



SEASONAL WAVE POWER DISTRIBUTION AROUND THE INDIAN COAST

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ABSTRACT

The ship reported wave data published in Indian Daily Weather Report were compiled for the period of 16 years from 1968 to 1983 for $5^\circ \times 5^\circ$ grids around the Indian coast. The distribution of wave power potential during the three different seasons viz. southwest monsoon, northeast monsoon and nonmonsoon periods were computed for various regions in the form of 10 grids and are presented here. The study shows that average annual wave power potential per metre length of the wave crest along the Indian coast vary between 11.4 KW to 15.2 KW. The highest potential of 15.2 KW was observed at grid 6 off south Kerala and southernmost region of Tamil Nadu coast. The minimum wave power of 11.4 KW was observed at grid 3 off Andhra coast. The seasonal distribution shows that the wave power potential is high during the southwest monsoon season constituting to about 55 to 65% of the total of the year.

1. INTRODUCTION

The recent energy crisis and depleting conventional sources of energy have brought an awakening need for scientific research for extracting power from the non-conventional energy resources of the ocean such as waves, tides, currents, temperature gradients, salinity gradients etc. India has a vast coastal zone with about 7000 Km long shoreline encompassed by Bay of Bengal in the east, Indian ocean in the south and Arabian sea in the west. The possibility of extraction of wave energy depends on the wave climate prevailing at a particular location. The wave power potential along the Indian coastline is quite substantial though it may vary from place to place and season to season. The oceanographic conditions around the Indian region is dominated by the three different seasons viz. southwest monsoon (June to September), northeast monsoon (October to January) and nonmonsoon (February to May). The feasibility of extraction of wave energy could be evaluated based on the prevailing wave climate and estimation of directional and seasonal distributions of wave power. Evaluation of wave power distribution around such a large continent needs reliable wave information. India has a vast coastal zone, but is lacking in reliable longterm data on waves. The wave height as well as directional information on waves have not been

measured on a long-term basis for realistic estimation of the directional distribution of wave power. Hence, in the absence of such instrumentally recorded waves, it would be useful to study the historical wave data as reported from the ship observations.

2. METHOD OF STUDY

The regions around the Indian coast have been divided into 10 grids each of 5° latitude \times 5° longitude as shown in fig.1. The swell data published in Indian Daily Weather Report for the period of 16 years from 1968 to 1983 were compiled for each grid. These visually reported wave heights have been treated as the significant wave heights H_s and the periods as the zero crossing wave period T_z (Shore Protection Manual, 1975).

For a regular first order sinusoidal wave trains, the energy E per unit area is equal to (Panicker, 1976),

$$E = \rho g H_{rms}^2 / 8 \quad (1)$$

where,

E = Energy in Joules/m²

ρ = Sea water density (1025 Kg/m³)

g = Gravitational constant (9.81 m/sec²)

H_{rms} = Root mean square wave height in m.

The wave power which is the flux of wave energy per unit crest length is given by,

$$P = E.Cg \quad (2)$$

In deep water,

$$P = \left(\rho g H^2_{rms} / 8 \right) (gT/2\pi) \\ = 0.980 H^2_{rms} T \quad \text{KW/m} \quad (3)$$

For a fairly narrow band spectrum of waves, the significant wave,

$$H_s = 1.414 H_{rms} \quad (4)$$

Using equation(4) in (3),

$$P = 0.490 H^2_s T \quad \text{KW/m} \quad (5)$$

where,

H_s = Significant wave height in m

T = Wave period in sec.

3. RESULTS AND DISCUSSION

3.1 Annual distribution

The average annual wave power potential per metre length of wave crest computed for each grid is shown in Table 1. It shows that the wave power potential along the Indian coast vary between 11.4 KW to 15.2 KW. The wave power potential calculations show that the wave power of about 15.2 KW is available in grid 6 followed by 14.6 KW in grid 5, 14.5 KW in grid 7, 13.8 KW in grids 1 and 2, 13.2 KW in grid 9, 12.5 KW in grid 4, 12.4 KW in grid 10, 11.7 KW in grid 8 and 11.4 KW in grid 3.

The above values indicate that the southern most regions of the Indian peninsula namely at grids 5, 6 and 7 have comparatively higher wave power potential, owing to the fact that these regions are more exposed to the Indian ocean. Among the remaining grids, the grids 1 and 2 receive comparatively high power which could be obvious that these regions form along the convergence zone of the funnel shaped Bay of Bengal. The middle parts of the east and west coasts (grid 3 and 8) derive less wave power compared to the remaining part of the Indian coast.

Narasimha Rao and Sundar (1982) reported that a wave power potential of about 20 KW as an annual average in grid 3 as maximum compared to the other grids in Bay of Bengal. The method employed in their study was very approximate since the wave power was computed using a single representative value as the average wave height and period for each of the southwest, northeast and nonmonsoon seasons. Further, these values were computed based on 6 years of ship data from 1968 to 1973 and the ship reported wave heights were treated as root mean square wave height (H_{rms}) rather than signi-

ficant wave height (H_s).

A similar computation from ship reported data compiled for only 6 years from 1968 to 1973 have been made (Anonymous, 1981) which showed an average wave power of about 23.1 KW, 22.9 KW, 21.4 KW, 24.2 KW, 20.7 KW and 25.1 KW for grids 1,3,4,6,8 and 9 respectively. Here again a single average wave height and period for each month has arrived at and used in the estimation of wave power potential.

3.2 Seasonal distribution

The average wave power potential per meter length of wave crest during the southwest monsoon season (June to September), northeast monsoon (October to January) and nonmonsoon season (February to May) in different grids are shown in Table 2. It shows that in general the wave power potential is high during the southwest monsoon (June to September) than the remaining period of the year. During this season, a maximum wave power of about 26.5 KW is observed at grids 6 and 7 and a minimum of about 16.3 KW is observed at grid 4. The grids (1 to 4) in Bay of Bengal contribute 55 per cent of the total wave power in a year during the southwest monsoon whereas the grids (7 to 10) in Arabian sea seem to contribute about 65 per cent of the total wave power in a year.

The average wave power potential during the north east monsoon (October to January) is less when compared to that of the southwest monsoon. The grid 4 constitutes about 13 KW during northeast monsoon being the highest among all grids. The general pattern shows that during the northeast monsoon the regions along the Bay of Bengal indicate large wave power potential of about 25 per cent of the total in a year whereas those regions along the Arabian Sea indicate 17 per cent of the total wave power potential of the year.

The wave power potential during the nonmonsoon season (February to May) is about 20 per cent of the total in a year in all grids except at grid 1 and 5 where it is 31 per cent and 26 per cent respectively.

The above estimation indicates that the wave activities are higher during the southwest monsoon all along the Indian shoreline. Though the wave activities are comparatively less during the rest of the year, Bay of Bengal is subjected to higher wave activity during the northeast monsoon period. The frequent occurrence of cyclones in the Bay

of Bengal during the northeast monsoon period would further increase wave activities along this region, though for a shorter period.

4. CONCLUSION

The average wave power potential around the Indian coast estimated in the present study is based on the ship reported visual observations which has its inherent limitation. The instrumentally recorded wave data over a long period of time can lead to a more realistic estimate on the wave power potential at a given location. However, in the absence of longterm instrumental data on waves, the present study based on the ship reported data would give a better overall picture of the wave climate and the prevailing wave power potential along the Indian coast.

The study indicates that along the Indian coast, the wave power potential vary between 11.4 KW to 15.2 KW. The highest potential of 15.2 KW prevails in grid 6, for the region off south Kerala and southernmost region of Tamil Nadu. The grid 3 off Andhra coast shows a minimum wave power potential of about 11.4 KW. The seasonal distribution shows that the wave power potential is high during southwest monsoon period contributing to around 55 to 65 percent of the total available power per year.

Table 1: Annual Average Wave Power per Metre Crest length

Grid	Wave Power (KW)
1	13.8
2	13.8
3	11.4
4	12.5
5	14.6
6	15.2
7	14.5
8	11.7
9	13.2
10	12.4

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NOTATIONS

- C_g = Group velocity
 E = Wave energy
 g = Acceleration due to gravity
 H_{rms} = Root mean square wave height
 H_s = Significant wave height
 P = Wave power
 T = Wave period
 ρ = Sea water density

Table 2: Seasonal Wave Power Distribution

Grid	Average wave power in KW/m crest length		
	SW monsoon (June-Sept.)	NE monsoon (Oct. -Jan.)	Nonmonsoon (Feb.-May)
1	21.5	7.0	12.9
2	22.9	9.9	8.7
3	18.4	9.0	6.9
4	16.3	12.9	8.3
5	20.4	12.0	11.3
6	26.5	10.0	9.1
7	26.9	8.1	8.5
8	22.9	5.9	6.3
9	22.1	5.9	6.5
10	24.2	5.7	7.3

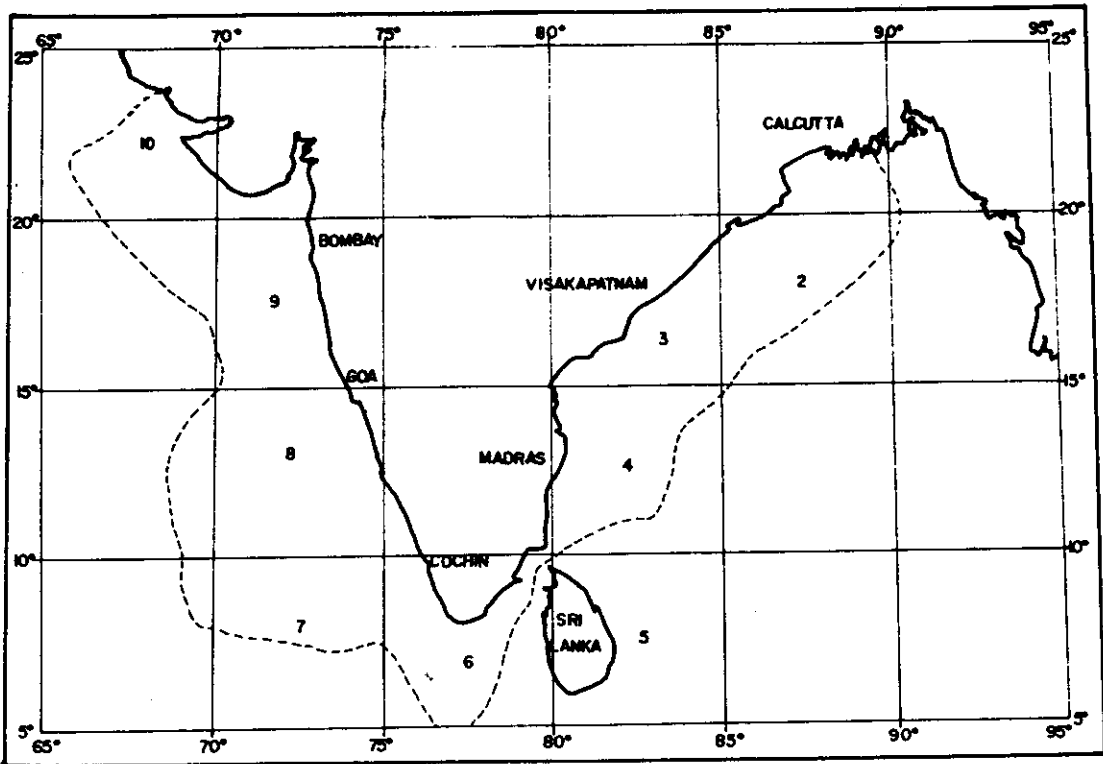


Fig.1 LOCATION MAP