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Correlation of Rainfall Data and Stream Flow

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Abstract: A drought is a period of time when a part of the country or region receives less rain than usual. Droughts have a significant negative impact on global social and economic development. In 2014, water rationing was implemented in nearly all Johor districts, including Batu Pahat, Kluang, Mersing, Kota Tinggi, and Kulai Jaya. The aim of this study is to intensify the influence of rainfall is the biggest influence for the drought season. Mann Kendall Test was the main method employed in this study in order to determine rainfall characteristic in Rantau Panjang, Johor and determine water level of Sungai Johor at Rantau Panjang, Johor. The Mann Kendall Test is used to look for consistently expanding or diminishing patterns (monotonic) in Y values in data collected over time. It may be a non-parametric test, which suggests it works for all dispersions The result shows there are significant positive relationship between the rainfall and stream flow data, r (12) = 0.41, p > 0.05 (alpha = 0.05) and a significant positive relationship between the rainfall and water level data, r (7) = 0.24, *p* > 0.05 (alpha = 0.05). In future reseach study it is recommended that more data analysis from more stations will be requested to obtain an overall pattern in Peninsular Malaysia.

Key word: Drought, Mann–Kendall, non-parametric regression, meteorological parameters.

1. Introduction

Rain is the source of freshwater for many societies where streams, lakes, or aquifers are not easily available. Rainfall, is a precipitation of liquid water drops larger than 0.5 mm in diameter (0.02 inch). Since this ascent is brought approximately in three ways, there are three fundamental sorts of

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precipitation. These are Conventional Rainfall for condensation and precipitation to occur there must be an obvious rising of air mass. Since this rising is brought around in three ways, there are three fundamental sorts of precipitation. These are: Ordinary Precipitation Orographic or Alleviation Precipitation and Frontal or Cyclonic[1] Rains can happen as strati form rain or convective rain (rain cells). Strati form rain is the overwhelming from of rain within the high scopes, whereas convective rain is the dominant form of rain within the tropics and subtropics (within the tropics, 50 to 80 percent of the precipitation is convective rain).[2] The rate of rainfall distribution in a place is very important because it can have a big impact on a sector. The importance of this amount of rainfall has been realized in the agricultural and related sectors.[3]

There is no single definition of drought that applies to all situations, but most definitions are based on a lack of precipitation resulting in a water shortage for some water-related activities. Drought can clearly be viewed solely as a physical phenomenon, regardless of definition.[4] A drought is defined as a period of time during which a part or region receives less rain than usual. Droughts can result in decreased soil moisture or groundwater, reduced streamflow, crop damage, and a general lack of water. Drought can occur in both locations with high and low rainfall.[5] It is a condition relative to some long-term average balance of rainfall and evapotranspiration in a specific area, a condition that is frequently perceived as "normal".[6] Water rationing was implemented in the districts of Kluang and Batu Pahat. In 2015, many districts including the city of Johor Bahru and also the industrial area of Pasir Gudang were subjected to water rationing.[7]

The aim of this study is to spread more widely that rain is the biggest influence for the drought season. Two objectives must be achieved in order to accomplish this: determine rainfall characteristics in Rantau Panjang, Johor, and determine the water level of Sungai Johor in Rantau Panjang, Johor. This study has its own significance to achieve the desires objectives which are to analysis amount of annual rainfall using several method and explore the characteristics rainfall.

2. Materials and Methods

The methods used in this study include the rainfall data, stream flow data and water level data that obtained from the Malaysian Meteorology Department (MMD). The main method used in this research is The Mann Kendall Test. The obtained data were then analyzed using Mann Kendall Test to calculate the rainfall distribution at the site.

2.1 Methods

Numerous considers have utilized the nonparametric Mann-Kendall (MK) factual test to recognize monotonic patterns in hydro-meteorological information, such as water level, rainfall, and streamflow. In the is that there is no trend test, the null hypothesis H0 in the population from which the data set is drawn and, j =1, 2, …, n} is independent the sample of statistics {xj and identically distributed.[8]

The significance of the trends is measured using the test statistic Z. In reality, the Mann-Kendall (MK) test's null hypothesis Ho assumes that there is no trend and is compared to the alternative hypothesis H1, which assumes that there is.[9] The null hypothesis is invalid if the estimated Z statistic is greater than the critical value at the given significance levels, meaning that the alternative hypothesis "there is a trend" is commonly accepted.[10]. An upward trend is indicated by a positive Z value, whereas a downward trend is shown by a negative Z value.[11] In this study, significance levels $\alpha = 0.01$ and $\alpha = 0.05$ were used. At the 5% significance level, the null hypothesis of no trend is rejected if $|Z|>1.96$ and rejected if $|Z|>1.645$ at the 1% significance level.

2.2 Equations

The test statistic, H1 Kendall's S is described as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} Sign(x_j - x_{k^1}) \quad \textbf{Eq. 1}$$

Where's :

n = Number of observations

xj, xk = Sequential data values

Where xj and xk represent sequential data values and n represents the number of observations.[12] The value of sgn(θ) is computed as follows, assuming (xj – xk) = θ[13]:

$$Sign(x) = \begin{cases} 1 & if\ x > 0 \\ 0 & if\ x = 0 \\ -1 & if\ x < 0 \end{cases} \quad \textbf{Eq. 2}$$

The positive test statistic, S, indicates a growing trend in the MK test, whereas the negative test statistic, S, suggests a decreasing trend. The S statistic's variance is defined as follows:

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_t^n ft(ft-1)(2ft+5)}{18} \quad \textbf{Eq. 3}$$

Where's:

t = Varies over the set of tied ranks.

ft = The number of times.

Where n signifies the number of tied groups (a set of sample data with the same value) and ft the number of ties in group t.[14]

The standardized Z statistic is computed as follows:

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}} & for\ S > 0 \\ 0 & for\ S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} & for\ S < 0 \end{cases} \quad \textbf{Eq. 4}$$

3. Results and Discussion

The results of this study are based on a graph and table created with SPSS and the Mann Kendall Test.

3.1 Results

Based on **Figure 1**, rainfall is directly proportional with stream flow. Rainfall and stream flow data is measured in millimetre (mm). Data on the **Table 1** shows information on 8 years. At α = 0.05 test the hypothesis that there is relation between rainfall and stream flow data.

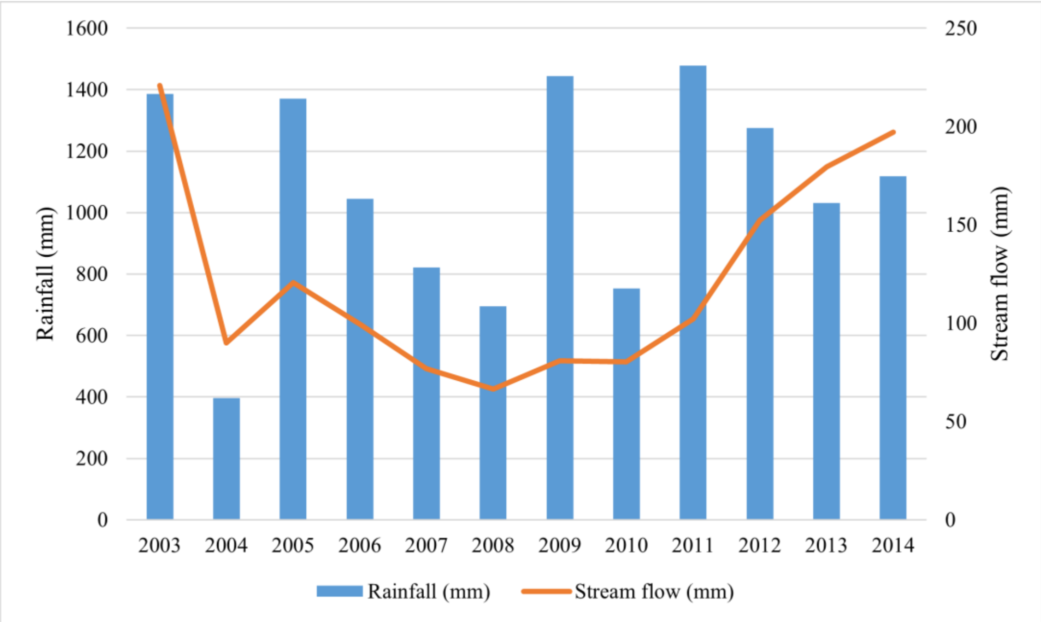

Figure 1 Rainfall and Stream Flow

Table 1 Monthly Average of Rainfall and Stream Flow for 8 Years

Months	Rainnfall (mm)	Stream Flow (mm)
Jan	216.63	1413.76875
Feb	61.88	575.32625
Mar	214.25	772.30
Apr	163.38	637.38
May	128.38	491.72
Jun	108.63	425.99
July	225.75	517.41
Aug	117.63	513.72
Sep	230.88	653.91
Oct	199.25	975.48
Nov	161.13	1148.523
Dec	174.75	1261.32

3.2 Discussions

The non-parametric Mann-Kendall test was used to compute the rainfall pattern for 8 years, from January to December, from 2003 to 2010. The Z statistics highlighted the series' tendency for 8 years for individual 12 months (January to December) in the Mann-Kendall test -1.86, 0.87, -0.12, -0.37, 0, -0.12, -0.12, -0.12, -2.35, -1.11, 0.37 and -0.25 respectively. For February and November there is an evidence of increasing trend while Zc value is showing negative trend in Jan, March, April, Jun, July, August, September, October, and December. The Zc value of May is zero shows no trend. Thus, Zc values demonstrate a positive trend for two months and a negative trend for the remaining nine months, indicating a nearly non-significant condition.(**Figure 2**).

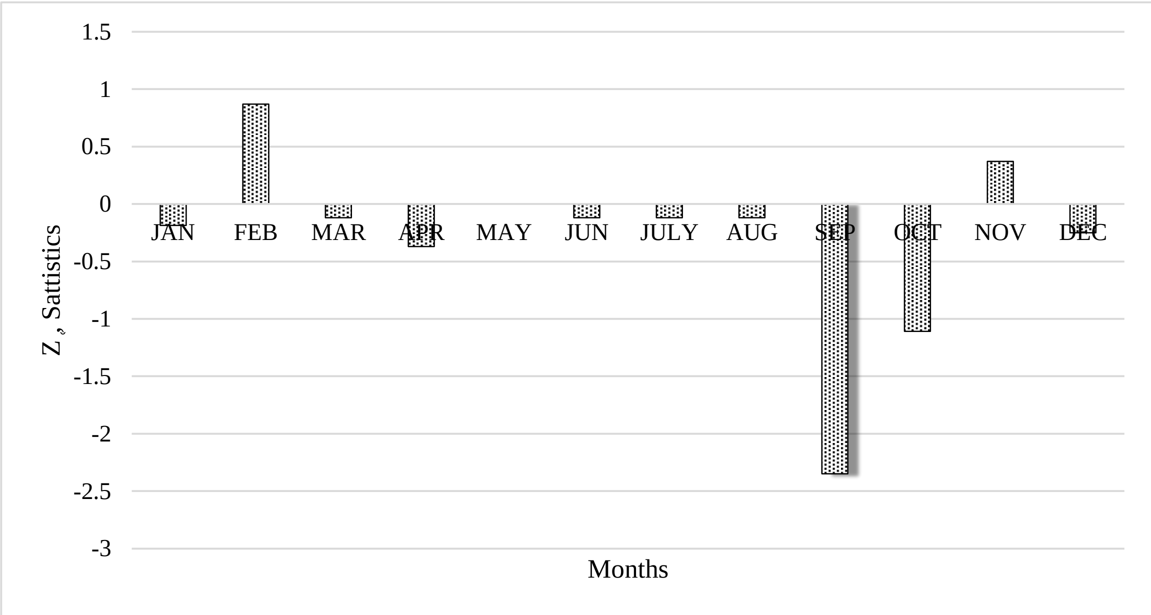

Figure 2 Monthly Average of Z Trend

The Z statistics of stream flow for 8 years is 0, 0, 0.37, 1.86, 1.86, 0.62, 1.61, 2.60, 1.86, 0.12, -0.12 and 0.37, respectively. There is evidence of a rising trend in March, April, May, June, July, August, September, October, and December, while the Zc value only demonstrates a downward trend in November. The Zc value of January and February are zero shows no trend. As a result, Zc values for the last 9 months show a positive trend, while Zc values for 1 month show a negative trend, indicating a condition that is almost non-significant.(**Figure 3**).

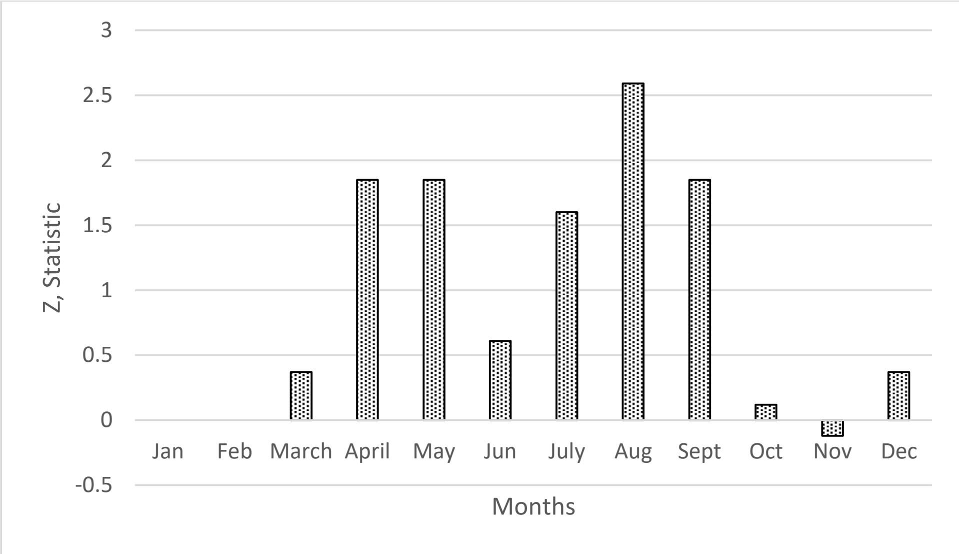

Figure 2 Monthly Average of Z Trend

Table 2 Statistical Analysis of rainfall of selected station in Johor River

Months	Mean	Median	P – value	Variance	Standard Deviation	Kendall's Tau
Jan	0	236.5	0.10	65.33	-16.00	-0.57
Feb	0	34.5	0.39	65.33	8.00	0.29
Mar	7	183	0.90	65.33	-2.00	-0.07
Apr	14	167	0.71	65.33	-4.00	-0.14
May	41	110.5	1.00	64.33	-1.00	-0.036
Jun	0	130	0.90	65.33	-2.00	-0.07
July	28	168	0.90	65.33	-2.00	-0.07
Aug	9	109	0.90	65.33	-2.00	-0.07
Sep	83	215	0.02 *	65.33	-20.00	-0.70
Oct	14	167	0.27	65.33	-10.00	-0.36
Nov	52	177.5	0.71	65.33	4.00	0.14
Dec	1	183	0.80	64.33	-3.00	-0.11

Note: *: $\alpha = 0.05$ level of significance.

Table 3 Statistical Analysis of stream flow of selected station in Johor River

Months	Mean	Median	P – value	Variance	Standard Deviation	Kendall's Tau
Jan	1413.7	1017.43	0.00 **	65.33	0.00	0.00
Feb	575.33	675.39	0.00 **	65.33	0.00	0.00
Mar	772.30	682.59	0.71	65.33	4.00	0.14
Apr	637.38	581	0.10	65.33	16.00	0.57
May	491.72	555.5	0.10	65.33	16.00	0.57
Jun	425.99	398.675	0.54	65.33	6.00	0.21
July	517.41	579.175	0.12	65.33	14.00	0.50
Aug	513.72	606.385	0.01 *	65.33	22.00	0.79
Sep	653.91	784	0.10	65.33	16.00	0.57
Oct	975.48	821.47	0.90	65.33	2.00	0.07
Nov	1148.53	1074.99	0.90	65.33	-2.00	-0.07
Dec	1261.32	796.81	0.71	65.33	4.00	0.14

Note: *:α = 0.05 level of significance

The result of Mann-Kendall trend test for the rainfall and stream flow are presented in **Table 2** and **3**. The Mann-Kendall trend test was conducted to check the null hypothesis that there is no trend, where the alternative hypothesis is to test the existence of trend, whether the trend is decrease or increase in the mean of the time series. **Table 2** and **3** show the parameters, mean, median, p-value, variance, standard deviation, and Kendall's tau respective. The significance level alpha = 0.05 which means it has 5% possibilities of rejecting the null hypothesis when it is true. The star one is consider as α = < 0.05 (= <5% possibilities). The result for Mann-Kendall test which the p-value = 0.02 for rainfall, where the average of September for 8 years shows statistically significant decreasing trend at 5% level. But the value of Z statistic is lower than 1.96, so the null hypothesis of no trend is accepted. For stream flow (p-value = 0.01) for August shows the statistically significant increasing trend at 5% level and p-value = 0.00 for two months (January and February) shows the statistically significant but there is no trend which means no increasing or decreasing trend at 5% in range 0.01 level. We can conclude the result of January and February is statistically significant but there is no trend. It is because, maybe there is a mistake when find the missing data or we incorrectly entered the data when calculating using the Mann Kendall test.

Ho: There is no relation between rainfall and water level (p = 0)

H1: There is relation between rainfall and water level (p ≠ 0)

Where's,

*Ho = Null hypothesis.

*H1 = Alternative hypothesis

Note: P-value > 0.05, positive relationship. P-value < 0.05, negative relationship.

Table 4 Summary Output

Regression Statistics	
Multiple R	0.416545417
R Square	0.173510085
Adjusted R Square	0.090861093
Standard Error	51.23537848
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5510.957486	5510.957486	2.099361	0.177982755
Residual	10	26250.64008	2625.064008		
Total	11	31761.59757			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	114.5984093	38.99577721	2.938738947	0.014817	27.710403	201.4864155	27.710403	201.4864155
STREAM FLOW (mm)	0.066833839	0.046126747	1.448917246	0.177983	-0.035942958	0.169610636	-0.035942958	0.169610636

By referring **Table 4**, value of p-value and significance F has same value (0.17). There is a significant positive relationship between the rainfall and stream flow data, r (12) = 0.41, p > 0.05 (alpha = 0.05). That means when annual rainfall is high, the annual stream flow is high. When the amount of rainfall is low it is because the occurance of drought season. We can conclude at February and Jun is the critical drought season in this 8 years. By referring **Table 4** the amount of rainfall is quite low than stream flow and it makes no sense if amount of stream flow high than rainfall. This happened because we do not do the outlier before analysing the missing data using the SPSS. The data that we obtained after using SPSS is not accurate and affected the result of this study.

4. Conclusion

In the conclusion, rainfall characteristic and water level of Sungai Johor at Rantau Panjang, Johor were succesfully determined as the main objective of this study is to spread more widely that rain is the biggest influence for the drought season. The rainfall in the east coast region of peninsular Malaysia is generally influenced by the north east monsoon (NEM), particularly during November or in the December.[15] This study also performed to help in flood assessment and forecasting of flood event in the future. For this study it is recommended to use more than one method to determine the trend analysis for the results comparison to improve the accuracy of the trend analysis, such as the Mann Kendall and Sen's Slope test. Another suggestion is to learn more about the temporal rainfall pattern, which entails studying the intensity of the rainfall. Aside from that, it is recommended to conduct forecasting and drought analysis to estimate floods and droughts.

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