THE STUDY OF POTENTIAL EVAPOTRANSPIRATION (PET) IN UMP GAMBANG

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

Potential evapotranspiration (PET) is a term represents the combination of two processes water cycle whereby water is lost to the atmosphere from the soil and water bodies by evaporation meanwhile transpiration from vegetation or plant. PET is a complex and one of the most essential process in the hydrological cycle. It is useful to measure the atmospheric water demand of the region and hence could be used for various applications such as irrigation scheduling, drought monitoring, and crop production and understanding climate change impacts. The objectives of the study are to analyse the value of PET by using radiation-based methods; Penman-Monteith (PM) and Turc and temperature-based methods; Blaney-Criddle (BC) and Thornthwaite (TW) method in UMP Gambang and to evaluate the performance of PET estimation method. In this study, the comparison was made in term of values of PET by using Penman-Monteith, Turc, Blaney-Criddle and Thornthwaite methods with the exact PET values. It was found that radiation-based methods gave better performance compared to temperature-based methods in estimation of PET in the study. In radiation-based methods, PM method is the appropriate method to estimate PET in UMP Gambang with the highest accuracy of (R^2 = 0.6447 for 2016, 0.6028 for 2017 and 0.6007 for 2018) and the lowest value of (RMSE = 0.3056 for 2017, 0.5836 for 2018) compared to the other methods.

ABSTRAK

Penyejatpeluhan yang berpotensi (PET) adalah istilah yang mewakili gabungan dua proses kitaran air di mana air akan diserap ke atmosfera daripada tanah dan air dari penyejatan manakala transpirasi dari tumbuh-tumbuhan atau tanaman. PET adalah kompleks dan salah satu proses yang paling penting dalam kitaran hidrologi. Ia berguna untuk mengukur permintaan air atmosfera di rantau ini dan oleh itu ia boleh digunakan untuk pelbagai aplikasi seperti penjadualan pengairan, pemantauan kemarau, dan pengeluaran tanaman serta memahami kesan perubahan iklim. Objektif kajian ini adalah untuk menganalisis nilai PET dengan menggunakan kaedah berasaskan radiasi; Penman-Monteith (PM) dan Turc dan kaedah berasaskan suhu; Blaney-Criddle (BC) dan Thornthwaite (TW) di UMP Gambang dan untuk menilai prestasi kaedah anggaran PET. Dalam kajian ini, perbandingan akan dibuat dari segi nilai PET dengan menggunakan kaedah Penman-Monteith, Turc, Blaney-Criddle dan Thornthwaite dengan nilai PET yang tepat. Ia telah didapati bahawa kaedah berasaskan radiasi memberikan prestasi yang lebih baik berbanding kaedah berasaskan suhu dalam menganggar PET dalam kajian. Dalam kaedah berasaskan radiasi, kaedah PM adalah yang paling sesuai digunakan untuk mencari nilai PET di UMP Gambang dengan ketepatan tertinggi nilai (R^2 = 0.6447 untuk 2016, 0.6028 untuk 2017 dan 0.6007 untuk 2018) dan nilai RMSE yang terendah (RMSE = 0.3056 untuk 2017 dan 0.5836 untuk 2018) berbanding deengan kaedah yang lain.

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LIST OF SYMBOLS

Δ	slope of saturation vapour pressure curve of air at absolute temperature T_m (mm Hg/ °C)
γ	psychrometric constant, 0.49 mm Hg/ °C
H	heat budget at evaporating surface in equivalent evaporation (mm/day)
f(u)	wind-related function
ET_o	the reference evapotranspiration (mm/day)
ET_{osc}	the gross evapotranspiration
p	mean daily percentage of annual daytime hours
T_{mean}	mean daily temperature (°C)
T_{med}	mean daily temperature (°C)
I	the monthly heat index
d_m	the number of days per month
N	the maximum number of sunny hours in function of the month latitude
n	monthly sunshine hours
RH	relative humidity (%)
R_s	the solar radiation ($MJ \cdot m^{-2}$)
R_n	net radiation of the crop surface ($MJm^{-2}\ day^{-1}$)
R_a	extra-terrestrial radiation ($MJm^{-2}\ day^{-1}$)
e	exponential function
r	reflection coefficient or albedo
R	correlative coefficient
G	soil heat flux density ($MJm^{-2}\ day^{-1}$)
U_2	wind speed at 2m height (ms^{-1})
e_a	actual vapor pressure (kPa)
e_s	saturation vapor (kPa)
K_c	specific coefficient
a	monthly sunshine conversion coefficient
b	monthly sunshine conversion coefficient

LIST OF ABBREVIATIONS

ET	Evapotranspiration
PET	Potential Evapotranspiration
AET	Actual Evapotranspiration
MMD	Malaysian Meteorological Department
RMSE	Root Mean Square Error
RMSD	Root Mean Square Deviation
R^2	Coefficient of Determination
ET_o	Reference Crop Evapotranspiration
ET_c	Crop Evapotranspiration
PM	Penman-Monteith
BC	Blaney-Criddle
TW	Thornthwaite
FAO	Food and Agriculture Organization
ASCE	American Society of Civil Engineers
WATCH	Water and Global Change
USGS	United States Geological Survey

CHAPTER 1

INTRODUCTION

1.1 Introduction

Hydrological cycle is a process that is powered by solar energy, which moves water between the oceans, sky and land. The process that occurs in hydrologic cycle are evaporation, condensation, precipitation, interception, infiltration, percolation, transpiration, runoff and storage. The process starts with water evaporation from the surface of the ocean. When the moist air is lifted into the atmosphere from oceans, land surface, and water bodies and the water vapor condenses to form clouds. Then it will fall to the Earth's surface as precipitation.

Evaporation is one of the major processes in the hydrologic cycle. It is the process of water that changes from liquid to gas or steam. It occurs when water moves to the air from sources, canopy interception, and water bodies. Meanwhile transpiration is the evaporation of water from plant leaves, stems, flowers or roots back into the atmosphere. It means the movement of water in plants and subsequent loss of water as vapor through stomata in the leaves. Thus, the combination of evaporation and transpiration process become evapotranspiration. Evapotranspiration (ET) is an important component in the movement of water and water vapor through the hydrological cycle which water is transferred from the soil to the atmosphere by evaporation from the soil and by the transpiration of living plant (Gharbia *et al.*, 2018). Figure 1.1 shows the process of hydrologic cycle.

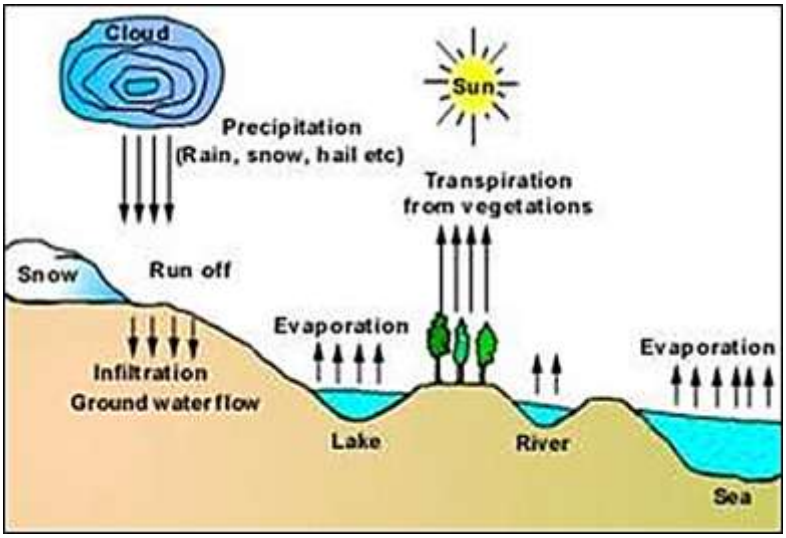

Figure 1.1 Hydrological cycle

Source: Mentzafou, Wagner and Dimitriou (2018)

Potential evapotranspiration (PET) is the ability of atmosphere to remove water from the surface through evaporation and transpiration processes by not taking control over water supply (Li *et al.*, 2016). It requires energy for the evaporation process and the main source of this energy is from the Sun. This demand combines the energy that available for evaporation and lower atmospheric capabilities to transport evaporative humidity from the ground surface. It is useful to measure the atmospheric water demand of the region and hence could be used for various applications such as irrigation scheduling, drought monitoring, and crop production and understanding climate change impacts. Potential evapotranspiration is higher in the summer, on a less cloudy day, and closer to the equator, due to the higher levels of solar radiation that provide energy for evaporation. PET also higher on windy days because the moisture evaporators can be moved quickly from soil or plant surface, which allows more evaporation to fill its place. The difference between potential evapotranspiration and precipitation can potentially be used in irrigation scheduling (Lang *et al.*, 2017).

Actual evapotranspiration (AET) is the actual quantity of water that loss from the surface caused by the process of evaporation and transpiration if the total amount of water is limited. This can be measured (directly or indirectly) or estimated. For example, for research purposes in plant eco- physiology, ET must be accurately measured, while it can be estimated for farm irrigation management. If the level of accuracy in the estimation is

low, the waste water with the wrong irrigation management will be greater. Crop evapotranspiration is useful for measuring the atmospheric water demand in the region and therefore can be used for a variety of applications including irrigation scheduling, drought monitoring, and understanding of the effects of climate change.

1.2 Problem Statement

The environment is important where it includes all living things and non-living which occurs naturally in the earth or in part which consist of several major components in the environment. It is also including the landscape that serves as the system naturally without human interruption where including flora and fauna, as well as natural phenomena such as earthquakes, eruptions of volcanoes, floods and others (Kuchment, 2004).

Malaysia is one of the countries that are on the way towards as a developing country. In order to improve the standard of living of the population, various development programs have been introduced. Thus, this rapid development must be consistent with protecting the natural cycle. The rapid uncontrollable gives the negative consequences of climate change such as rising from time to time. Climate change has been recognized as one of the higher challenges in the PET process (Patra, 2008). The estimation of the PET value was found as the important issue in this study through the combination of evaporation and transpiration. Thus, the PET value is required due to the change of the climate which mainly expected to affect the air temperature, precipitation intensity and distribution.

Apart from precipitation, the most significant component of the hydrologic budget is evapotranspiration. Evapotranspiration varies regionally and seasonally; during a drought it varies according to weather and wind conditions. Because of these variabilities, water managers who are responsible for planning and adjudicating the distribution of water resources need to have a thorough understanding of the evapotranspiration process and knowledge about the spatial and temporal rates of evapotranspiration (Wang *et al.*, 2012).

Droughts are among the most expensive natural disasters, harming agriculture, the economy, and human health, and creating ideal conditions for wildfires. The intensified drought conditions projected under climate change will present challenges for

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