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***Research paper***



# Flood Risk Pattern Recognition Analysis in Klang River Basin

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**Abstract**

This study was implemented to identify the specific factors that lead to major contribution of floods in Klang River Basin. A thirty-year (1987-2017) database obtained from Department of Irrigation and Drainage (DID), the selected data was analyzed by using integrated Chemometric techniques. The finding from Correlation Analysis revealed strong correlation between stream flow and water level is more than 0.5 (= 0.799). The finding from Principal Component Analysis proved that the selected parameters were significant with the result of $R^2 > 0.7$ was applied as a main tool for further analysis. Based on the result, it revealed that stream flow and water level were the most significant hydrological factor that influenced flood risk pattern in Klang River basin. Based on the result from Statistical Process control (SPC), the finding showed that the Upper Control Limit (UCL) for water level was 30.290m. The plotted data which is more than 30.290 m can cause flood to occur in Klang River Basin. Thus, it is very important to continuously monitor and maintain the mitigation measure of flood in the study area to avoid flood to occur. This study also helps to provide visualization of flood pattern and show the optimal rates for the maximum limit for flood control in Klang River Basin.

***Keywords***: *Chemometric Techniques; Correlation Analysis; Principle Component Analysis; Statistical Process Control.*

## 1. Introduction

Flood has been categorized in three types which are monsoonal flood, high tides and flash floods [1]. Based on the hydrological prospects, the main difference between these phenomena is the period taken by the river flow to recede back to the standard level. Flash floods take only several hours to return to the normal water level, but the monsoon flood will last up to a month [2].

This study examines the Klang river basin that flows through the capital city, Kuala Lumpur and the suburban area of the heavily populated and highly industrialized Klang Valley. Since independence in 1957, the economy in Malaysia has undergone rapid structural and development especially in Klang Valley that increase the growth of urbanization. The urban growth is vigorously developed that contribute to the rapid economic growth industrialization that lead to the high needs of improvement of facilities such as electricity, water supply, transportation, environment and drainage [3, 4].

In 2000, about 2.5 million Malaysian lived on the flood plain. This shows that many people have always interested to live at the city, and hence most of the Malaysian urban places have experienced revolutionary growth since 1957. Furthermore, flash flood can be happened by natural causes such as local weather known as line-squalls and non-natural causes such as inefficient urban drainage system and an increase in urban built-up areas. [5, 6] Due to the geographical changes and the increasing population, a lot of people in the city areas are exposed to the flood disaster. Most flash floods that occur in Malaysia's Klang Valley are the outcome of these factors

## 2. Materials and Methods

### 2.1. Experimental Study Area

The study design applied of this study is descriptive analysis study. The main purpose of this research is to conduct a case study at the local spatial scale in Klang River Basin regarding flood risk assessment by referring to the geographical information systems and historical flood data.

Klang River Basin is located in the most urbanized region in Malaysia which encloses the Federal Territory of Kuala Lumpur and compromises with part of the state of Selangor. The estimated population of Klang valley area is 4.4 million (about 16% of the national population) with growing rate of 5% annually. The catchment area of the Klang river basin is 1,288 square kilometers ($km^2$).

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The Klang River has a total length for 120 km and it covers about 35% of the basin was developed for residential, commercial, industrial and for institutional purposes. The upper catchment of the Klang River and its creeks the Gombak and Batu Rivers are surrounded with well-maintained forests. Klang River has 11 main streams which include Gombak River, Batu River, Kerayong River, Damansara River, Keruh River, Kuyoh River, Penchala River and Ampang River. The geographical of Klang is located at latitude 3° 13′ 58″ of the equator and longitude 101° 45′ 0″ east of the Prime Meridian on the Map of Kuala Lumpur. Four monitoring stations were selected along the Klang River basin by using four variables which are Rainfall, Suspended Solid, Stream Flow and Water Level. The data collection has been taken from the Department of Drainage and Irrigation. All the data collection has been analyzed by using XLSTAT software by using integrated chemometric techniques.



**Fig. 1:** Location of monitoring station at Klang river basin

**Table 1:** Location of monitoring station at Klang river basin

| Variables | Station Number | Latitude | Longitude | Location |
|---|---|---|---|---|
| Rainfall | Site 3116006 | 03° 11' 00" N | 101° 38' 00" E | Ldg. Edinburgh Site 2, KL |
| Stream flow | Site 3116434 | 05° 29' 55" N | 100° 70' 42" E | Sg. Batu, Sentul |
| Suspended solid | Site 3116434 | 05° 29' 55" N | 100° 70' 42" E | Sg. Batu, Sentul |
| Water level | Site 3116434 | 05° 29' 55" N | 100° 70' 42" E | Sg.Batu, Sentul |

## 2.2. Statistical Analysis

For this research, the Correlation analysis was applied to identify the tough relationship between variables to use in another analysis. This analysis is suitable to measure two variables where the relationship is between -1 to 1. In this study, the types of products that can be applied are Pearson Coefficient and Spearman Coefficient, but the former was universally applied should have a connection between two variables [7]. These products have been applied in this study in order to determine the relationship between main parameters in hydrological data and also to determine the parameter with the toughest relationship. Therefore, the development with the biggest effect on the hydrological modeling in Klang River Basin can be identified.

The two most common types of correlation are Spearman's and Pearson's rank coefficients which are the former that needs ordinal data as the calculation will depend on data ranking. In other hands, it also assesses the degree of strength for the coefficient between variables considered in the research [8, 9]. For this method, there can be either positive or negative correlation; the positive correlation will specify one variable increasing together in a linear condition and for negative correlation, it indicates one variable increasing but the other decreasing in a linear condition. At the same time, the Pearson rank coefficient needs actual data for the calculation and all variable considered need to be in the form of the ratio scale. Both tests were applied in this study, and only the good result was utilized for the discussion section in this study.

## 2.3. Principle Component Analysis (PCA)

PCA is one of the technique that able to identify a large number of variables into smaller sets of data [10]. It also provides information on the most significant parameters based on the spatial and temporal variations that designate the whole data set by keeping out the less significant parameters with minimum loss of original information [11]. This method also shows multicollinearity (two or more variables that are correlated), that was applied in this study as well. The equation for this method was:

$$Zij = ai^1 xj^1 + ai^2 xj^2 + ai^3 xj^3 + aimx \quad (2)$$

where Z = Component score, a = Component loading, x = Measured of variables, I = Component number, m = Total variables.

## 2.4. Statistical Process Control

The Time Series Analysis is an application of the SPC to predict the water level of the study area. This method will be able to evaluate the process from the performance of the analyzed data effectively. This method also produced three important results, which were vital in predicting the future hydrological modeling, and those results were Upper Control Limit (UCL), Average Value (AVG), and Lower Control Limit (LCL). The Sigma in control chart is present as the range value of a set of data. In addition, the Control Chart are able to uncover some trends and patterns that shows the actual data deviations from the historical baseline and dynamic threshold, being able to capture uncommon resource usage and creating the best base lining to identify how actual data have deviated from the historical baseline [12]. The equation for this method was:

Moving Range = Plot: MRt for t = 2, 3, …, m.

where

MR = average moving range,
t = time,
m = individual values

Average Value:

$$\tilde{X} = \frac{\sum_{i}^{m=1} x_i}{m} \quad (3)$$

where

$\tilde{X}$ = moving range,
m = individual values,
xi = difference between data point.

# 3. Results and Discussion

From the result in Table 2, Correlation analysis showed that stream flow and water level have the highest correlation with the result of correlation coefficient is 0.799. Meanwhile, the correlation for suspended solid and rainfall is 0.039 and it is evaluated as a weak correlation. Based on the previous study, the correlation coefficient can be considered as a strong correlation if the correlation coefficient is 0.7 and above and it is suitable to be chosen for further analysis [13].

**Table 2:** Result for Correlation analysis

| Variables | Stream Flow | Suspended Solid | Water Level | Rainfall |
|---|---|---|---|---|
| Stream flow | 1 | -0.013 | 0.799 | 0.222 |
| Suspended solid | -0.013 | 1 | 0.435 | 0.039 |

| | | | | |
|---|---|---|---|---|
| Water level | 0.799 | 0.435 | 1 | 0.225 |
| Rainfall | 0.222 | 0.039 | 0.225 | 1 |

### 3.1. Factors that Contribute to Flood Occurrence

From Table 3, it showed that Stream flow and Water Level has the highest coefficient; 0.916 for stream flow and 0.948 for water level. When the coefficient is more than 0.7, it is categorized as strong coefficient. Therefore, it is proved that stream flow and water level are affected from the unsustainable human development that causes massive erosion of the river bank. This trigger a condition where the river becomes shallower as the impact of deposited residual from the erosion process [14].

Based on the Fig. 2, it is proved that the increasing of water level caused the changes of stream flow rate depending on the intake of suspended solid flow into the river. The positive pattern of the water level changes significantly caused the increasing speed of stream flow in Klang river basin.

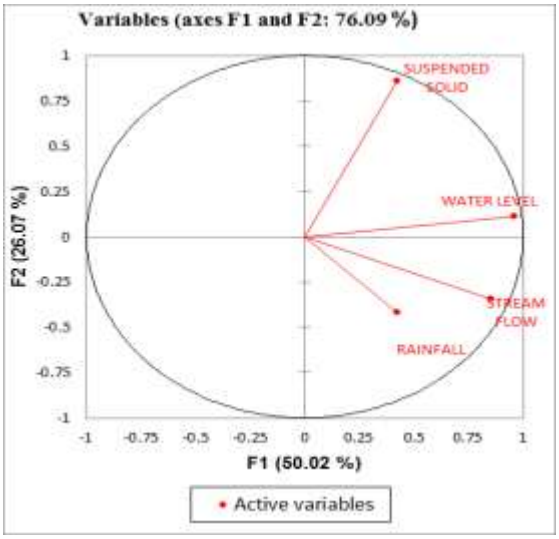


**Fig. 2:** Correlation coefficient between variables and factor loading

**Table 3:** Correlation coefficient between variable factors from 1987-2017

| Variables | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| Stream Flow | 0.853 | -0.344 | 0.349 | 0.181 |
| Suspended Solid | 0.422 | 0.859 | 0.273 | -0.100 |
| Water Level | 0.958 | 0.112 | -0.163 | 0.206 |
| Rainfall | 0.422 | -0.418 | 0.805 | -0.003 |
| Variability (%) | 50.025 | 26.066 | 21.773 | 2.136 |
| Cumulative (%) | 50.025 | 76.091 | 97.864 | 100 |

### 3.2. Flood Control Warning System

The result for Time Series Analysis can be applied for further analysis as an improvement of flood early warning system in the Klang River Basin. There are three categories for control limit and those categories are Upper Control Limit, Control Limit and Lower Control Limit.

Based on the SPC result for water level in Klang River Basin, it showed that the Lower Control Limit (LCL) was 29.821 m, the Control Limit (CL) was 30.055 m and the Upper Control Limit (UCL) was 30.290 m. Results showed in Fig. 3 (a) indicate the flood patterns in the study area. The plotted data which is more than 30.290m can be assumed as UCL and it can cause flood to occur in the study area. Furthermore, when the water level plotted within the range of CL that starts from 30.055m until 30.134m can be assumed as adequate for the water to support by river basin. The range of CL level can be classified as within the safe zone and does not cause flood to occur. Besides that, when the water level falls between 29.821m until 29.899m, it can be classified as no issue for flood to occur at Klang River Basin. The highest reading for water level was 30.8m which happened in year 2010. This condition happened because the base of the river turn to shallow and cause danger for flood occurrence if heavy downpour occur within this period of time.

Fig. 3 (b) showed the whole result for control limit value of rainfall in Klang River Basin. The result shows that -21.843 mm for the Lower Control Limit (LCL), about 7.845 mm for the Centre Limit (CL) and 36.813 mm for Upper Control Limit (UCL). The result proved the rainfall patterns in the study area. The data that has been plotted above UCL can be said as an abnormal condition of rainfall phenomena. The patterns also can be considered as above the ordinary limit of rainfall value in the study area.

The highest reading for rainfall was 100.5 mm that occurred in February 2009 which is not occur in the monsoon season. This is due to the climate changes that cause imbalance water cycle in the study area.

By referring to Fig. 3 (c), the result is referred to control limit value for stream flow in Klang River Basin. From the result, it shows that the LCL for stream flow was 2.542 m/s, the CL was 12.188 m/s and UCL for stream flow was 21.839 m/s. The highest reading for stream flow was 88.830 m/s. According to the research carried out by [15] flood that happened on urban area are caapplied by improper drainage system when the water discharge from the stream becomes too high to be accommodate in the small stream channel and thus, it can cause flood to occur. The stream widens its channel when the discharge is too high and then overtopping its banks and flooding the low-lying areas surrounding the stream. In addition, most of the river in urban areas was covered with cement. Thus, cement cannot absorb water as quickly as soil and the urban development makes river become shallow and narrower.

Next, Fig. 3 (d) showed the result for control limit of suspended solid in the Klang River Basin. Based on the result, it shows that 387.874 tonnes/day for the Lower Control Limit (LCL), 700.779 tonnes/day for the Centre Limit (CL) and 1013.684 tonnes/day for Upper Control Limit (UCL). The result indicates the suspended solid pattern occurred in the study area. The highest reading for suspended solid was 3641 tonnes/day that happened in October 2008. The rate of suspended solid which is above control limit gave an effect to the changes of water level that lead to flood.

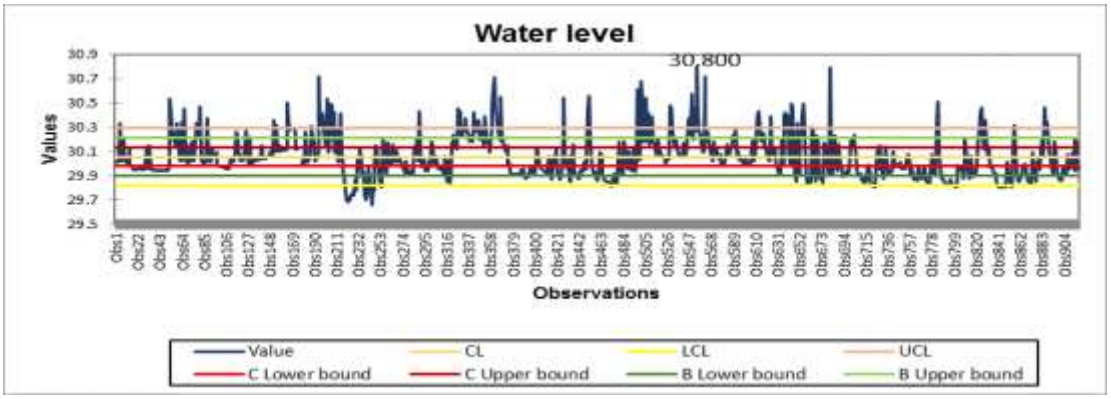


**Fig. 3 (a):** Result of SPC for water level in Klang River Basin

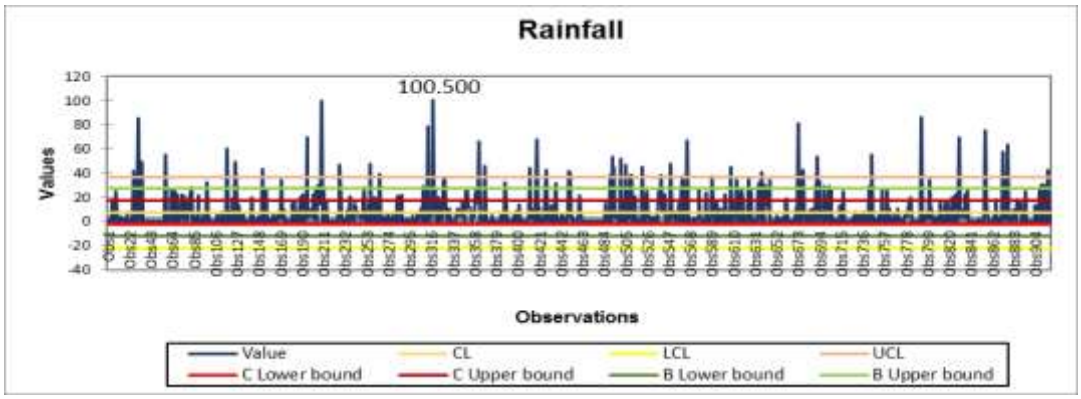


**Fig. 3 (b):** Result of SPC for rainfall in Klang River Basin

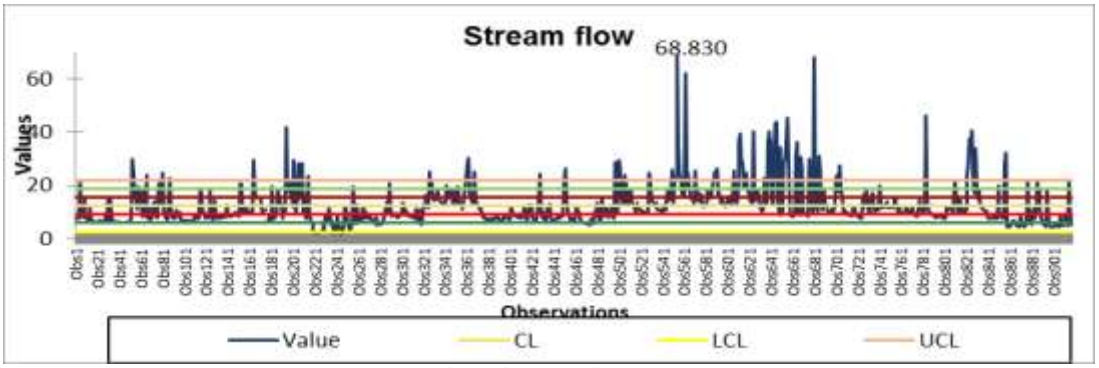


**Fig. 3 (c):** Result of SPC for stream flow in Klang River Basin

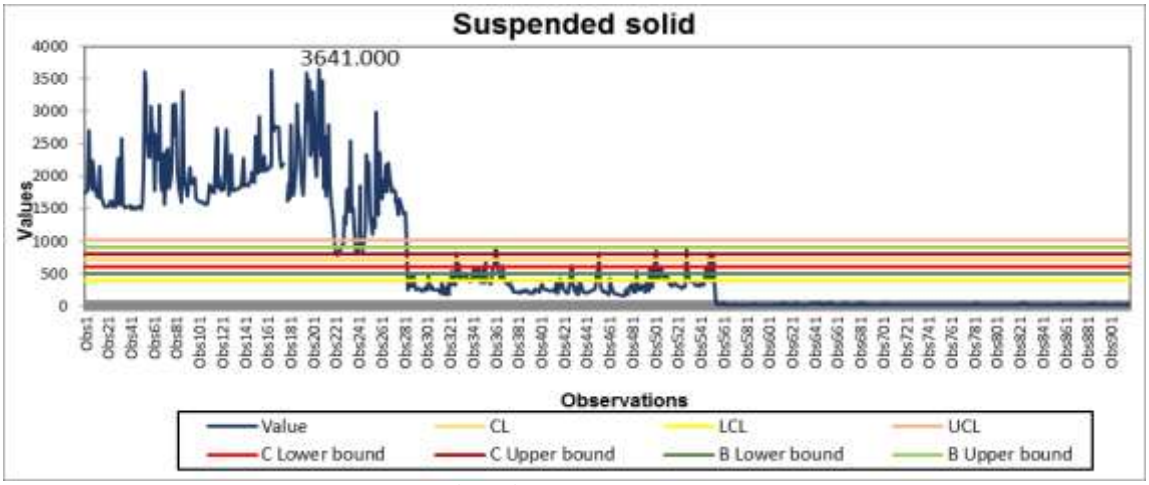


**Fig. 3 (d):** Result of SPC for suspended solid in Klang River Basin

## 4. Conclusion

This study could be summarized that there was significant correlation between all variables and parameter in this study. Stream flow and was the major contribution for the changes of water level in Klang River Basin. This is due to the reason where human development caused the changes of surface runoff into the river. The impact of this condition has caused the Klang river become shallower than before. This situation will lead to the increasing rate of stream flow in the study area and able to become flash flood during short period of heavy rainfall. The SPC analysis applied in this study provides early warning system for flood. Control limit set by this analysis able to alarm the local authority at the early stage for preparing emergency response plan before, during and post flood event to the affected public. Flood risk model created in this study able to assist the state government and local authority to create a systematic and effective mitigation measures for flood control in Klang Valley.

## Acknowledgement

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## References

[1] Zakaria, S. F., Zin, R. M., Mohamad, I., Balubaid, S., Mydin, S. H., & MDR, E. R. (2017). The development of flood map in Malaysia. AIP Conference Proceedings, 1903(1), 1-8.

[2] Noorazuan, M. H. (2006). Urban hydrological changes in the Sankey Brook catchment. PhD thesis. University of Manchester.

[3] a, N. A., Ghani, A. A., Abdullah, R., Sidek, L. M., Kassim, A. H., & Ainan, A. (2004). MSMA–A new urban stormwater management manual for Malaysia. Advances in Hydro-Science and – Engineering, 6, 1-11.

[4] Toriman, M. E., Hashim, N., Kamarudin, M. K. A., Hassan, A. J., Gasim, M. B., Muhamad, A., & Aziz, N. A. A. (2015). Assessment of water salinity model using hydrodynamic numerical modelling in estuary of Selangor River, Malaysia. Malaysian Journal of Analytical Sciences, 19(5), 1109 – 1119.
[5] Mohamad, S., Hashim, N. M., Aiyub, K., & Toriman, M. E. (2012). Flash flood and community's response at Sg. Lembing, Pahang. Advances in Natural and Applied Sciences, 6(1), 19-26.
[6] Moore, D. S., Craig, B. A., & McCabe, G. P. (2012). Introduction to the practice of statistics. WH Freeman.
[7] Altman, D. G. (1990). Practical statistics for medical research. CRC press.
[8] Saudi, A. S. M., Ridzuan, I. S. D., Balakrishnan, A., Azid, A., Shukor, D. M. A., & Rizman, Z. I. (2017). New flood risk index in tropical area generated by using SPC technique. Journal of Fundamental and Applied Sciences, 9(4S), 828-850.
[9] Saudi, A. S. M., Kamarudin, M. K. A., Ridzuan, I. S. D., Ishak, R., Azid, A., & Rizman, Z. I. (2017). Flood risk index pattern assessment: Case study in Langat river basin. Journal of Fundamental and Applied Sciences, 9(2S), 12-27.
[10] Juahir, H., Zain, S. M., Yusoff, M. K., Hanidza, T. T., Armi, A. M., Toriman, M. E., & Mokhtar, M. (2011). Spatial water quality assessment of Langat River Basin (Malaysia) using environmetric techniques. Environmental Monitoring and Assessment, 173(1-4), 625-641.
[11] Saudi, A. S. M., Juahir, H., Azid, A., Kamarudin, M. K. A., Kasim, M. F., Toriman, M. E., Aziz, N. A., Hasnam, C. N., & Samsudin, M. S. (2014). Flood risk pattern recognition using chemometric technique: A case study in Kuantan River Basin. Jurnal Teknologi, 72(1), 137-141.
[12] Herman, I. (1994). Selangor: Tekno Edar–Descriptive statistical analysis.
[13] United States Geological Survey's Water Science School. (2016). How much water flows during a storm. https://water.usgs.gov/edu/stormflow.html.
[14] Yoon, K. Y., Azima Bahrun, N., & Kun, Y. (2010). A study on the urban flooding
[15] Kong, Y., & Pang, Z. (2012). Evaluating the sensitivity of glacier rivers to climate change based on hydrograph separation of discharge. Journal of Hydrology, 434, 121-129.