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# Monthly Mean Solar Radiation by using Ambient Temperature for Tilted Wick Type Solar Still

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**ABSTRACT:** Solar energy is an effective and non-conventional source of energy which is inexhaustible and can be used both directly and indirectly. The availability of solar radiation in the location of interest is indispensable for the development of any solar energy system. Pyranometer and Pyrhemometer are being used to record the amount of global and direct solar radiation. However, installations of the devices are limited due to day-to-day recording and maintenance, which is both a tedious and an expensive exercise. An alternate approach will be to correlate global solar radiation with meteorological parameters, where the data is available. Also, the simulation of solar thermal devices at various locations is necessary for large-scale installations with a better performance.

**KEYWORDS:** -Solar Energy, Solar Radiation, Ambient Temperature

## I. INTRODUCTION

The use of energy is divided among four economic sectors viz., residential, commercial, transportation and industrial. The sectors in the society consume large amounts of energy in the form of light, heat, electrical, mechanical and chemical etc. Also the development of socio-economic-political civilization is closely linked with the availability of energy in more useful forms. Most of the energy is ultimately generated by the combustion of natural resources such as fossil fuels, petroleum, and natural gas. Both increasing levels of energy consumption concern has risen about the depletion of natural resources to produce energy and will be exhausted in the near future. Further the combustion of these fuels releases various pollutants, such as carbon monoxide and sulfur dioxide, which pose various health risks and also may contribute to acid rain and global warming. In addition, environmentalists have become increasingly alarmed at the widespread destruction imposed on sensitive wild lands during the exploitation of their resources. The appetite for oil, natural gas, and other energy sources is growing dramatically, with worldwide energy consumption projected to increase by more than 40 percent by 2035. The growing demand is fueled by a population that is predicted to increase 25 percent in the next 20 years. The rising energy demand from economic output and improved standards of living are also to impose added pressure on energy supplies.

### Solar Radiation and Its Components

The cause of all meteorological phenomena is only due to the radiation from the sun. The radiant energy is reflected, absorbed and scattered by the atmospheric molecules, both at the surface of the earth and the clouds; it is finally reradiated from the surface and from clouds and atmosphere in modified spectral distribution as terrestrial long-wave radiation. About 99% of solar radiation falls within the wavelength spectrum between 0.29nm and 4.0nm, while the energy of the terrestrial component is within the band from 4.0 nm to 100nm, excluding only about 1% on either side. Thus, solar radiation can be subdivided into direct solar radiation, the radiation component received in normal incidence from the sun's disc; the sky radiation, observed at a horizontal receiver with an acceptance of 2S solid angle; the global radiation, the sum of the direct solar radiation and the sky radiation and the reflected radiation, the component reflected by the planetary surface and the location of the horizontal. These four components are measured either over the whole spectrum of solar radiation or within the selected spectral bands of specific interest.



## II. LITERATURE REVIEW

**Naseer T. Alwan et al. (2021)**, the low freshwater productivity of a conventional solar still is considered a challenge for researchers due to the high temperature of the glass cover or basin water depth. In current work, a newly designed solar still was suggested according to the climatic conditions of Yekaterinburg/Russia, which included an enhanced condensation and evaporation process by spraying a thin water film on a hot absorber plate and then passing the generated water vapor by free convection over the aluminum plate (low temperature).

**Alwan et al. (2020)**, water is the most important source for human being and other living creatures. The natural sources of water started to decline especially in the recent years. Researchers have focused on the productivity of drinking water as one of the main live requirements. Conversion of salt water into drinking water using solar distillation technology can be considered as the most viable methods in the dry climate regions. The productivity of solar stills effected by various parameters such as design, operational and environmental parameters. The current study aims to study the effect of different environmental conditions on improvement rate of productivity for suggested solar still.

**Alwan et al. (2020)**, the solar still's productivity affected by various conditions such as design, operational and environmental conditions. The current study aims to investigate the effect of water depth on the suggested solar still productivity. The results showed that the productivity decreased with increasing the basin water depth from 1 cm to 3 cm, and the higher freshwater productivity obtained at lower water depth. It is found that the productivity of solar still at 1 cm water depth started early in comparison with the other two depths (2 and 3 cm), the highest distillate for the three perfect days it was recorded with the lowest water depth of 1 cm, while the lowest distillate was with the largest depth 3 cm.

**Alwan et al. (2019)**, one of the most effective methods of solar water desalination without energy exhaustion is the use of thermal energy storage materials such as paraffin wax (PCM). These materials have been approved as one of the most acceptable alternatives for energy supply in distillation plants. These materials (sensible and latent) are used in the solar still to store energy in sunshine hours and release in evening hours to increase production at nighttime. In this study, the effect of using PCM Cells was investigated experimentally in a rectangular-basin solar still with a single slope, and according to Kirkuk city climate in Iraq. Two solar stills were investigated in the current work using two different techniques for the desalination process. The first type (A) is a simple type saline water distiller, which represents the conventional distiller with single inclined from the horizontal (30 degrees). The second type (B) is a suggested type with an integrated PCM in the basin. The basin coated with black colour to absorb the greatest amount of solar energy.

**Ahmed et al. (2017)**, Water is a basic human necessity and is the essential source of life on earth. Fresh water demand is growing everyday all over the world. Solar desalination using a still has been regarded as the sustainable solution in particular in rural and arid areas. Investigations and research has focused on exploring methods and finding ways to enhance the efficiency of solar stills and increase the production rates. This work is an experimental investigation on the effect of incorporating a passive built-in condenser into a conventional solar still daily productivity rate. It has been found that solar still with a built-in condenser gives about 16.7% higher production rate as compared to the conventional solar still. Temperature profiles of the glass cover, the condenser galvanized cover, the saline water, and the galvanized basin have been studied and analyzed.

**Gairaa et al. (2016)**, proposed a new combined model by incorporating the linear autoregressive moving average with the nonlinear artificial neural network model to estimate of daily solar radiation. The results of the study revealed the improvement of the combined model over the ARMA and ANN models used in isolation.

**Yaici & Entchev (2016)**, found the applicability of adaptive neuro-fuzzy inference system for predicting the performance parameters of solar thermal energy systems. The predicted values are in good agreement with the experimental results.

**Ayodela & Ogunjuyigbe (2015)**, used probability distribution of clearness index to determine global solar radiation. The Validation of the model was done by measuring global solar radiation for a period of eight years in Ibadan, Nigeria. It was found to be effective in predicting the monthly average global solar radiation.

**Chen et al. (2015)**, proposed support vector machines model for estimating of global solar radiation from air temperature. It was found that accuracy of the prediction depends on distance, temperature difference between the estimation and the source site and the altitude of source site.





**Olatomiwa et al. (2015)**, attempted to find the accuracy of a soft computing technique for predicting solar radiation based on monthly mean minimum and maximum temperature and sunshine duration. The results revealed the efficiency of the proposed model.

**Qazi et al. (2015)**, attempted to use artificial neural network techniques for designing solar systems and predicting solar radiations on the basis of prediction accuracy and inadequacies. It was inferred from the results that the prediction accuracy using artificial neural network was less than 20%.

**Shamim et al. (2015)**, used numerical weather prediction model to find the cloud cover index influencing the incident solar radiation. It was found that it is important to estimate global solar radiation compared with previous approaches.

**Dumas et al. (2015)**, discovered the linear relationship between global daily solar radiation and the product of sunshine hours with daily maximum temperature variation. The results showed a comparative accuracy with monthly averaged daily values.

### III. METHODOLOGY

Since the ambient air temperature is measured at a lot of locations, the objective of the study is to correlate the solar radiation with the difference between the maximum and minimum ambient air temperatures for three Indian locations viz., Chennai, Trivandrum and Visakhapatnam. Figure 1 shows the variation of monthly mean maximum ambient air temperature for the three locations for each month of the year. It can be observed that, in the case Chennai and Visakhapatnam, the monthly average ambient air temperature gradually increases from January and reaches a maximum of 37.4qC and 33.1qC in May. It decreases gradually in the forthcoming months upto December. In Trivandrum, the monthly average ambient temperature reaches a maximum of 32.1qC in April, which is slightly lesser than that of the other two coastal areas considered. This is due to the fact that Trivandrum is located along the path of the south-west monsoons and gets its first shows even as early as early June. Similarly Figure 2 shows the variation of monthly mean minimum ambient air temperature for the three locations. The graph, shows that the similar trends in variation of minimum air temperature throughout the year for both Chennai and Visakhapatnam. In Trivandrum, the monthly mean ambient air temperature for all the months is less than that of Chennai, Trivandrum and Visakhapatnam. The monthly average solar radiation for all the months of the year for Chennai, Trivandrum and Visakhapatnam has been found using the long term data collected from Indian Meteorological Department, Pune.

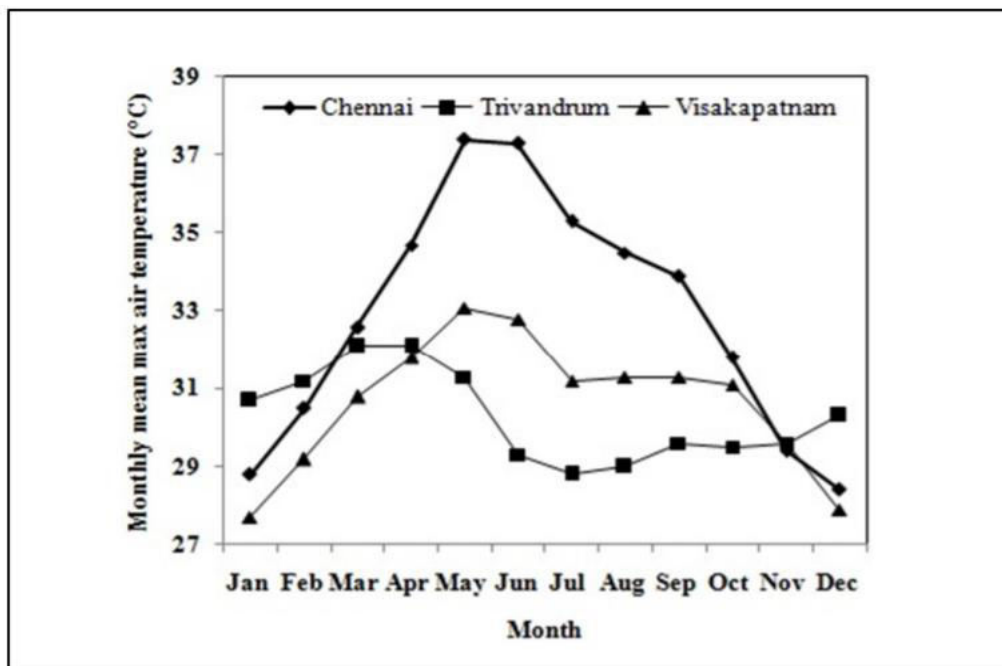


Figure 1: Variation of monthly mean maximum ambient air temperature



This data has been plotted against the months of the year and is depicted in Figure 3. From the graph it is clear that for all the locations, monthly mean solar radiation is maximum from March to May. This is due to the bright sunshine as the sky is clear during the months. Among the three locations, Chennai received large amount of solar radiation for all the months and Trivandrum received a smaller amount of solar radiation when compared to the other two locations.

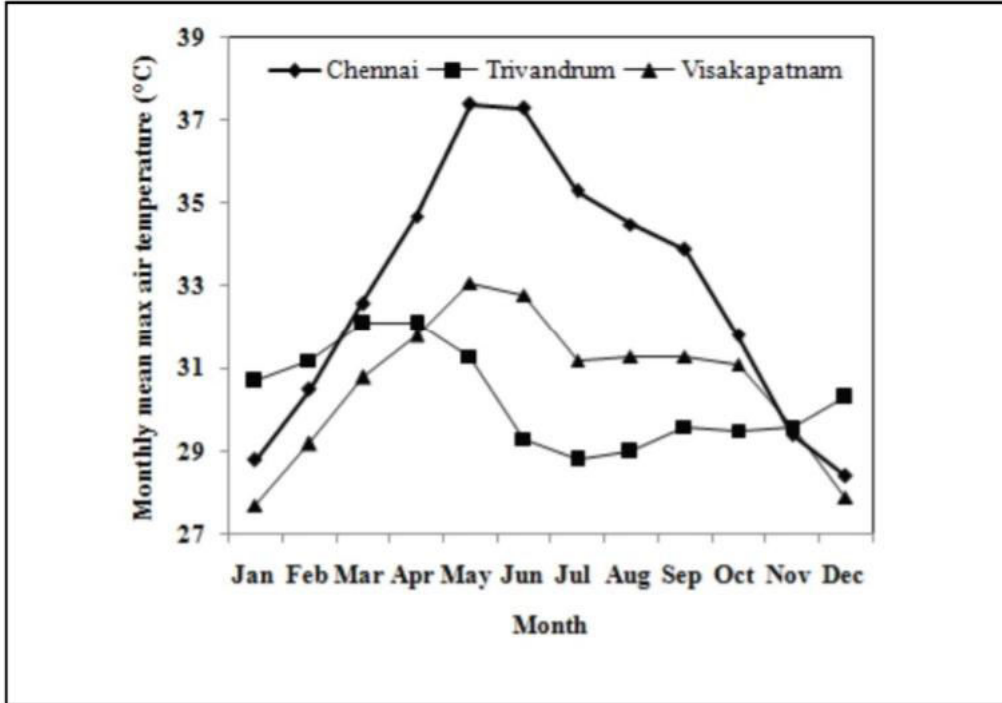


Figure 2: Variation of monthly mean minimum ambient air temperature

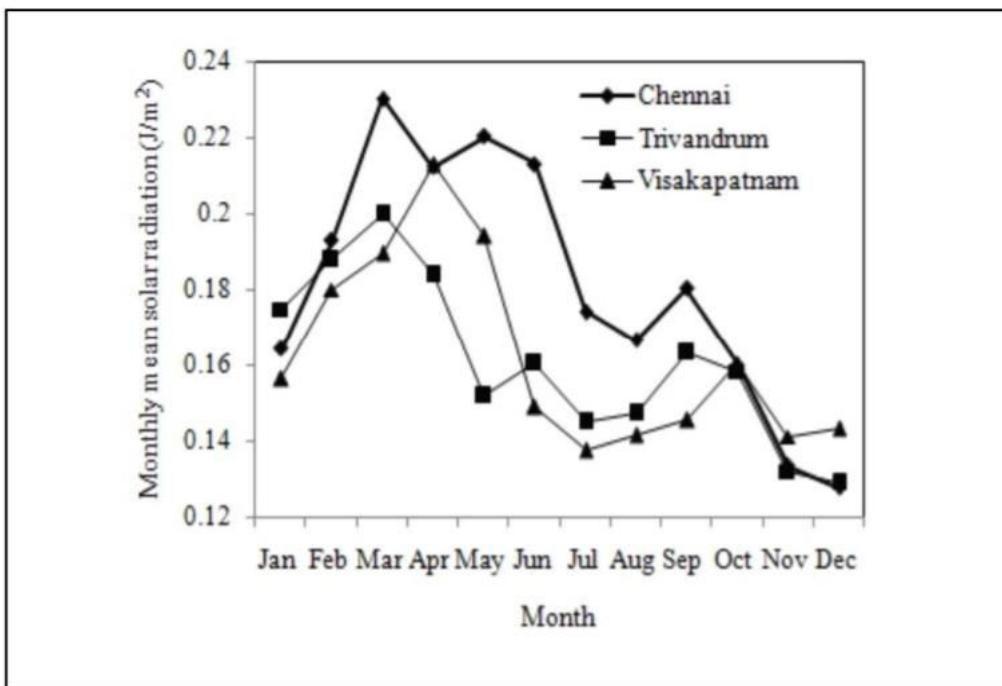


Figure 3: Variation of monthly mean solar radiation



IV. RESULTS

In order to highlight the closeness of the monthly mean measured and calculated solar radiation, the monthly mean solar radiation for all the months for all the three locations have been found by using the correlation equation derived. Graphs have been drawn for the measured and the calculated solar radiation for these three locations with respect to the months of the year, graphs have been plotted and analyzed. Figures 4-6 show the measured and calculated solar radiation for the locations considered

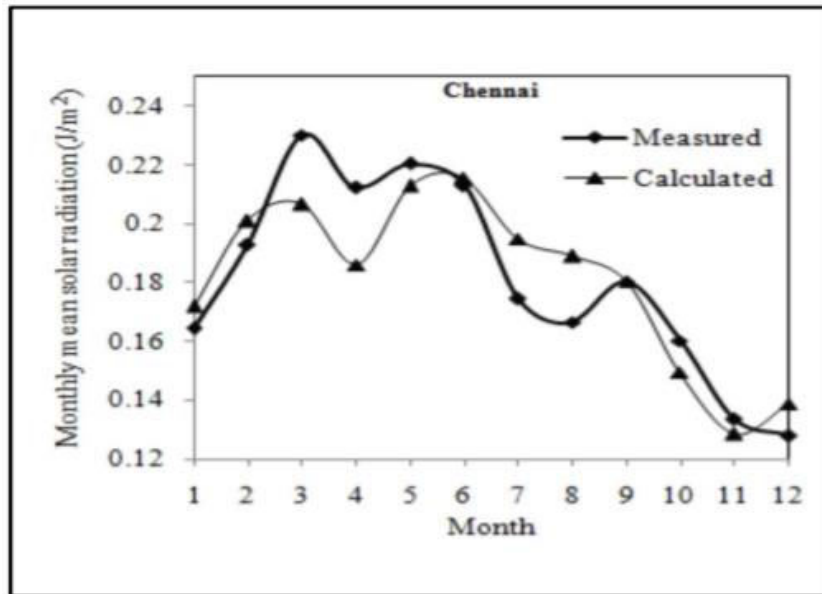


Figure 4: Variation of measured and calculated monthly mean solar radiation at Chennai

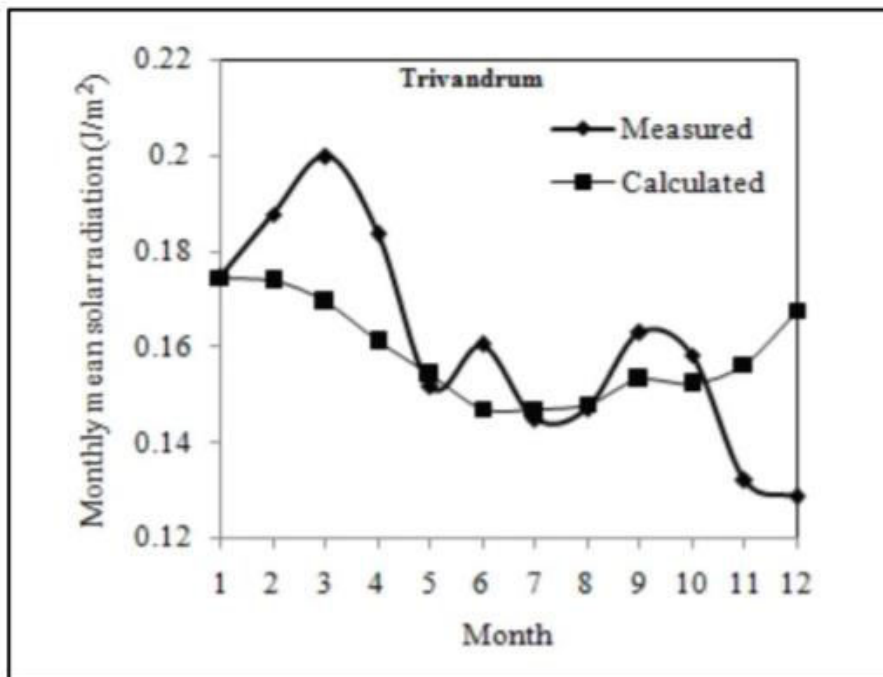


Figure 5: Variation of measured and calculated monthly mean solar radiation at Trivandrum

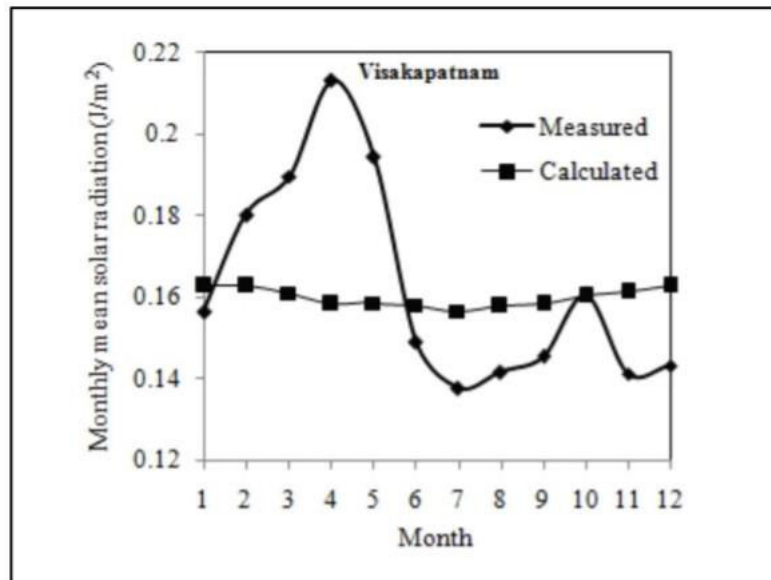


Figure 6: Variation of measured and calculated monthly mean solar radiation at Visakhapatnam

From the graphs, it can be observed that for Chennai, the measured and calculated solar radiation by using the power correlation developed has the same trend and the R<sup>2</sup> value of 0.809 has been obtained. Hence, the equation holds good for predicting of monthly mean solar radiation at Chennai with least error. In Trivandrum, Calculated value seems to have been underestimated for all the months, except for November and December when compared to the measured solar radiation. In November and December, the calculated value of solar radiation has been overestimated.

## V. CONCLUSION

The monthly mean solar radiation and maximum and minimum ambient air temperature data are important for designing and implementation of solar thermal and photovoltaic devices. Differences in monthly mean maximum and minimum ambient air temperature and the monthly mean solar radiation have been correlated to derive power correlation for the predicting monthly mean solar radiation for Chennai, Trivandrum and Visakhapatnam. The developed equation for Chennai shows good correlation with minimum errors, while the equation underestimates and overestimates monthly mean solar radiation at Trivandrum and Visakhapatnam. Hence the power correlation for Chennai can be used for the predicting the monthly mean solar radiation with known values of the difference in maximum and minimum ambient air temperature.

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