

Wave Power Potential along the Indian Coasts

V. KESAVA DAS, B.A. RAMESH AND M. J. VARKEY

National Institute of Oceanography,

Wave power potential along the Indian coasts has been estimated using the wave data published by the India Meteorological Department. The coast line is divided into 6 zones and wave power has been computed and presented month-wise for each zone. The estimated wave power varies seasonally and geographically from 1.2 to 39.6 kw/m with an average of 9.4 kw/m. The largest wave power potential occurs along the Konkan coast in July. The southwest monsoon period (May-September) offers a greater potential all along the coast with a mean of about 15.5 kw/m. Some of the problems and prospects of energy conversion have also been discussed.

THE EVER INCREASING DEMAND FOR ENERGY accompanying the growth of population and living standard, and the awareness of the exhaustible nature of the conventional energy resources are sufficient reasons to search for alternate and renewable energy sources. One such energy source is the wave energy available in the sea. Wave power potentials on a global scale were estimated by Kinsman⁽¹⁾, Isaacs & Seymour⁽²⁾, and Panicker⁽³⁾. The estimated wave power is of the order of 10^{14} watts and is renewable at the rate of 10^{12} to 10^{11} watts⁽⁴⁾. Panicker⁽³⁾ estimated the wave energy dissipation rate along the coastlines of the world as about 2.6×10^{12} watts which is comparable with those of Isaacs & Seymour⁽²⁾ (2.5×10^{12} watts) and Kinsman⁽¹⁾ (2.2×10^{12} watts). Several power devices have been designed and tested in countries like U.K., Japan, U.S.A. but so far no

commercial scale plant has come into existence⁽⁵⁾.

Since India has a long coastline of about 5700 km, it is worthwhile to explore the potential available along the coastline. Here, an attempt has been made to evaluate the wave power potential along the Indian coastline. Some of the problems and prospects of harnessing this energy source have also been discussed in relation to environmental factors.

DATA AND METHODS:

Wave data (visual observations by ships of opportunity) published in the Indian daily weather reports have been used in this study. Data for a period of six years (1968-1973) have been compiled and pooled together. The Indian coastline has been divided into 6 zones (Fig. 1) for the purpose of computation as the wave characteristics vary from

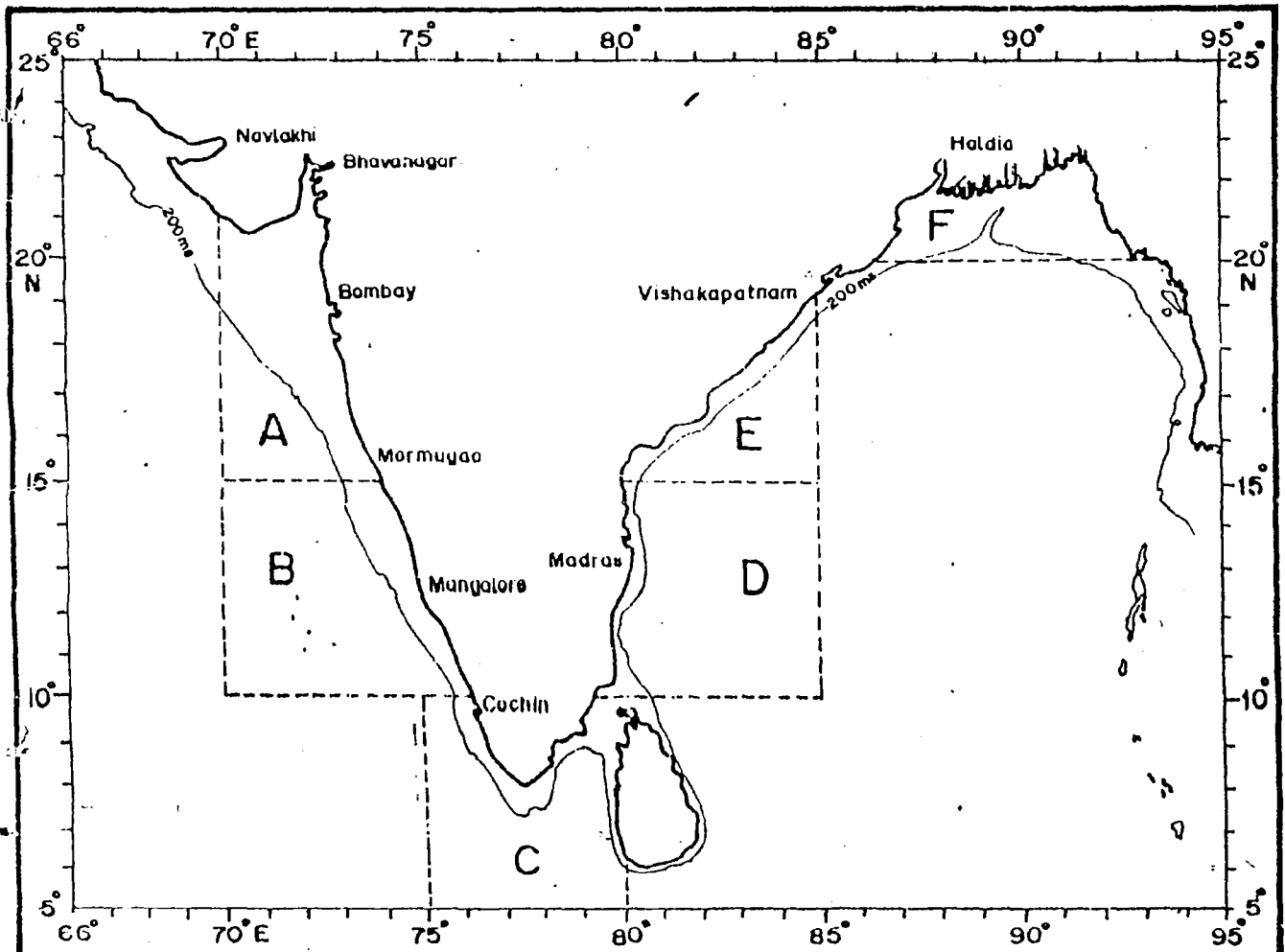


Fig 1: Map showing different zones

Table 1 - Wave Statistics for Different Zones

Zone	Ha(m)	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
A	T (sec)	5.6	6.9	6.6	6.9	7.7	7.9	7.6	7.5	7.8	6.5	7.3	6.4
	Hs	1.19	1.24	0.82	0.71	1.31	2.15	2.66	2.16	1.52	1.12	1.02	1.22
B	T	7.4	6.7	6.8	6.3	7.5	7.6	7.8	7.5	7.2	7.4	6.9	7.4
	Hs	1.68	1.10	1.03	1.24	1.84	2.25	2.18	2.03	1.67	1.41	1.33	1.47
C	T	6.7	7.5	7.8	7.3	6.9	7.6	7.6	7.6	7.4	7.4	7.7	7.1
	Hs	1.23	1.13	0.93	1.0	1.71	2.13	1.98	1.85	1.53	1.50	1.74	2.01
D	T	7.8	8.2	7.8	7.3	7.4	7.5	7.7	7.5	7.4	7.2	7.4	7.1
	Hs	0.93	0.67	0.88	1.13	1.73	2.0	2.24	2.07	1.55	1.38	1.72	1.36
E	T	9.5	7.7	6.2	5.9	7.6	8.8	7.1	7.7	7.8	7.4	6.7	6.2
	Hs	0.71	0.7	1.0	1.62	2.12	1.85	1.85	2.13	2.0	1.25	0.91	0.67
F	T	5.0	5.8	6.7	9.6	6.5	7.1	7.9	7.5	8.2	8.2	6.9	8.4

Table 2 - Wave Power (kw/m)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
A	3.02	3.73	3.91	4.47	6.98	26.77	39.57	24.84	10.03	2.69	3.58	4.74
B	5.13	5.05	2.24	1.56	6.31	17.21	27.04	17.14	8.15	4.55	3.52	5.40
C	9.26	4.45	4.05	5.50	11.44	18.85	17.69	15.34	10.11	7.21	6.67	7.52
D	5.78	5.13	3.30	3.58	10.60	16.67	14.79	12.57	8.49	7.94	10.98	14.05
E	4.03	1.69	2.35	3.69	11.14	17.24	17.45	16.16	9.18	6.90	9.71	5.62
F	1.24	1.39	3.28	12.34	14.31	11.90	13.24	16.67	16.07	6.28	2.80	1.85

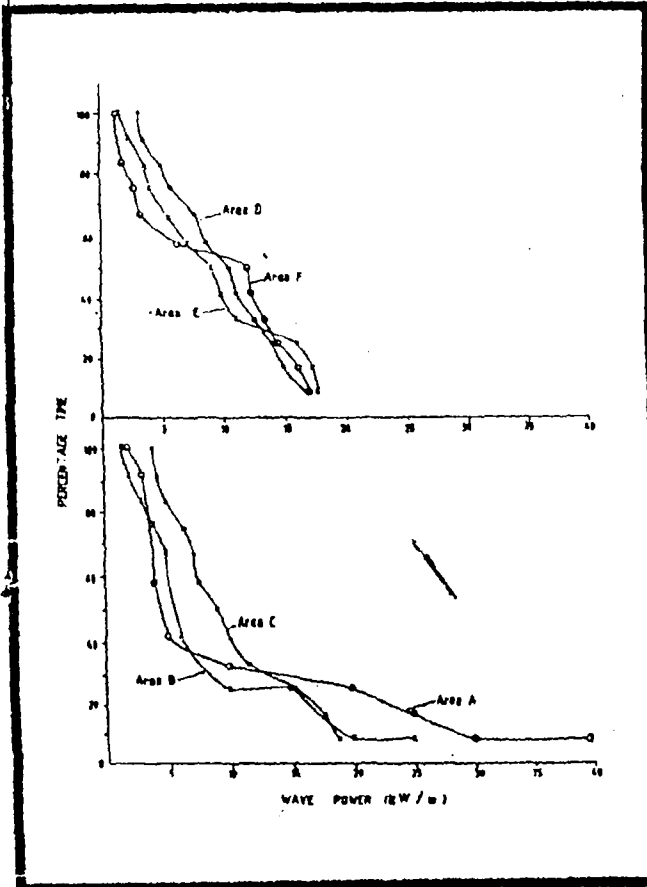


Fig. 2. Percentage of time Vs wave power potential

place to place. The wave power has been estimated month-wise for each area using the formula⁽¹⁻⁴⁾,

$$P = \frac{\gamma g H_s^3 T}{64 \pi}$$

where P is the power per metre of crest width, γ is the specific weight of sea water in Newtons, g is the acceleration due to gravity, H_s is the significant wave height, (m) and T is the period (sec.).

Significant wave height (H_s) and period T were calculated month-wise for each area. H_s for an area was calculated as the average of the wave heights reported for that area in a particular month as the visually observed wave heights have been considered as equivalent to the significant wave height. Average of all periods reported in that area is taken as T. The data mainly represent deep water waves. A casual comparison of monthly mean of visually observed data with the H_s computed from the data recorded by the shipborne wave recorder in certain areas (not simultaneously observed) reveal that the two are rather comparable.

Results and Discussion

Table 1 gives monthly average of H_s and T and Table 2 gives the wave power (kw/m) for each area. It can be seen from these Tables that the wave characteristics and wave power vary from region to region. The wave power varies from 1.24 kw/m in area F to 39.57 kw/m in area A with an annual average for all the areas of 9.39 kw/m. The wave power varies from 2.69 (October) to 39.57 kw/m (July) in area A, from 1.56 (April) to 27.04 kw/m (July) in area B, from 4.05 (March) to 18.85 kw/m (June) in area C, from 3.30 (March) to 16.67 kw/m (June) in area D, from 1.69 (February) to 17.45 kw/m (July) in area E and from 1.24 (January) to 16.67 kw/m (August) in area F. It can be noticed that the wave power is greater in southwest monsoon period (May to September) than the rest of the year. Average wave

power in the southwest monsoon for all areas is about 15.5 kw/m which is 3 times greater than that of the non-monsoon period. It is emphasized here that the estimates have to be considered with caution as the data is based on visual observations. However, these figures are rather comparable with those estimated by Gopinathan et al⁽⁹⁾ for the months of August and September, 1978 in areas B, C and D, based on wave data recorded by a shipborne wave recorder.

Taking the average wave power potential along the Indian coastline at about 9.4 kw/m and the total length of the coastline as 5700 km, the total power potential at a given time is estimated to be about 5.36×10^7 kw all along the entire coastline. Even after allowing for a 75% loss of energy (may be much less in reality) due to inefficiency in conversion and transmission, the net average power would be about 13.4 GW and if it is possible to deploy power extraction devices at least for 1% of the coast length (57 km), the available power is about 134 MW.

The availability of wave power in terms of percentage of time for all the regions is shown in Fig. 2. It gives an estimate of the percentage of time, a power plant can operate in an area with its optimum capacity as designed. For example, if a plant is designed to extract power from the potential of 10 KW/m, then it can be operated only for 33% of the time in the year in area A, and 50% of the time in the year in area D and so on.

Energy Conversion Considerations

It is seen from Table-2 that the wave power potential varies considerably from month to month and place to place due to the varying wave climate. This aspect has to be seriously taken into consideration before going in for exploitation. However, it is very much required to estimate the wave power more realistically and for reduced grid sizes using recorded data. Unfortunately, recorded wave data for all the regions along the coast and for all months are not available at present.

It is worthwhile to mention that waves in deep water possess energy of an order of magnitude greater than that of waves in shallow water because the dispersive and shoaling processes such as refraction, reflection, diffraction, etc. reduce the energy of waves by the time they reach the coast. Therefore, from the resource point of view, it may be more feasible to have wave energy conversion in deep waters than coastal waters. However, the economics of wave energy conversion depends much on the efficiency of the system, its construction and

maintenance cost, transmission capability and environmental impacts, apart from the magnitude and dependability of the resource.

The environmental aspects to be mainly considered are the effects on coastal, littoral and shore line processes, sea life, navigation and perhaps, aesthetics. Deep water devices may pose least environmental problems although it may affect the sea life in surface layers. Shallow water devices are likely to affect the littoral processes and change the shore line structure. The environmental effects may be beneficial in some cases. For example, where coastal erosion problem exists, the wave power devices can perform dual roles of producing power and protecting the coast by extracting the energy from waves which cause erosion. In India, this may be considered as an option especially during southwest monsoon when the wave energy potential is more and for the same reason, eroding potentials are more at different places along the coast. □

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The Authors:

V.Kesava Das is at present working as managing Editor of Mahasagar - a quarterly journal published by National Institute of Oceanography

M.J.Varkey is a physical oceanographer. He specialises in wind generated waves in the sea.

B.A.Ramesh was attached to NIO as a scientist working in Ocean Engineering aspects during the presentation of the present paper.

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