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Dredge spoil disposal off Kavaratti island, Lakshadweep, India

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Maintenance dredging has been carried out along the navigational channel at Kavaratii Island and dredge spoil is disposed in the open sea. This paper describes the movement of sediment plume while dredging and disposal. The study indicates that for the present disposal location, the sediment plume settles down before reaching 50 m water depth, whereas shifting the disposal location to a distance of 1000 m from the reef, would cause the sediments to settle down before 200 m water depth. The study confirms that there is no settlement of dredge spoil in the lagoon bed or on the reef.

The Lakshadweep group is an archipelago of coral islands in the Arabian Sea, situated between the latitude 8°-12°N and longitude 71°-74°E. It consists of 36 islands, 12 atolls, 3 reefs and 5 submerged coral banks. Reef formations in the Lakshadweep are of the atoll type, generally elliptical in shape, not exceeding 10 km in the largest axis. These islands are encircled by fringing reefs with the formation of lagoon on the western side. Fringing reefs protect these small islands from the waves. The wave induced currents govern the sediment processes along the open coast and the tidal currents influence the lagoon beaches[1,2]. Earlier studies on this island focused to wave height distribution around the island and the characteristics of longshore currents[3,4].

In order to provide berthing facilities at Kavaratti Island, two jetties were constructed in the lagoon and maintenance dredging is being carried out every year from October to April along the navigational channel (Fig. 1). The dredge spoil is then transported and disposed in the deeper water outside the lagoon in open sea. The pattern of sediment movement on disposing in the sea is of concern to verify as to whether the disposal reaches the coral reef, which may eventually destroy the ecosystem[5,6]. In the present study, the movement of suspended material was monitored while dredging and disposal during October and April, covering the northeast monsoon and fair weather periods. The results obtained from the field study were compared with theoretical study.

Materials and Methods

The dredging of the navigational channel was carried out using Grab Dredger during the study period (October 1993 and April 1994). The dredge spoil is presently disposed at 200 m water depth, about 375 m away from the reef, on the northeastern side of the entrance channel (Fig. 1). Current measurements were carried out over two tidal cycles at 4 locations using self recording S4 current meter in October 1993 and April 1994. While the dredging was in progress, the sediment laden water samples were collected at mid depth at 30 locations. The collected water samples were filtered to quantify the suspended sediment load. The transport of sediment particles were estimated theoretically by the explicit finite difference method using basic convection-diffusion equation[7]:

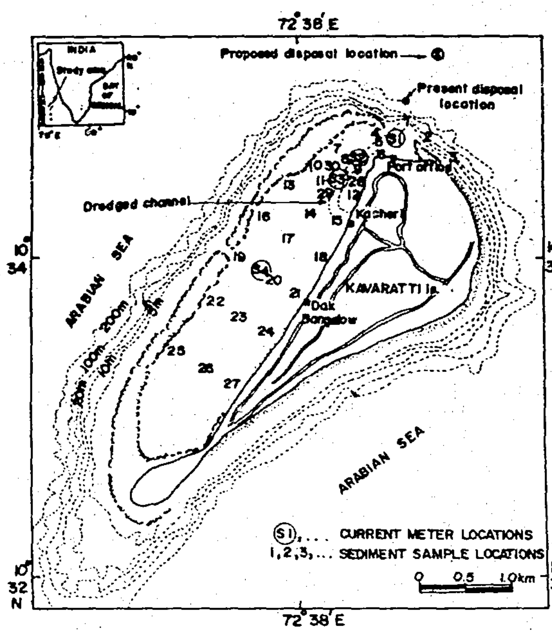


Fig. 1—Location map

$$W_{s,m}\, C+\varepsilon_{s,cw}\frac{dc}{dz}=0 \qquad \ldots (1)$$

$$c=0.015\,\rho_s\frac{d_{50}\,T^{1.5}}{a\,D_*^{0.3}} \qquad \ldots (2)$$

where, $W_{s,m}$ = particle fall velocity of suspended sediment in fluid-sediment mixture, W_s = particle fall velocity, $\varepsilon_{s,cw}$ = sediment mixing coefficient in combined waves and currents, ρ_s = sediment density, a = reference level, d_{50} = median particle diameter of bed material, T = bed shear stress parameter, D_* = particle diameter.

The estimation of current related bed and suspended load transports was followed from Rijn[7]. The total time averaged sediment transport rate in a current superimposed by waves were obtained by vector addition of the total current related transport rate and net wave related sediment transport rate. The terminal fall velocity (W_s) for non spherical particles was determined from the following formula:

$$W_s=\frac{10\,\nu}{d}\sqrt{1+\frac{0.01\,(s-1)\,gd^3}{\nu^2}}-1 \qquad \ldots (3)$$

where, d = sieve diameter, s = specific gravity and ν = coefficient of kinematic viscosity. Bed level changes are computed from the cross section integrated mass balance equation[8].

Results and Discussion

Variation of current speed and direction measured at 4 locations in October 1993 and April 1994 are shown in Fig. 2. At st 1, the current was towards 90° during the ebb tide, and 180° during the flood in October as well as in April. The ebb current was relatively stronger showing 0.15 m/s than the flood current, which is around 0.1 m/s. At st 2, the ebb tidal current dominated the flood current in October. The flood current was about 0.2 m/s and the ebb current was about 0.35 m/s. In April, the current was weak about 0.05 m/s, with the flood towards 270° and the ebb towards 100°. At st. 3, the current speed persisted around 0.2 m/s in October. In April, it was weak about 0.05 m/s with 190° during flood tide and 30° during ebb tide. At st. 4, the current was mostly unidirectional irrespective of the tidal phase in October and April. The flow was towards 310° in October and 30° in April. The current was weak with a consistent speed of about 0.07 m/s. The southern part of the lagoon is very shallow with weak currents less than 0.05 m/s. The study shows that though the currents are generally weak in the lagoon, it was relatively stronger in October (northeast monsoon) than in April (fair weather peri-

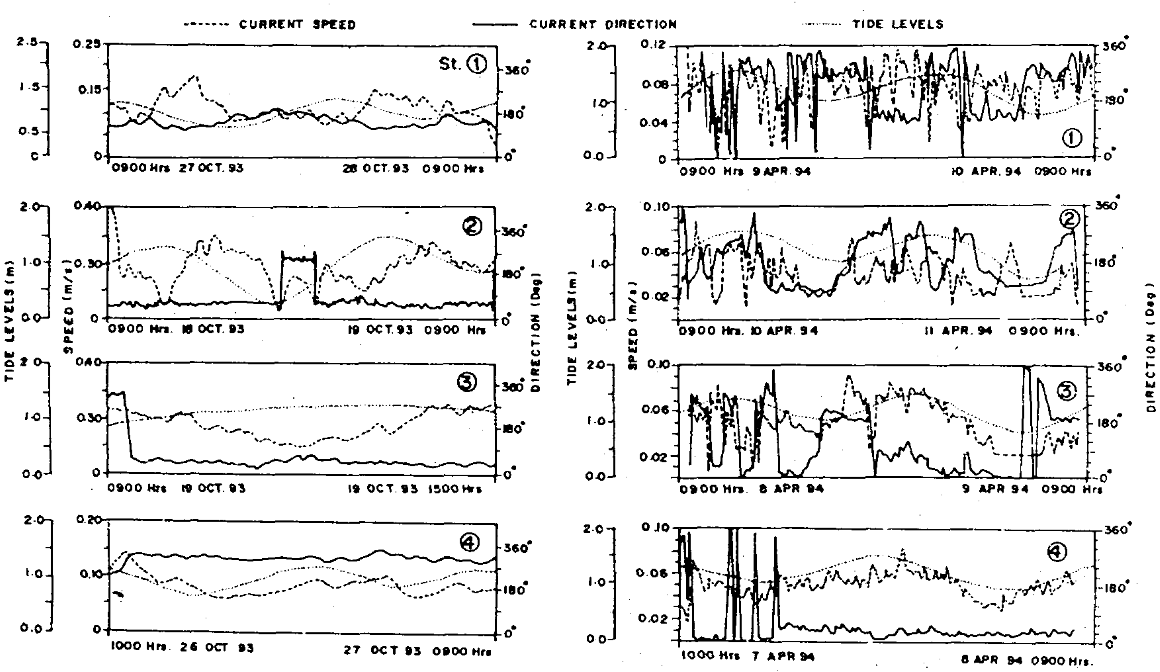


Fig. 2—Current characteristics in October and April

od). Due to the wave propagation over the submerged reef during the high tide and partial opening of the reef at the middle in the western side, the currents flowing out of the channel (ebb currents) dominates than the currents flowing in (flood currents).

Based on the water sample collected, the suspended sediment loads at 30 locations in October and April are shown in Table 1. When the water samples were collected, dredging in the channel was being done at st 28. In October, the suspended sediment load near the dredger was 184 mg/l (st. 28), whereas 5 m away from the dredger, at sts. 29 and 30, the sediment load was 1.5 mg/l and 5.74 mg/l respectively. Similar feature was also observed in April. The concentration shows that the distributed sediment plume while dredging moves predominantly northeast, agreeing with the current measurements. In October, along the channel, at sts. 8, 11 and 14, the sediment load was relatively higher, with 4.02, 7.96 and 6.09 mg/l respectively. At other locations the sediment load was around 1-2 mg/l. Due to weak currents, the sediment load was low around 1 mg/l at most of the places in April. Near the disposal location, at sts. 1-3, the sediment load was about 2 mg/l in October and 1 mg/l in April.

Table 1—Measured suspended sediment load

St No	Sediment load (mg/l)	
	October '93	April '94
1	1.72	1.12
2	2.21	1.02
3	2.48	1.04
4	1.34	1.00
5	1.37	1.07
6	2.04	0.90
7	1.62	1.06
8	4.02	1.05
9	1.34	0.97
10	1.29	0.92
11	7.96	1.01
12	1.34	1.01
13	1.19	0.91
14	6.09	1.18
15	1.87	1.21
16	1.22	1.76
17	2.15	1.34
18	2.40	1.53
19	0.26	1.66
20	1.50	1.63
21	0.92	2.05
22	1.09	1.02
23	1.29	1.05
24	1.32	1.14
25	1.68	1.05
26	1.12	1.01
27	1.77	1.08
28	184.74	101.05
29	1.50	1.01
30	5.74	4.06

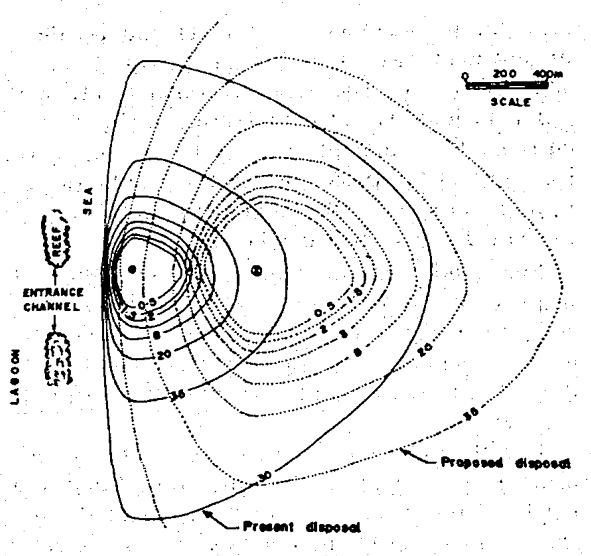
The study shows that while dredging, the suspended sediment load was relatively higher along the navigational channel than at other places in the vicinity. The disturbed sediments settle down fast to seabed within 10 m distance from the dredger.

The theoretical estimate of the sediment load using Eqs (1) and (2), for the transmitted wave height of 0.2 m and the tidal current of 0.1 m/s, shows that due to the combination of oscillatory waves and currents, the sediment load in the lagoon is negligible showing $<1\times10^{-6}$ mg/l. Further, the persistence of constant water depth over the years in the lagoon and the presence of only coral bed without sand on the southern part of the lagoon indicate that there is no settlement of sediment in the lagoon bed or on the reef.

For the sediment sample collected from the navigational channel at st. 28, the percentage fraction of different particle sizes and their fall velocity estimated using Eq. (3) are shown in Table 2. The mode of dredge spoil release is instantaneous and the location of disposal is at a distance about 375 m from the reef and at a water depth of about 200 m. The extent of spreading of disposed spoil sediments for the tidal currents of 0.08 m/s is shown in Fig. 3. It is seen that all sediments settle down within a distance of 100 m on the reef side and within 1500 m on the sea side. It is further estimated that when the current is in the order of 0.5 m/s, the disposed sediments deposit over a distance of 200 m on the reef side and 9000 m distance on the sea side. It indicates that

Table 2—Percentage fraction of different particle sizes and fall velocity

Particle size (mm)	Percentage fraction (%)	Fall velocity (m/s)
0.2	30.0	0.016
0.3	35.0	0.031
0.4	20.0	0.046
0.5	8.0	0.059
0.6	3.0	0.070
0.7	2.0	0.080
0.8	1.5	0.090
0.9	0.5	0.098



CONTOUR VALUES ARE THE PERCENTAGE OF SEDIMENT DEPOSITED
● PRESENT DISPOSAL LOCATION ● PROPOSED DISPOSAL LOCATION

Fig. 3—Spread of the dredge spoil

the disposed spoil migrating towards the reef, settles down to sea floor completely before 50 m water depth and hence the sediment approaching the reef is found to be remote.

In order to further improve the disposal condition, a location at a distance of 1000 m away from the reef, having a water depth 400 m was attempted. The spreading pattern of the disposed sediments for the tidal current of 0.08 m/s at the proposed location are shown in Fig. 3. This shows that all disposed sediments would settle down to seabed before 200 m water depth. This condition would considerably improve the environment and protect the coral system.

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References

1 Chandramohan P, Anand N M & Nayak B U, *Indian J Mar Sci*, 22 (1993) 198.
2 Prakash T N & Suchindan G K, in *Proc Indian National Conf on Harbour and Ocean Engg*, Central Water Power Research Station, Pune, India, 1 (1994) D-31.
3 Baba M, *Indian J Mar Sci*, 17 (1988) 330.
4 Kesava Das V, Varkey M J & Rama Raju D V, *Indian J Mar Sci*, 8 (1979) 211.
5 Wiilen de Lange & Terry Healy, *J Coastal Res*, 10 (1994) 946.
6 Hens R Moritz & Robert E Randall, *J Waterway, Port, Coastal & Ocean Engg Div*, 121 (1995) 36.
7 Rijn L C van, *Handbook of sediment transport by current and waves*, (Delft Hydraulics) 1990.
8 Rijn L C van, *Mathematical modeling of morphological processes in the case of suspended sediment transport* (Delft Hydraulics) 1987