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Estimation of the potential evapotranspiration using data of volumetric lysimeter for Chhattisgarh plain agroclimatic zone

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Abstract
An accurate determination of evapotranspiration is required for many studies that involve estimation of the water balance. One methodology is the use of lysimeters. Considering for the Chhattisgarh plain agroclimatic zone the volumetric lysimeter was used for calculating daily E To from January 1993 to December 2016. The volumetric lysimeter provided rapid, reliable, and field-transferable research information. This provided us with the statistical power to compare variables of interest to study the interaction of water quality and quantity on plant ET. Data obtained from the VLS during the cultivation of rice for respective years. The objective of this study is to estimate the Measured PET on weekly, monthly, seasonal as well as annual basis. The highest measured PET found high in 24th SMW indicates the high water demand of crop. As in the monthly and seasonal basis the maximum measured PET observed in the March month and in pre-monsoon season which indicates the high PET occurred in this time span.

Keywords: lysimeter, agroclimatic zone, agroclimatic

1. Introduction
Evaporation is the diffusive process during which water changes into gas. It is physical process by which any liquid escapes from the surface into the air in gaseous state. Water evaporates from a variety of surfaces, for example, lakes, waterways, asphalts, soils and wet vegetation. It senses significant that the most of the water removed for beneficial uses and ultimately returns to rivers and aquifers, which become available for reuse. Transpiration is defined, as a natural plant physiological process in which water is extracted from the soil capillary moisture by roots and passes to plant system which is transpired from stomata cells found in the leaves. The measure of water held in a plant is under 1 percent.
Evaporation and transpiration occurs at the same time and there is no easy way to differentiate between both the processes. The evaporation from a cropped soil is mainly determined by the amount of solar radiation that enters the soil surface, apart from the topsoil. The degree of radiation decreases over the growing period because the crop develops and crop canopy shades more and more of the ground area. When the crop is in nursery stage, most of water is primarily lost from soil evaporation, but when crop is completely developed and completely covers the soil, transpiration becomes the main procedure.
Evapotranspiration of any crop can be obtained by direct method using lysimeter and indirect method by empirical equation. Lysimeter is a measuring device which can be used to measure crops actual evapotranspiration. Lysimeter records the amount of precipitation that an area receives, amount of water lost through the soil and the amount of water lost by evapotranspiration. Lysimeter is most accurate to measure crop evapotranspiration, in which vegetation is grown in a large soil tank which allows the rainfall input and water lost through the soil are easily recorded. The amount of water lost by evapotranspiration can be calculated by the difference between the weight before and after the precipitation input. Requirement of lysimeter is that, the crop grows in isolated tanks filled with either disturbed or undisturbed soil and vegetation both inside and outside of the lysimeter have to be perfectly matched with each other (same height and leaf area index). This requirement has historically not been closely affixed, to in a majority of lysimeter studies and has resulted in severe mistakes.

2. Study area

2.1 Orography

Chhattisgarh is located in the centre-east of the country and Raipur is the largest and the capital city of the state of Chhattisgarh situated in the central part of Chhattisgarh. The gps coordinates of Raipur is 21° 15' 0.0000" N and 81° 37' 47.9892" E. The elevation of Raipur from the mean sea level is 298.15 m (978.18 ft).

2.2 Climate

Raipur has a tropical climate with the both wet and dry seasons. The weather is pleasant throughout the year, with the exception of the hotter summer months (March-June). In April and May, the temperature might reach 47 degrees Celsius. During the summer, there are also dry and hot winds. During the monsoon season, which runs from late June to early October, the city receives approximately 1,142 mm of rain. Winters last from November to January and are mild, although it can fall up to 5 °C making it reasonably cold."

3. Material and Methods

3.1 Collection of weather data

The data of lysimeter is additionally taken from the Department of Agro meteorology, Raipur from 1993-2016. After collecting the data it was organized systematically in MS Excel.

3.2 Data quality checking

The lysimeter data of the relevant station was reviewed in MS Excel once it was collected. The column was previously picked and filtered for this purpose. As a result, we have a set of values like positive, negative, and blank. Following that, essential corrections were made to the data that was discovered to be incorrect. While inspecting the lysimeter data, a variety of missing values were discovered which leading the process of evaluation to be hindered. Normals for the various parameters were calculated to fill in those values.

3.3 Conversion of PET data into monthly, weekly and annual values

After inserting a row at the end of each month, the lysimeter data was changed into monthly format and the sum of all parameters was calculated using the Auto sum Function, which was repeated for the entire data. Data was then filtered, and then the whole Auto total of all months was filtered, selected, then copied and pasted onto the next page. As a result, we obtained monthly data, and the same procedure was followed for weekly and annual data processing. In MS Excel, the same procedure is used to convert daily weather data into seasonal data. Winters (Jan-Feb), Pre-Monsoon (March-April-May), Monsoon (June-Sept), and Post-Monsoon (Oct-Dec) are the four distinct seasons (Nov-Dec). At the end of each season, a row was inserted, and the Auto total was calculated. After that, the data was filtered and pasted onto the next sheet, where seasonal information was collected.

3.4 Description of software used

Weather cock is software developed by I Ramamohan, on AICRP of Agro meteorology CRIDA Hyderabad, which is used for many of objects example for checking data quality, data management and for the conversion of daily data. As for the run the software for those objects a specified layout of input file are required and those file were made in MS EXCEL in CSV format. So after filling the browse with input file that software did processing of the data and gave output as desired objects.

3.5 Measured ET converted into measured PET

The measured ET is data taken from volumetric lysimeter from rice field. The data is taken from 1993 to 2016 from department of Agrometeorology, Raipur. That was measured evapotranspiration data which needs to be converted into potential evapotranspiration data. To convert the evapotranspiration (lysimeter data) into potential evapotranspiration data there is K_c value of rice crop needed.

$PET = K_c * ET$

The lysimeter data is taken from rice field and average value of crop coefficient of rice is 1. So as like this Measured ET data is changed into Measured PET data.

4. Result and discussion

The potential evapotranspiration of Raipur district was calculated on weekly and monthly seasonal as well as annual basis for the above mentioned period using the "Weather cock software" developed by CRIDA, Hyderabad. Output of analysis and the results are presented and discussed.

4.1 Weekly total measured PET

The average weekly total measured PET data quantified through volumetric lysimeter data for a period of 1993-2016 are presented in Fig. 4.1. It can be clearly seen that the weekly total measured PET increased continuously From 6th SMW and further decreases but this reached its maximum in 24th SMW. From 46th SMW the PET decreased and remained low but in 49th SMW these increases and after that reached to minimum in the 51th SMW. The highest measured PET is found 37.3 mm in the 24th SMW and lowest PET is found 20.6 mm in the 51th SMW. The annual average total weekly measured PET is found 1608.1 mm.

The highest PET in 24th SMW indicates maximum temperature leads to high water demand of crop growth timing this period so especially vegetative growth needs to regulate their discharge of water in the field to cope up with ET losses of crops.

4.2. Monthly total measured PET

The average monthly total measured PET recorded with the help of volumetric lysimeter for a period of 1993-2016 are presented in Fig. 4.2. Data of table indicates that the average monthly total measured PET increases continuously from January to July but in April month these remain low. During August PET decreases and remains low during September with increases during month of October, November then decreases afterwards. The maximum measured PET was found 153.4 mm in the month of March and minimum PET was recorded 110.2 mm in the month of December. The average total of 12 months measured PET recorded through lysimeter was 1608.1 mm.

It indicates that during month of March the PET demand will be very high which can be met out with the help of judicious application of available water in crop production. It also helps for rational distribution of water in different sectors considering the critical stages of crops.

4.3 Seasonal total measured PET

The seasonal average total measured PET recorded through volumetric lysimeter for a period of 1993-2016 are presented in Fig. 4.3. The outcome of our study indicates that out of four seasons, the maximum average seasonal PET value

recorded in the monsoon season i.e. 550.3 mm followed by pre-monsoon season i.e. 418.9 mm whereas minimum PET was recorded in the winter season i.e. 256.2 mm.

Seasonal PET loss is very valuable information, on that basis we can allocate the water for irrigation in advance to cope up with adverse climate condition.

4.4 Annual total measured PET

The annual data of measured PET by volumetric lysimeter are presented in Fig. 4.4. From the table it is quite clear that in the year 1996 maximum value of PET was recorded through volumetric lysimeter while the minimum value of PET was associated in the year 2016. That was decreasing trend of PET from 1993 to 2016.

Trend of weekly, monthly, seasonal and annual measured PET of Raipur was depicted in Fig. 4.1, 4.2, 4.3 and 4.4.

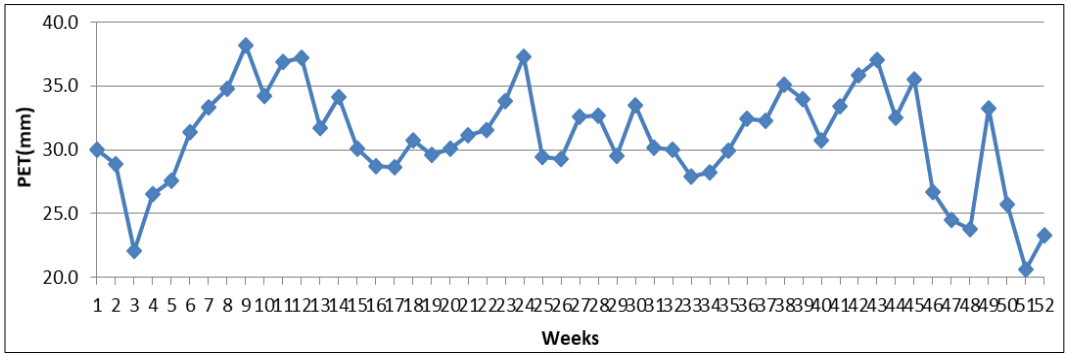

Fig 4.1: Weekly pattern of measured PET

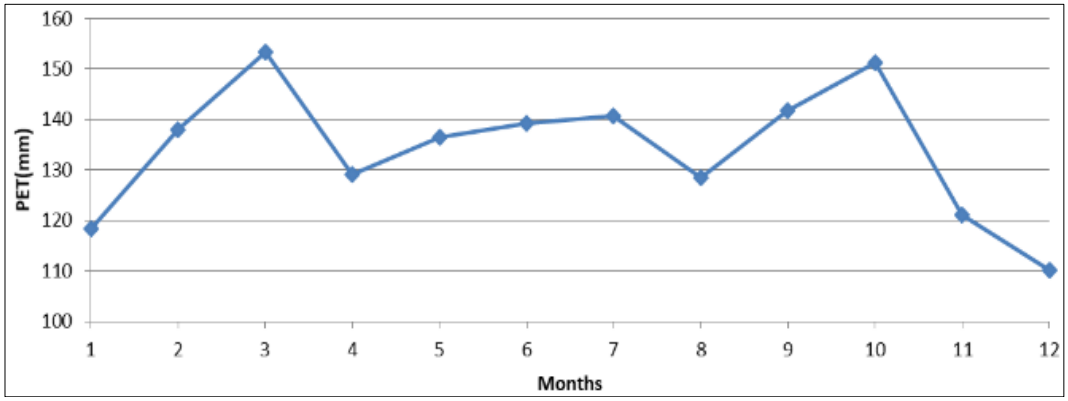

Fig 4.2: Monthly pattern of measured PET

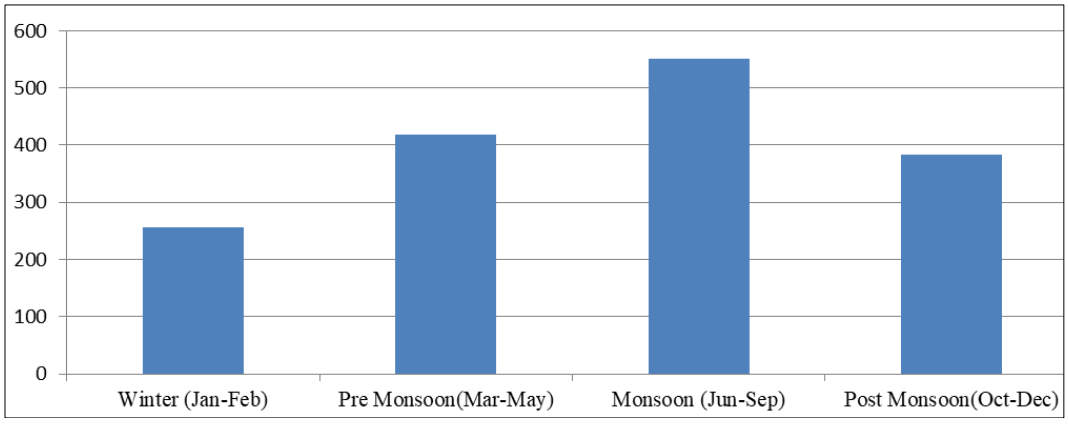

Fig 4.3: Seasonal pattern of measured PET

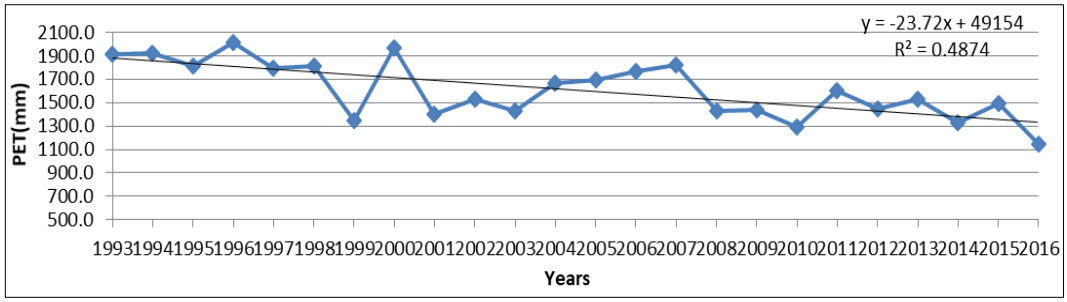

Fig 4.4: Annual pattern of measured PET

The pattern of weekly, monthly, seasonal and annual PET presented in Fig. 4.1, 4.2, 4.3 and 4.4. It is quite clear from the figure that there was decreasing trend of measured PET on annual basis. However on annual basis trends were significant. Fig. 4.4 clearly shows that the rate of decreased trend was @ -23.72 mm/year on annual basis.

5. Conclusion

The volumetric lysimeter design described here has a number of advantages. The ability to instrument a large number of experimental units provides greater latitude for quantifying the response of plants to varying water quality and irrigation application rates. Accurate quantification of the irrigation scheduling will improve our understanding of crop response to water stress on different phenological stages. It is found clear from the research that the annual pattern of the measured PET over the period is found in decreasing trend.

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