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Rainfall Analysis for Rainwater Harvesting in Politeknik Ungku Omar

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ABSTRACT

Rainwater Harvesting System (RWHS) is a collection and storage of rainwater for future use and have many benefits related to the economy, environment, technology, and society. Malaysia is well positioned to harvest rainwater because of number of rainy days in Malaysia is high and average of rainfall amount 2500 mm annually. Because of the effects of the topography of Peninsular Malaysia, rainfall distribution varies significantly. Thus, rainfall data analysis for rainwater harvesting potential should be made based on local climate and influences from the monsoon. The objective of this study was to analyse the rainfall data for rainwater harvesting potential in Politeknik Ungku Omar (PUO). To simplify analysis, rainfall distribution is discussed within two monsoons which is Southwest monsoon and Northeast monsoon while rainfall trend is determined under the year 2000 to 2019. The result indicates that PUO will be potential for RWHS regarding to high number of rainfalls event and increasing trend in annual rainfall amount in that area. Further research is clearly needed to investigate the roof size and water consumption to increase the effectiveness of the RWHS.

Keywords: Rainwater harvesting system; rainfall distribution; rainfall trend

INTRODUCTION

Freshwater scarcity become a global issue especially in developing countries effect from population rise, climate change and pollution. To reduce and minimize the problem, the use of rainwater from rooftops may be one of the sustainable strategies in water supply management. Rainwater Harvesting System (RWHS) has been widely accepted around the world and has gained recognition as a reliable alternative for sustainable development.

RWHS is a collection and storage of rainwater for future use and have many benefits related to the economy, environment, technology, and society. Tam et al. (2010) indicated that annual domestic cost saving up to $240 per house when implementing RWHS in in Gold Coast, Brisbane, and Sydney. RWHS also are more economical for higher water tariff (Farreny et al. 2010). In terms of environmental benefits, RWHS can reduce up to 10% of flood in South Korea (Kim & Yoo 2009). Furthermore, Vaes and Berlamount (2001) reported that large scale rainwater tank can reduce peak flow in sewer system. Shaaban and Appan (2003) anticipated that if all houses in the residential area in Malaysia are installed with RWHS, it can meet up to 34% of domestic water use and 10% reduction in peak discharge.

In Malaysia, the government suggested RWHS as alternative resources to reduce over dependence on river and other surface water. Therefore, RWHS is compulsory for every new development both for water supply and flood control (DID, 2012). The amount of rainwater that can be harvested depends on roof area, rainfall amount and storage and roof material and design (Thomas & Martinson 2007) and rainfall amount is a major contributor to the effectiveness of RWHS. This statement is supported by Ali et al. (2020) which states that efficiency of RWHS is largely depends on spatial variation of rainfall, tank size and rainwater requirement. Being in humid tropic region, number of rainy days in Malaysia is high with 138 days to 181 days/year (Hafizi et al. 2018) and average of rainfall amount 2500 mm annually. Thus, Malaysia is well positioned to harvest rainwater. Furthermore, based on the study conducted by Abdul Ghani et al. (2016), it is revealed that Kuantan River Basin will be potential and suitable site for RWHS because this area received high number of rainfalls. However, the distribution of rainfall event in Malaysia are different in each place and strongly influenced by the two main monsoon seasons which is Southwest (SW) monsoon and Northeast (NE) monsoon. As mentioned by Suhaila et al. (2010), Northeast monsoon seasons bring more rainfall especially in east coast region. In contrast, the northwest region experienced the driest condition during this monsoon. Therefore, rainfall data analysis for rainwater harvesting potential should be made based on local climate and influences from the monsoon. Furthermore, because of the effects of the topography of peninsular Malaysia, rainfall distribution varies significantly. For this reason, the objective of this study was to analyze the rainfall data for rainwater harvesting potential in the Politeknik Ungku Omar by considering for both seasons.

METHODOLOGY

STUDY AREA AND HYDROLOGICAL

Politeknik Ungku Omar (PUO) located at Ipoh, Perak in northern region of Peninsular Malaysia. PUO has varying rainfall patterns due to the influence of the SW monsoon and NE monsoon. The SW monsoon occurs from May to August and the NE monsoon is experienced from November until February. The inter monsoon periods are experienced between these two monsoons from March to April and from September to October. There is a rainfall station with ID number 4511111 in PUO area which is maintained by Department of Irrigation and Drainage (DID), Malaysia. The rainfall data were obtained using automatic recorded rain gauges and measured using tipping bucket rain gauges. Twenty years daily rainfall data (2000–2019) collected from this rainfall station was analyzed to determine the rainfall distribution and rainfall trend for the study area. Rainfall stations with more than 20 years of historical data were chosen based on suggestions from United States Environmental Protection Agency (USEPA). According to USEPA (2009), at least 20 to 30-year period of rainfall record are recommended for analysing rainfall events. The rainfall data were obtained from the Water Resources Management and Hydrology Division, Department of Irrigation and Drainage (DID), Malaysia.

LINEAR REGRESSION

Microsoft Excel was used to calculate the trend lines and statistical values of linear regression analysis. The equation of linear regression line is given by

$$Y = a + bX \tag{1}$$

Where, b is the slope line and a is the intercept (value of y when x=0). The Y is the dependent variable and x is the explanatory variable. The slope of regression describes the trend whether positive or negative. The value of R-square (R^2), or the square of the correlation coefficient from the regression analysis is used to show how strong the correlation and relationship between the variable X and Y.

RESULTS

RAINFALL DISTRIBUTION

The distribution of rainfall event was divided into four types as mentioned in Babar and Ramesh (2014) which is light type for rainfall depth between 1 to 10 mm, moderate for rainfall depth between 11 to 30 mm, heavy for rainfall depth between 31 to 60 mm and very heavy when rainfall depth is more than 61 mm. Table 1 shows a number of rainfall event for every month and Figure 1 depicts the percentage in graph form. Overall, rainfall station ID number 4511111 in PUO recorded 2784 numbers of rainy day in 20 years and 139 day/year on average. A total of 1432 events (36%) were recorded for light type while 838 events (21%), 378 events (9%) and 1336 events (33%) for the moderate, heavy, and very heavy rainfall respectively. For light type, the highest number recorded in November and the lowest in February. The highest number of events for moderate type happens in October, April, and May for heavy rainfall type. In contrast, August recorded the lowest for moderate type and July for heavy rainfall. The wettest month of the year are in April and May with the highest number of very heavy rainfall type while February and July recorded the lowest.

TABLE 1. The distribution of rainfall event

Type	Depth (mm)	Number of events												Total event
		Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Light	1 - 10	128	87	125	121	121	93	77	99	127	145	174	135	1432
Moderate	11-30	70	51	73	90	90	53	48	50	73	103	73	64	838
Heavy	31 - 60	29	19	27	48	48	33	16	35	20	36	43	24	378
Very Heavy	> 61	107	72	111	159	159	90	72	93	98	146	128	101	1336

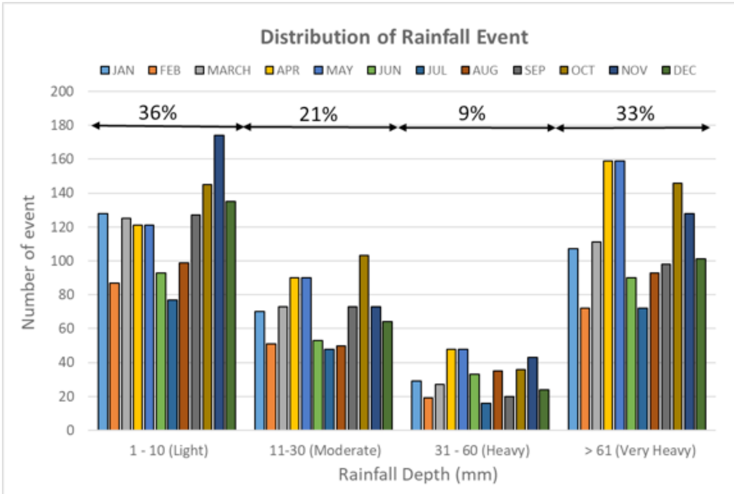

FIGURE 1. Percentage of rainfall event distribution

Table 2 reveals the percentage of rainfall distribution by monsoons and Figure 2 depicts it in graph form. In total, 1154 rainfall event happens in SW monsoon and 1305 in NE monsoon. For SW monsoon, the highest percentage is in heavy and very heavy rainfall (45%) type. However, light, and heavy to very heavy rainfall gives same percentage (40%) for NE monsoon. From the record, only 21% of rainfall event consist moderate type in SW monsoon

TABLE 2. Percentage of rainfall distribution for SW monsoon and NE monsoon

Type	SW Monsoon (May to August)		NE Monsoon (Nov to Feb)	
	Event	%	Event	%
Light	390	34	524	40
Moderate	241	21	258	20
Heavy and Very Heavy	523	45	345	40
TOTAL	1154		1305	

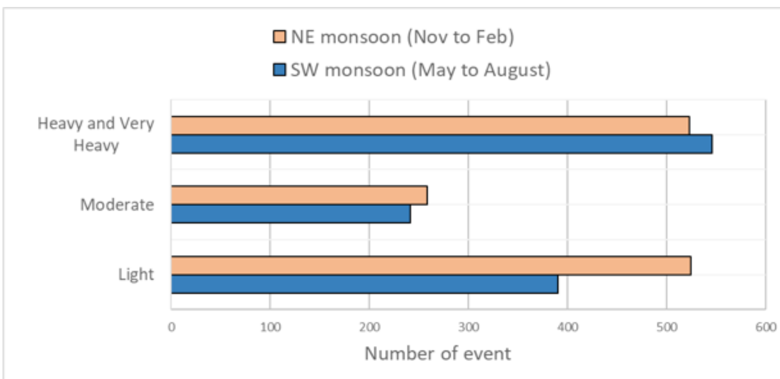

FIGURE 2. Rainfall distribution for SW Monsoon and NE Monsoon

RAINFALL TREND

A graph showing the annual rainfall between 2000 and 2019 is shown in Figure 3. Within 20 years of observation, every year has recorded annual rainfall of more than 1000 mm. Highest annual rainfall occurred in the year 2008 with a rainfall amount of 4027 mm compared to 1006 mm for the lowest in the year 2007. From year 2000 to year 2007, it shows a decreasing trend, but the trend continues to increase after that year.

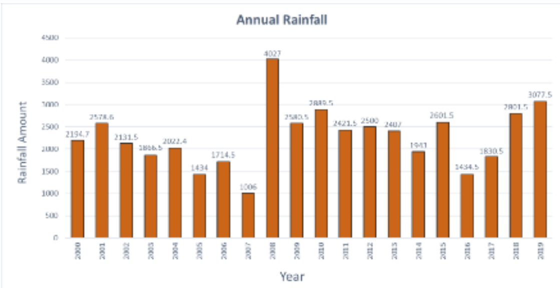

FIGURE 3. Annual Rainfall for PUO

Fitting trend lines show positive magnitude in slope as shows in Figure 4. Based on the graphs, there is a clear upward trend in annual rainfall in PUO with the positive value of slope line. Decreasing amount of annual rainfall happens from year 2001 to 2007 but increase in year 2008. Again, it shows a decreasing amount from year 2008 to 2016. However, an increase can be seen in 2016 where the amount of annual rainfall continues to increase from 1434 mm in 2016 and 1830 mm, 2801 mm, and 3077 mm in 2017, 2018 and 2019, respectively. The value of R-square which is 0.037 shows weak correlation between years and rainfall amount.

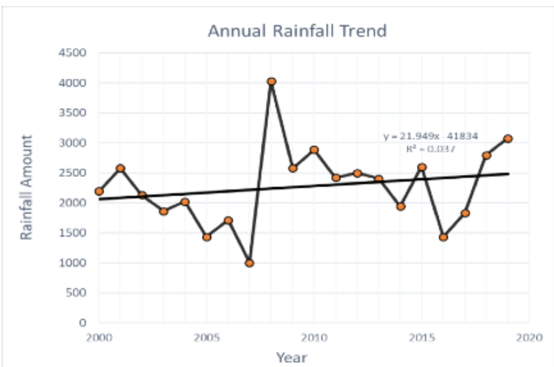

FIGURE 4. Annual Rainfall Trend for PUO

DISCUSSION

This study focused on the investigation of rainfall distribution and rainfall trend in Politeknik Ungku Omar. It is revealed that PUO will be potential for RWHS because rainfall data series consist of a large number moderate, heavy, and very heavy rainfall type with 63% in total. Rainfall depth of less than 10 mm (Light) contributes the highest percentage toward the overall record. For RWHS, this type of rainfall does not contribute a lot of water into collection tank because most of it will be diverting to the first flush system. The distribution of rainfall event depicts the same pattern for both monsoons. However, Suhaila et al. (2010) conclude that NE monsoon gives lesser impact on rainfall distribution in the western part of Peninsular Malaysia. This difference occurs because of her study used data from 1975 to 2004 while this study uses data from 2000 onwards. It is also possible that global warming and climate change has changed the pattern of rainfall distribution in Peninsular Malaysia.

Average annual rainfall for the study area is 2273 mm. This indicates that PUO has potential to use RWHS because the annual rainfall value is more than 1300 mm. It is comparable to the one obtained by Hajani & Rahman (2014) who stated that the reliability of RWHS will increase from 40% to 71% with annual rainfall within 743 mm to 1325 mm. The annual rainfall in PUO show an increasing trend with positive value of slope line. This information is important for the future planning of RWHS. The rainfall trend used in this study is the simplest method and the results obtained need further verified. Therefore, a non-parametric approach, the Mann-Kendall test is suitable to be used because this method has been widely used for detection of trend in hydrology and climatology.

CONCLUSION

The major findings and conclusions of this study are as follows:

1. Campus PUO will be potential for RWHS regarding to high number of rainfalls and increasing trend in annual rainfall amount in that area. Therefore, management should consider implementing RWHS on the campus as it not only benefits the economy but also the environment.
2. Further research is clearly needed to investigate the roof size and water consumption to increase the effectiveness of RWHS.

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DECLARATION OF COMPETING INTEREST

None

REFERENCES

Abdul Ghani, N.A.A.; Mohamad, N.A.; Hui, T.W. 2016. Rainfall analysis to determine the potential of rainwater harvesting site in Kuantan, Pahang. *ARPN Journal of Engineering Applied Science* 11: 7264–7268.

Ali, S., Zhang, S., & Yue, T. 2020. Environmental and economic assessment of rainwater harvesting systems under five climatic conditions of Pakistan. *Journal of Cleaner Production* 259: 120829

Babar, S., and H. Ramesh. 2014. Analysis of extreme rainfall events over Nethravathi basin. *ISH Journal of Hydraulic Engineering* 20(2): 212-221.

Department of Drainage and Irrigation (DID). 2012. *Urban Stormwater Management Manual for Malaysia*. Kuala Lumpur: Department of Irrigationand Drainage (DID) Malaysia

Farreny, R.; Gabarrell, X.; Rieradevall, J. 2010. Cost-efficiency of rainwater harvesting strategies in dense Mediterranean neighbourhoods. *Resources, Conservation and Recycling* 55: 686–694.

Hajani, E. & Rahman, A. 2014. Reliability and cost analysis of a rainwater harvesting system in peri-urban regions of Greater Sydney, Australia. *Water* 6: 945–960.

Hafizi Md Lani, N., Yusop, Z., & Syafiuddin, A. 2018. A review of rainwater harvesting in Malaysia: Prospects and challenges. *Water* 10(4): 506.

Kim, K. & Yoo, C. 2009. Hydrological modeling and evaluation of rainwater harvesting facilities: Case study on several rainwater harvesting facilities in korea. *Journal of Hydrologic Engineering* 14: 545–561.

Shaaban, A. & Appan, A. 2003. Utilising rainwater for non-potable domestic uses and reducing peak urban runoff in Malaysia. In Proceedings of the 11th International Rainwater Catchment Systems Conference, Mexico City, Mexico, 25–29 August 2003.

Suhaila, J., Deni, S. M., Zin, W. Z. W. & Jemain, A.A. 2010. Trends in peninsular Malaysia rainfall data during the southwest monsoon and northeast monsoon seasons: 1975–2004. *Sains Malaysiana* 39(4): 533-542.

Tam, V.W.Y.; Tam, L.; Zeng, S.X. 2010. Cost effectiveness and tradeoff on the use of rainwater tank: An empirical study in Australian residential decision-making. *Resources, Conservation and Recycling* 54: 178–186.

Thomas T. H. & Martinson, D. B. 2007. Roofwater harvesting: a handbook for practitioners. Technical paper series, no 49, IRC International Water and Sanitation Center Delft, The Netherlands,160 pp

US Environmental Protection Agency (USEPA). 2009. Technical guidance on implementing the stormwater runoff requirements for federal projects under section 438 of the energy independence and security act. Washington DC, US Environmental Protection Agency (USEPA).

Vaes, G. & Berlamont, J. 2001. The effect of rainwater storage tanks on design storms. *Urban Water* 3: 303–307.