Estimation of Solar Radiation from Sunshine Hours in Dacca, Bangladesh*

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ABSTRACT

Solar radiation and sunshine hours data of the Dacca area are analysed. An attempt is made to relate monthly mean daily total horizontal radiation with the extra-terrestrial daily horizontal radiation and mean fraction of daily possible sunshine hours by a regression equation. Good correlation is found. The equation is used to estimate the radiation for a few months whose data are not used to compute the regression coefficient and the resulting estimated values are seen to be in reasonably good agreement with the actual values.

INTRODUCTION

Adequate information about solar radiation is necessary for the design and estimation of the performance of any solar energy device. The meteorological stations spread all over Bangladesh record sunshine hours and other meteorological data, but they do not have the facilities for the measurement of solar insolation. In the past solar radiation was measured at the campus of the BangladeshUniversity of Engineering and Technology in Dacca as and when required to carry out experiments with solar devices. No effort was ever made for continuous recording of insolation by any organisation except the Bangladesh Rice Research Institute (BRRI) which started collecting the data in 1974 at Joydevpur near Dacca (latitude = 23° 43′N). As sunshine duration is always the best parameter to use to estimate insolation (1-3), and as it has been recorded by Meteorological stations at many places for many years, an attempt is made in this paper to establish a relationship between solar insolation and sunshine hours using the data collected from BRRI (4). The relationship may be used to obtain rough estimates of solar radiation which would reasonably serve as starting points in solar equipment design for any location of interest in Bangladesh.

RADIATION DATA, ESTIMATION EQUATION AND DISCUSSION

The monthly mean values of daily total (beam + diffuse) radiation on a horizontal surface for the months of the last five years (1975-1979) are considered. Yearly variation in the means is shown in Figs. 1 and 2. The widest variation is found in the month of September whereas the smallest is in the month of March. The unpredictable monsoon weather during the months of June to September has a considerable effect on solar radiation. Although the sun is almost overhead at noon time during the whole month of June in Dacca, the highest of both the maximum and minimum insolation values occurs in the month of April indicating the effect of the onset of the monsoon around June. In general more radiation is received during the first half of the year.

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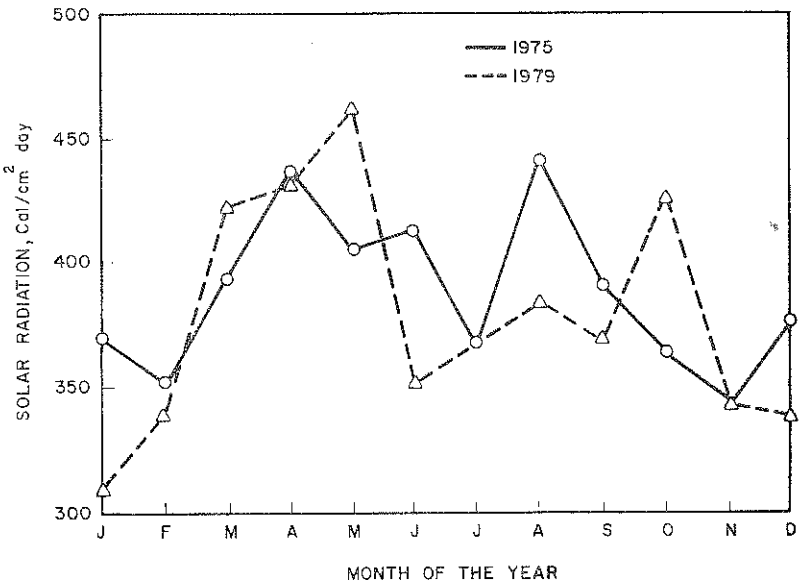

Fig. 1. Monthly mean daily total horizontal radiation for the year 1975 and 1979

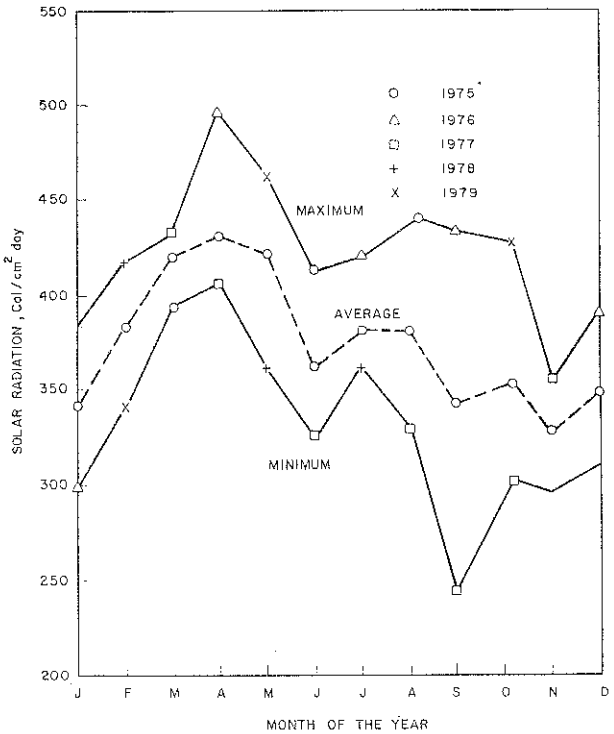

Fig. 2. Yearly variation of monthly mean daily total horizontal radiation

A least squares analysis based on a linear regression equation is carried out to relate the mean daily total radiation with the mean daily sunshine hours. The equation is of the following form:

$$H/H_o = a + bn/N, \tag{1}$$

where H is the monthly mean daily total horizontal radiation, H_o is the extra-terrestrial daily horizontal radiation calculated at the middle of the month in question, n is the monthly mean daily sunshine hours, N is the maximum possible daily sunshine hours calculated at the middle of the month in question and a, b are constants determined by least squares analysis of reported data. The results are shown in Table 1.

Table 1. Values of a and b

Year	100 H/H_o		100 n/N		a	b
	Range	Average	Range	Average		
1975	39 - 68 (Jul) (Dec)	51	34 - 90 (Jul) (Dec)	66	0.24	0.41
1976	41 - 71 (June) (Dec)	52	35 - 86 (June) (Jan)	65	0.26	0.40
1977	30 - 61 (Sept) (Dec)	46	24 - 82 (June) (Dec)	55	0.23	0.43
1978	34 - 66 (June) (Jan)	48	36 - 89 (June) Dec)	63	0.17	0.48
1979	37 - 61 (June) (Dec)	50	35 - 83 (June) (Jan)	66	0.24	0.39
1975-1979	38 - 63 (June) (Dec)	49	37 - 86 (Jul) (Dec)	64	0.21	0.44

It is seen that for equations covering yearly data, the constants, a and b, vary from year to year. The data for the five years considered together yield $a = 0.21$ and $b = 0.44$. Therefore, the monthly averages of daily total solar radiation on a horizontal surface in Dacca may be estimated by the following equation:

$$H/H_o = 0.21 + 0.44\, n/N. \tag{2}$$

The calculated values of H_o and N are given in Table 2.

The correlation coefficient and the standard error of estimate are found to be 0.979 and 0.019 respectively. Equation (2) has been used to estimate the radiation for a few months of 1980 whose data have not been used to compute the regression coefficient. The resulting estimated radiation values are found to be within about $\pm$ 10% of the actual values.

Table 2. Values of H_o and N for Dacca calculated at the middle of the month

Month	H_o cal/cm^2 per day	N hours
January	582	10.7
February	678	11.2
March	795	11.9
April	891	12.6
May	940	13.2
June	953	13.5
July	944	13.3
August	905	12.8
September	825	12.1
October	710	11.4
November	603	10.8
December	551	10.5

CONCLUSION

Rough estimates of solar radiation in Dacca area can be obtained by equation (2) from the knowledge of sunshine hours. Better correlation could be obtained if the data for many more years were available. As at present solar radiation is not measured in other areas of Bangladesh and as it lies between a narrow range of latitude (20°30′N - 26°45′N) having almost the same terrain, climate and vegetation, the equation can be used by the solar device designers and users in those areas as well. It may also be used for those locations in the world which are similar to Bangladesh.

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