Sedimentation Study on the Teluk Datai Coral Reefs

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Abstract. - This study was carried out to determine the sedimentation rate on the fringing reef of Teluk Datai, Pulau Langkawi, Kedah. Samplings were carried out every 15 days following spring tide. The study was conducted with a sediment trap to determine the effect of the nearby river to the total sediment fallout on the fringing reef. Station 1 was found to have the highest sediment fallout of 447.6 ± 82.3 g in January. The most common particulate size was between 710 µm and 212 µm at station 1 but the size range of 212 µm and 63 µm of sediment was abundant at Station 2 and 3.

Keywords: Sedimentation, Teluk Datai, coral reefs.

Abstrak. - Kajian ini dilakukan untuk menentukan kadar sedimentasi di terumbu karang pinggir Teluk Datai, Pulau Langkawi. Persampelan dilakukan setiap kali air pasang surut purbani atau setiap 15 hari. Kajian ini dilakukan dengan menggunakan perangkap sedimen. Hasil kajian digunakan untuk menunjukkan kesan aliran sungai terhadap kadar sedimentasi di terumbu karang yang berhampiran. Stesen 1 di dapati memerangkap paling banyak sedimen pada bulan Januari iaitu sebanyak 447.6 ± 82.3g. Saiz sedimen yang terperangkap di Stesen 1 ialah di antara 710 µm dan 212 µm manakala sedimen bersaiz di antara 212 µm dan 63 µm banyak di dapati di Stesen 2 dan 3.

Introduction

Teluk Datai is situated on the north-west coast of Pulau Langkawi, originally a coastal forest reserve (LADA, 1991). The increase in tourism activities of Pulau Langkawi in the late 1980's has created a quantum leap on the infrastructural development involving areas with sensitive coastal ecosystems, for example the coral reef of Teluk Datai. Land works on the coastal area of Teluk Datai, had contributed to soil erosion and the presence of high suspended solids in the coastal waters resulting in high sedimentation on the fringing reefs. Further, heavy rainfalls increased erosion and sediment flow to the sea resulting in stresses to the coral reef ecosystem, especially the fringing reefs (Berwick & Faeth, 1988).

The sedimentation rate on the coral reef can be studied by the method of sedimentation trap (Rogers, 1983; Newman, 1984). Newman (1984) reported a sedimentation rate of 2,820 g m $^{-2}$ day $^{-1}$ on the shallow reef flat of Pulau Bidan and 30 g m^{-2} day^{-1} on the reef of Pulau Songsong, Kedah. Phosphorus enriched sediment may be found to increase during terrestrial erosion. Phosphorus exist in small quantities in sea water, and is replenished either by sea water nutrient upwelling or by terrestrial run off and erosion during heavy rains (D'Elia & Wiebe, 1990).

High sedimentation from terrestrial run off can disturb marine organisms by covering their body surface and hence decrease the underwater light penetration (Johnson, 1987). High sediment cover on the benthic organisms themselves will cause suffocation and finally mortality (Johnson, 1987). A preliminary study has shown that one of the major stresses on the fringing reef of Teluk Datai, was the high level of suspended material in the water from terrestrial development. Land clearing and earth works left the ground bare for some time and erosion occured when there was heavy rainfall. Thus this study was carried out to determine the quantity and the size ranges of the sediment particle settling on the fringing reef of Teluk Datai.

Materials and Methods

Sediment trap stations

Three replicates of sediment trap were set up at three stations on the fringing reef of Teluk Datai. The stations were assigned as Station 1, 2 and 3 (Fig. 1).

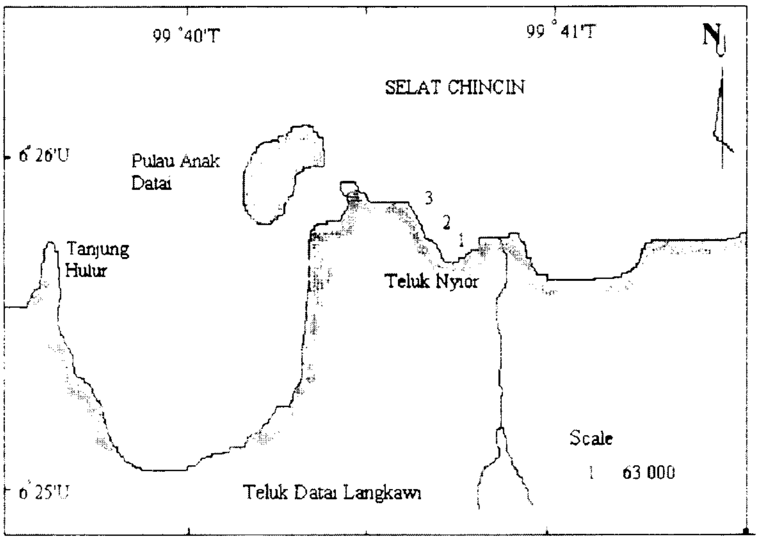

Figure 1 : Sediment trap stations (1, 2 & 3) at Teluk Datai

The sediment trap used was a modified version of Rogers (1983) who used three PVC cylinders attached to a spike. In this study the PVC cylinder was replaced by glass bottle with opening diameter of 8 cm and height of 20 cm. The bottles were attached to a spike embedded earlier at the station using rubber strap. Each trap consists of three glass bottles. The bottles were attached to the spike at approximately 20 cm from the bottom (Fig. 2). The sediment trap stations were located in waters more than 2 m in depth during high tide and between 0.0 - 0.5 m depth during low spring tide.

During trap recovery, the mouths of the bottles were covered to avoid sediment loss due to disturbances. The sediment was then poured into a plastic bag and labelled for each locations and dates. Silt inside the bottles was also collected by washing with distilled water. The samples were then taken back to the laboratory for analysis.

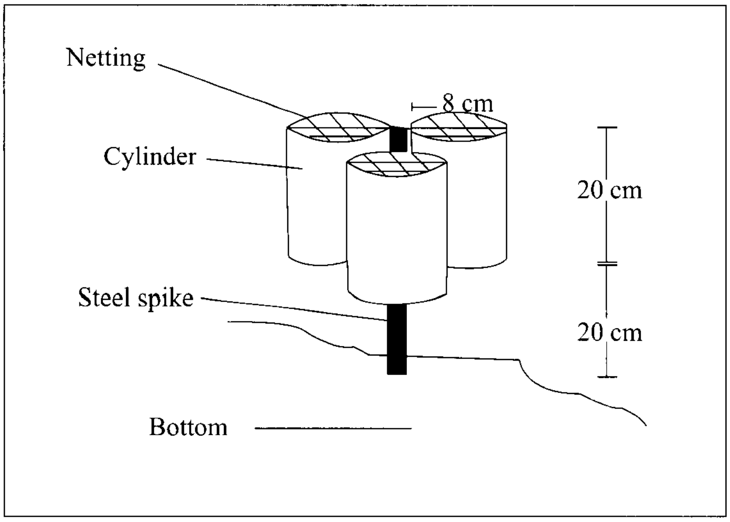

Figure 2 : Sediment trap used in this study

Determination of total sediment collected and particle sizes

In the laboratory, the samples were sieved using wet sieving method with mesh sizes of 2 mm, 710 µm, 212 µm and 63 µm (Stoddart, 1978a). Sediments in the sieve were oven dried at 105°C until it reached constant weight. The drying process usually takes between 4 - 8 hours depending on the quantity of the sediment. Dried samples on the sieve were shaken to free the smaller particles that were trapped in the sieve. The samples were then weighed and poured into plastic bags with appropriate labels. Graphs were plotted for sediment size versus station and sediment weight against sampling month. The water used for washing was also collected and let to settle in a container for 24 hours then dried for weighing of smaller particles.

Statistical analysis

The sediment weight data were analysed using descriptive statistics of Fowler & Cohen (1990) in order to determine the variation between;

a) pooled weight of sediment for each station against sampling time, and
b) pooled weight for each different sediment sizes within station

The first analysis was done to determine the existence of variation in data collection at each station whereas the latter was to determine the variation in the collected particle size.

The null hypothesis for this study was there is no significant difference of total weight and sediment sizes collected between stations at 95% confidence level.

Results

Total sediment collection

The mean sedimentation rates collected at Station 1, 2 and 3 were 447.568 ± 82.3, 274.835 ± 52.9 g and 115.295 ± 22.4 g m $^{-2}$ day $^{-1}$ respectively. Station 1 collected the highest sediment compared to the other two stations (Fig. 3). The standard deviation calculated shows that sediment collected at Station 1 rate was highly variable. The difference between the highest and the lowest total sediment collected was high. The standard deviations for Station 1, 2 and 3 were 287.057 g m $^{-2}$ day $^{-1}$, 183.391 g m $^{-2}$ day $^{-1}$ and 77.224 g m $^{-2}$ day $^{-1}$ respectively. As Station 1 was closest to the river mouth, silt from run off during rainfall may be the main contributor to the variation. The further the station was from the river mouth, the lower the sample variability of the sediment collection.

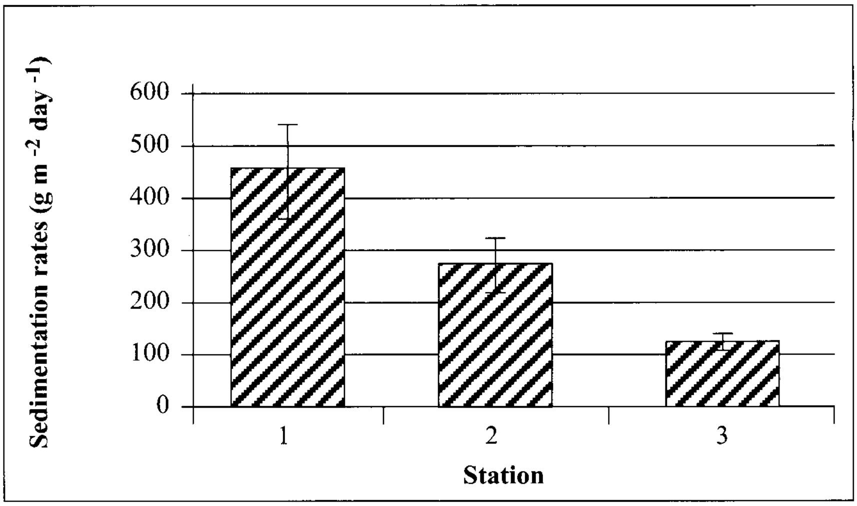

Figure 3 : Pooled mean sampling data showing the sedimentation rates at the three stations (1, 2 & 3 are sediment trap stations)

Temporal sedimentation collection

Samples were collected within four months in 1994, first sampling in January, second sampling in February, third and fourth in March and fifth and sixth in April (Fig. 4). Overall trend showed a decrease in sedimentation rate from the earliest to the end of the sampling period. The sedimentation trend coincided with the rainfall patterns of 1994 in which total monthly rainfall decreased from January to March and started to increase in April (Jabatan Kajicuaca Malaysia, 1994). This showed that the quantity of sediment collected was inversely related to the sediment trap distance from the river mouth.

Particle size

The sieved size range was selected according to Stoddart (1978b) who classified the particle sizes as very coarse sand, medium sand, fine sand and silt. The first class is particle size larger than 2 mm followed by those from 2 mm to larger than 710 μm, from 710 μm to larger than 212 μm, from 212 μm to larger than 63 μm and particle size of 63 μm and less. The particle size factor is crucial as it can be used to describe benthic sediment transportation, settlement and water current in that area. The results showed that Stations 1 and 2 have sediments with larger particle size than that of Station 3 (Fig. 5). Sample variances were high for bigger sediment sizes (medium sand and fine sand) found at Station 1 and 2.

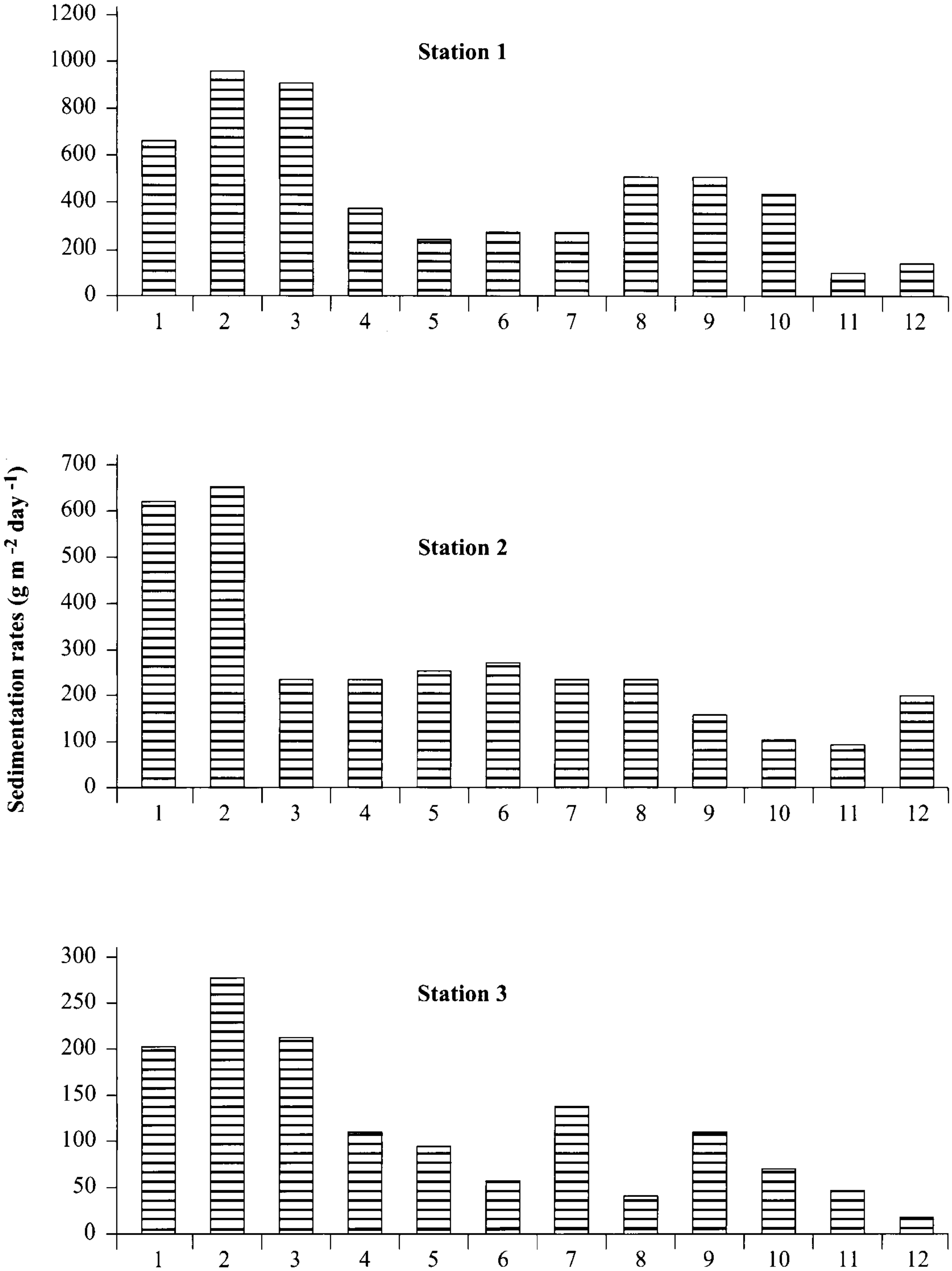

Figure 4 : The temporal sedimentation rates at the three sampling sites. Sampling time 1-3 (January), 4-5 (February), 6-9 (Mac) and 10-12 (April)

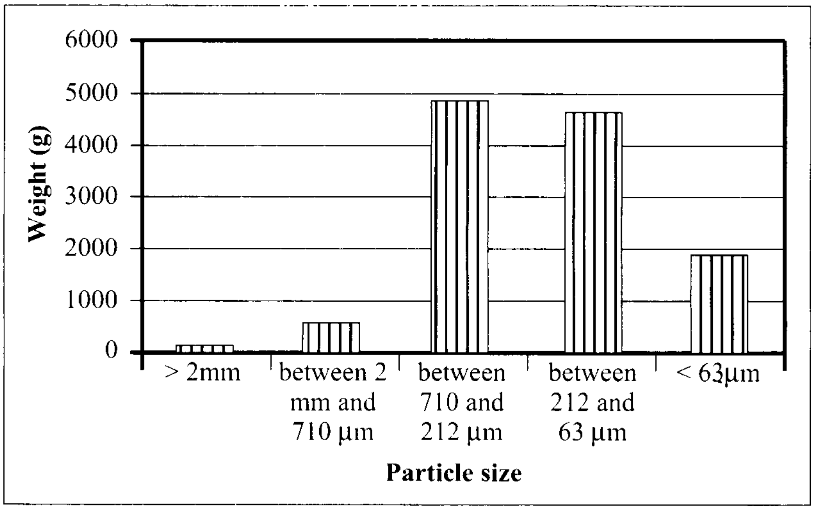

Figure 5 : Weight of sediment with different particle size collected at the stations

Discussion

From this study it was found that Station 1 collected the most sediment compared to the other two stations. Sedimentation rate was high in January, but low in February and March. However, this rate was found to increase in April. The constant river flow may be one of the factors contributing to the high sedimentation rate. This was supported by the lowest amount of total sediment collected at Station 3, the furthest from the river mouth.

Komar (1976) elaborated the relationship between sediment particle size and water current near beaches. The mean diameter of grains in beach sediments varies from boulders on exposed beaches to very fine sand on well protected beaches. In this study, sediment with particle size ranging from 710 to 63 µm (medium and fine sand) was observed to be the most dominant size. This indicated that Station 1 and 2 experienced stronger water current or wave movement. Sediment with smaller particle size takes longer time to settle as compared to the bigger ones of the same shape and material (Maiklem, 1968). Thus strong water movement at Station 1 and 2 inhibit the settlement of smaller particle size sediment and silt here. Water run off from the nearby river most probably disturbed the corals at the first two stations by limiting light penetration due to high sediment suspension, fresh water run off and additional nutrients from terrestrial erosion. Stronger water movement will also cause bedload transport of bottom sediment (Komar, 1976).

Lighter and smaller particle size sediment takes longer time and requires a calmer water condition to settle. This may be the reason why Station 3 collected more smaller particle size sediment as compared to the other two stations. But the effect of silt on this station was small and this may be due to the outward transport of suspended solid during tidal changes and long shore current movement. Thus, the corals here wasted less energy to clear sediment settling on them.

Water current velocity inside the reef flat was slower than the minimum speed (0.2 -0.3 ms^{-1}) needed to resuspend the settled sediment (Komar, 1976). So the most probable cause for sediment resuspension in the reef flat could be from wave action. Secondly the sediment which settled in the reef flat might be carried in by the stronger current from outside which when reaching the flat loses its energy and allow the sediment to settle. In the study area erosion by rainfall could be the cause contributing to the high level of suspended solid in the water which is then carried to the reef by the surface current. Other currents in the area for example longshore and tidal currents could be helping the reef in getting rid of the sediment by carrying it out of the reef area.

This study found that the most dominant particle size was between 63 μm and 710 μm. Stoddart (1978a) has classified this size range as coarse and fine sand. At the tidal zone, where splashing activity is active, the smaller particles do not have sufficient time to settle in the area as they will be resuspended again by wave action. Observation has shown that the bottom sediment shifting in the area of station 1 was active and this was proven by the concrete base sediment trap that was completely covered by sand after a few months of deployment. The quantity of sediment trapped which decreased from Stations 1 to 3 might be showing the effect of the proximity of the station to the river mouth which could be the source of sediment.

Sediment of smaller sizes (<63 μm) were seen to settle at the inner western side of the bay on the corals and killing them. Sediment settled on the corals became attached to the mucus membrane. The corals can clean off the attached sediment but they die off by wasting a lot off energy (Coffroth, 1988; Wahbeh & Mahansneh, 1988). The process of discarding the mucus membrane would cause the corals to loose 50% of their nitrogenous materials (Bythell, 1988).

At Station 1, the substrate (cobbles and bottom stones) were rounded, smooth and covered with algae. The rocks had silt and mud under the crevices and their upper surfaces were scoured by water current and thus appeared clean. Low silt coverage on the bottom substrate is an indicator of fast moving current (Komar, 1976) and this area might have a slightly faster water movement as compared to the other sites. Total suspended solid in the water was also observed to be high at Station 1 (0.038 ± 0.004 g l^{-1}). There is no absolute suspended solid level which can cause coral mortality because other factors, for example wave movement and water current, can minimise the effect of sedimentation on corals (Marshall and Orr, 1931; Motoda, 1939; Cortes and Risk, 1985). The most important effect of high sedimentation is that it minimises light penetration, which then causes the low photosynthetic activity in the corals. This factor limits the average depth where hermatyphic corals can be found. Sediment deposits on corals can cause mortality through suffocation, thus killing it (Chansang *et al.*, 1981).

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