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Estimation of Diffuse Solar radiation on Horizontal Surface at Quetta, Pakistan

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Abstract

Estimation of monthly average daily diffuse solar radiation for the period of 1999 – 2004 is estimated. Diffuse components of solar radiation are estimated. The empirical relationship of Klein is found to be justified.

Keywords: Solar Radiation; Variability; Extraterrestrial Radiation

Introduction

Estimation of monthly average daily diffuse solar radiation as a function of clearness index has been obtained for Quetta. Data for diffuse solar radiation is not available in Pakistan. Therefore, in the absence of measured diffuse data, some methods are suggested. Using the proposed correlations, we observed from the figure that diffuse radiations estimated are good agreement with the Page's correlation.

For the prediction of monthly average diffuse radiation of a horizontal surface, two methods have been described:

i. Monthly average diffuse radiation expressed in terms of the fraction of the maximum possible sunshine hours.

ii. Monthly average diffuse radiation, expressed in terms of cloudiness index. The global solar radiation comprises of two main components, namely direct and diffuse radiations. Diffuse solar radiation depends upon the evaluation of place and its latitude, the solar altitude, the sun's declination, the degree of turbidity, the amount of water vapour present in the atmosphere and cloudiness. Variability in the amount and type of cloud cover is the major factor in determining the ratio of diffuse component of the global radiation at particular places important for the design and the assessment of solar energy systems. Therefore, in the absence of measured data, methods were suggested to estimate the diffuse components of the total horizontal radiation. To obtain a rough estimate of monthly average daily diffuse radiation for Quetta (Pakistan), I.A. Raja et al. [1] considered a nearby station in Tehran (Iran) where the diffuse radiation is recorded. They computed the monthly average daily diffuse radiation from sunshine hours on the horizontal surface both for Tehran and Quetta. However, their estimates show scattering in the data. In this paper, we have estimated monthly average dairy diffuse solar radiation from clearness index both on horizontal and inclined surfaces.

Data Used

The data for different locations are recorded in the department of Physics, University of Balochistan, Quetta, Pakistan. The data represents the monthly average daily solar radiation for a period of five years i.e., 1999 – 2004.

Method of Estimation

Data for diffuse solar radiation is not available in Pakistan. Therefore, in the absence of measured diffuse data, the following correlations are used for estimating the monthly mean daily diffuse solar radiation on horizontal surface.

i. Monthly average diffuse radiation, exposed in terms of the fraction of maximum possible sunshine hours and using extraterrestrial radiation relationship by Iqbal is,

$$H_d / H = 0.163 + 0.478 (n / N_d) - 0.655 \quad (n/N_d)^2 \text{ ----------(1)}$$

where Nd is day length in hours and n is the time of bright sunshine hours.

ii. Monthly average diffuse radiation, expressed in terms of cloudiness index Kt = H / Ho. This relation was developed by Klein.

$$H_d / H = 1.390 - 4.027K_t + 5.531(K_t)^2 - 3.108 (K_t)^3 \text{ ----------(2)}$$

iii. Page developed a correlation between daily global radiation and its diffuse component for location between 400N and 400S and suggested the following relationship.

$H_d / H = 1.00 - 1.13 K_t$ ----------(3)

The same parameters are suggested by Iqbal in his correlation:

$H_d / H = 0.958 – 0.982 K_t$ ----------(4)

Results and Discussion

For the prediction of monthly average diffuse radiation, i.e., on a horizontal surface, two different types of correlations exist:

a. Monthly average diffuse radiation, exposed in terms of the fraction of maximum possible sunshine hours and using extra-terrestrial radiation relationship by Iqbal [2] is,

$H_d / H = 0.163 + 0.478 (n / N_d) - 0.655 (n/N_d)^2$ ----------(5)

where Nd is day length in hours and is the time of bright sunshine hours.

b. Monthly average diffuse radiation, expressed in terms of cloudiness index $Kt = H / H_o$. This relation is developed by Klien [3].

$H_d / H = 1.390 - 4.027K_t + 5.531(K_t)^2 - 3.108 (K_t)^3$ ----------(6)

Many authors [4-8] have treated the estimation of monthly average diffuse radiation as a function of clearness index but the most commonly used correlations are by Page [9] and Iqbal [10].

c. Page [9] developed a correlation between daily global radiation and its diffuse component for location between 400N and 400S and suggested the following relationship.

$H_d / H = 1.00 - 1.13 K_t$ ----------(7)

The same parameters are suggested by Iqbal [10] in his correlation:

$H_d / H = 0.958 – 0.982 K_t$ ----------(8)

The knowledge of horizontal global radiation is required to predict the efficiency and performance of a solar collector. A solar collector absorbs solar radiation for various orientations with respect to horizontal positions. The orientation of the collector would indeed depend on latitude, declination angle and on solar tracking mechanism. In this paper, we have over tracking mechanism. In this paper, we have over simplified the problem by only considering the geometrical orientation which is indeed helpful and beneficial in designing green houses, solar collector sees scattered and reflected radiations from the ground.

Quetta is situated at latitude 350 68^0N and latitude 1799m [11,12]. The variation of diffuse solar radiation on horizontal surface at Quetta is shown in (Figure 1). Monthly average daily diffuse radiations for Quetta are computed by using expressions 2,3 and 4. From the Figure it is obvious that there is an agreement in the estimate values obtained by Klien [3], Page [9] and Iqbal [10], and that two peaks for diffuse component of solar radiations on horizontal surface are observed. The profile of the peak is more pronounced during months of April and August.

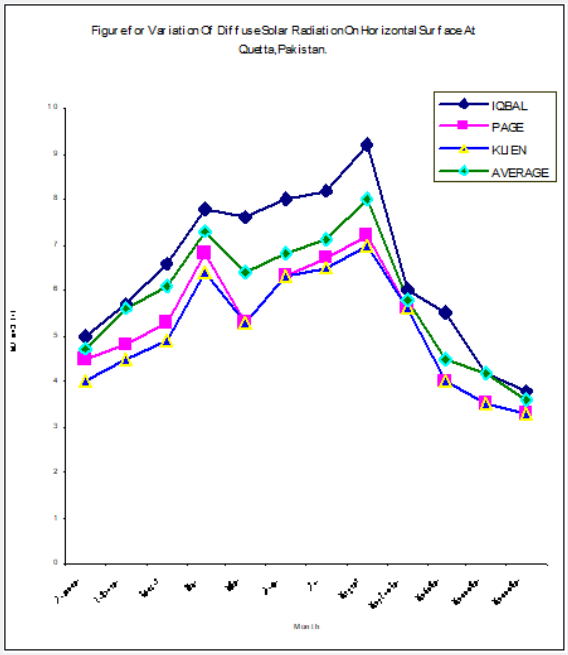

Figure 1: Variation of Diffuse Solar Radiation on Horizontal Surface at Quetta, Pakistan.

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Conclusion

We infer the following conclusions:

i. The correlation proposed by Liu and Jordan and developed by Klien for an estimate of monthly daily diffuse radiation is found better.

ii. The correlations proposed by Page [9] are in good agreements with Klien[3].

iii. Estimation from clearness index for monthly daily diffuse radiation is more reliable for Quetta.

iv. In order to establish reliable correlation, measurements of diffuse radiation over a long period are required.

Nomenclature

H Daily global radiation on horizontal surface.

H_d Diffuse radiation incident on horizontal surface.

Kt Clearness index.

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