}$ with respect to each of the above formulae.
### Table 5.3(b) Comparison of Sediment Transport Rates by Sand Trap, Kamphuis And Queen’s formulae (Daily values – March 2005)

<table>
<thead>
<tr>
<th>Month</th>
<th>Date</th>
<th>Sand Trap ( Q_{act} )</th>
<th>Kamphuis ( Q_{k} )</th>
<th>Kamphuis % Error</th>
<th>Queen’s Formula ( Q_{qe} )</th>
<th>% Error</th>
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<td>70.8</td>
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</tbody>
</table>

**Note:**

1. \( Q_{act} \) – is the actual sediment transport rate realized in the field by the sand trap method.
2. \( Q_{qe} \) – is the estimated sediment transport rate based on Kamphuis and Queen’s formula and % error is calculated between \( Q_{act} \) and \( Q_{qe} \) with respect to each of the above formulae.
Table 5.4 Comparison of Sediment Transport Rates by Kamphuis' Queen's formula with the Numerical Method (for 2005)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Month</th>
<th>Wave height ($H_s$ in m)</th>
<th>Wave angle (in deg)</th>
<th>Sediment transport ($Q_{\text{out}}$, Cu.m/month)</th>
<th>Kamphuis $(Q_{\text{km}})$</th>
<th>%Error</th>
<th>Queen's Formula $(Q_{\text{qe}})$</th>
<th>%Error</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>9500</td>
<td>90.8</td>
</tr>
<tr>
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<td>0.75</td>
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<td>3232.3</td>
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<td>93.8</td>
</tr>
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<td>March</td>
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</tr>
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<td>91.4</td>
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</tr>
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Note:
(i) $H_s$ is obtained by the numerical model
(ii) $Q_{\text{km}}$. Computed value of sediment transport rates using $H_s$ obtained by the numerical model.
(iii) $Q_{\text{qe}}$. Computed value of sediment transport rates using Kamphuis and Queen's formula.
Fig. 5.1(a) Location of Sand Trap Setup

Fig. 5.1(b) Sand Trap Setup
Fig. 5.1 (c) Top View

Fig. 5.1 (d) Side View

Fig. 5.1(c-d): Top and Side views of Sand Trap As Erected in the Field
SHORE LINE OF THE PONDICHERRY COAST

SOIL SAMPLE COLLECTION ZONE

SURF ZONE WAVES
Fig. 5.3 Bathymetry Profile Along The Transect of the location of Wave Measuring Instrument
Fig. 5.4 (a – d) : Monthly Sediment Transport Rate for the Pondicherry coast -2003 (CERC formula)
Fig. 5.4 (e – h): Monthly Sediment Transport Rates for the Pondicherry coast-2003 (CERC formula)
Fig. 5.4 (i - l) : Monthly Sediment Transport for the Pondicherry coast-2003 (CERC formula)
Fig. 5.5 (a – d): Monthly Sediment Transport for the Pondicherry coast - 2004 (CERC formula)
Fig. 5.5 (e–h): Monthly Sediment Transport for the Pondicherry coast–2004 (CERC formula) 

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Fig. 5.5 (i – l): Monthly Sediment Transport for the Pondicherry coast-2004 (CERC formula)
Fig. 5.6(a – d): Monthly Sediment Transport for the Pondicherry coast -2005 (CERC formula)
Fig. 5.6(e - h): Monthly Sediment Transport for the Pondicherry coast- 2005 (CERC method)
Fig. 5.6 (ah – al) : Monthly sediment transport for the Pondicherry coast- 2005 (CERC method)
Fig. 5.7: Comparison of Sediment Transport Rates by Kamphuis, Queen’s and CERC formula for the year 2005

Fig. 5.8 (a-b) Comparison of Sediment Transport Rates ($Q_{sed}$) by Kamphuis and Queen’s formulae with sand trap method for the year 2005
Fig. 5.9 Comparison of Sediment Transport Rates by Kamphuis, Queen’s and Numerical Method for the year 2005