The correlation between temperature and humidity with the population density of *Aedes aegypti* as dengue fever’s vector

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Abstract. The weather change in South East Asia have triggered the increase of dengue fever illness in Indonesia. Jakarta has been declared as one of dengue fever endemic region. This research aim to gain the dynamic of dengue fever incidents related to temperature, humidity and the population density of *Aedes aegypti*. This research implementated Design of Ecology Study. The samples were collected from April 2015 to March 2016, from houses located in the suburbs i.e. Pasar Minggu, Ciracas, Sunter Agung, Palmerah and Bendungan Hilir. The sampling based on Sampling Design Cluster and each suburb represents 153 samples. The research shows correlation between temperature (p value 0.000) and humidity (p value 0.000) with *Aedes aegypti* as dengue fever’s Vector. Therefore, an early warning system should be developed based on environmental factors to anticipate the spread of dengue fever.

Keywords: aedes aegypti, dengue fever, humidity, temperature

1. Introduction

As a DHF vector, *Aedes aegypti* can adapt to urban environments, contact with humans and transmit disease [1]. Climate change in a short time is a complex system because it is influenced by many factors that interact with each other. Dynamic models and stochastic models can be used to analyze dengue cases and climatic factors, mapping strategies, prevention and monitoring of DHF. The dynamic characteristic of this method comes from a unique structural model of a simulation model designed to predict future cases [2], [3]. Dynamics analysis is developed into a dynamic structure pattern in which each structure has a different pattern that is expressed through a loop or feedback. There are four more influence subsystems to contribute to disease: climatic subsytem, vector, human disease and dengue. These subsystems are interrelated, mutually influence and have separated the dynamics. This research was aimed at gaining the dynamic of dengue fever incidents that was related to temperature and neighbourhood’s humidity as well as the density population of *Aedes aegypti*.

2. Research Method

2.1. Research Design

This research used the cross sectional and ecologic study design [4].

2.2. Place and Time of Research

This research is performed in dry and wet season in one year period, since April 2015 until March 2016. All data was collected from South Jakarta (district Pasar Minggu), East Jakarta (district Ciracas), North Jakarta (district Sunter Agung), West Jakarta (district Palmerah), and Central Jakarta (district...
Bendungan Hilir). These locations include as region, which stated as endemic region of DHF by Government of Jakarta based on DHF outbreak.

2.3. Population and Sample
Vector of Aedes mosquito: calculation of the maturity Aedes is performed one time per week by calculate Man Landing Rate (MLR) by people feedback and calculating of resting habit as follow [4][5].

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\text{MLR} = \frac{\text{total of captured mosquito per species}}{\text{total of the captured hour} + \text{total of collector}}
\]

3. Results and Discussion
The observation result showed that there was a significant correlation between temperature, humidity and Aedes mosquito population. Aedes population increase is an indicator of increase in DHF cases. The lowest average environmental temperature was 32.37 °C in East Jakarta and the highest average was 33.77 °C in North Jakarta (Table 1).

| Month  | South Jakarta | East Jakarta | North Jakarta | West Jakarta | Central Jakarta | Mean |
|--------|---------------|--------------|---------------|--------------|-----------------|------|
| April  | 32.17         | 33.41        | 34.28         | 33.23        | 32.73           | 33.16|
| May    | 34.22         | 33.57        | 34.47         | 33.29        | 34.22           | 33.95|
| June   | 32.83         | 34.65        | 35.26         | 35.17        | 34.58           | 34.50|
| July   | 32.26         | 30.87        | 32.74         | 32.45        | 33.37           | 32.34|
| August | 32.75         | 31.18        | 32.58         | 32.49        | 32.85           | 32.37|
| September | 33.20   | 31.77        | 33.23         | 33.51        | 35.19           | 33.38|
| October| 34.65         | 32.25        | 33.86         | 32.72        | 33.64           | 33.42|
| November| 33.75        | 32.63        | 33.59         | 33.45        | 34.27           | 33.54|
| December| 30.12        | 32.14        | 34.42         | 33.83        | 32.25           | 32.55|
| January| 31.64         | 31.51        | 33.25         | 33.72        | 32.36           | 32.50|
| February| 32.15        | 31.87        | 33.67         | 31.73        | 32.29           | 32.34|
| March  | 32.10         | 32.55        | 33.92         | 32.59        | 33.74           | 32.98|

Mean 32.65 32.37 33.77 33.18 33.46 33.09

The lowest average humidity per region during one year of observation was 64.51% in East Jakarta and the highest of 67.12% in North Jakarta (Table 2).

3.1. Vector and DHF cases
MLR is calculated each two weeks once time, it shows total of the perched adult mosquito per person per hours are 1.46 (1.46 + 0.63). The lower of MLR: occur in July in Central Jakarta: 0.50, and higher 2.75 in September (South Jakarta). Average of MLR in West Jakarta is low, maximum occur in July-September and February. Although the positive correlation is low which occur in July, September and February Differ in Central Jakarta. From April until July, MLR feel decrease step by step and reach the first its peak in September when the rainfall curve feels decrease.
Table 2. Relative humidity (%) in Jakarta, April 2015–March 2016.

| Month      | South Jakarta | East Jakarta | North Jakarta | West Jakarta | Central Jakarta | Mean  |
|------------|---------------|--------------|---------------|--------------|----------------|-------|
| April      | 68.33         | 69.13        | 69.25         | 71.65        | 72.33          | 70.14 |
| May        | 58.75         | 65.87        | 67.95         | 62.33        | 62.75          | 63.53 |
| June       | 58.92         | 64.25        | 64.17         | 58.27        | 59.28          | 60.69 |
| July       | 59.77         | 58.73        | 64.21         | 62.00        | 62.33          | 61.41 |
| August     | 60.40         | 59.16        | 62.05         | 56.25        | 56.75          | 58.92 |
| September  | 60.65         | 60.28        | 62.87         | 58.20        | 56.83          | 59.77 |
| October    | 58.65         | 56.05        | 65.35         | 64.25        | 63.90          | 61.64 |
| November   | 60.78         | 61.29        | 64.73         | 61.72        | 62.15          | 62.13 |
| December   | 62.25         | 62.83        | 63.81         | 60.25        | 65.95          | 63.02 |
| January    | 78.50         | 70.65        | 72.65         | 75.15        | 78.00          | 74.99 |
| February   | 77.60         | 74.15        | 73.32         | 77.30        | 78.70          | 76.21 |
| March      | 72.45         | 71.76        | 75.07         | 78.25        | 78.55          | 75.22 |
| Mean       | 64.75         | 64.51        | 67.12         | 65.47        | 66.46          | 65.66 |

Multivariate analysis was used to calculate the p value of temperature (p: 0.000) and humidity (p: 0.000) as independent variable. The man landing rate (MLR) as dependent variable (Table 3). The correlation between temperature, humidity and man landing rate (MLR) is shown on the graph of Figure 1.

Table 3. Environmental factors with MLR in Jakarta 2015–2016.

| Variable | Std. Error | Beta | P value |
|----------|------------|------|---------|
| Temperature | 0.014 | -0.004 | 0.000 |
| Humidity  | 0.002 | -0.137 | 0.000 |

Dep.Var.: MLR

Tabel 4. MLR of Aedes in Jakarta, April 2015–March 2016.

| Month     | South Jakarta | East Jakarta | North Jakarta | West Jakarta | Central Jakarta | Mean  |
|-----------|---------------|--------------|---------------|--------------|----------------|-------|
| April     | 1.48          | 1.12         | 1.93          | 1.05         | 1.72           | 1.46  |
| May       | 1.03          | 1.20         | 1.70          | 0.84         | 1.51           | 1.26  |
| June      | 1.21          | 0.74         | 1.58          | 1.57         | 0.89           | 1.20  |
| July      | 1.68          | 0.65         | 1.00          | 1.85         | 0.50           | 1.14  |
| August    | 2.17          | 1.15         | 0.73          | 1.52         | 0.81           | 1.28  |
| September | 2.75          | 1.30         | 1.34          | 1.57         | 1.59           | 1.71  |
| October   | 1.82          | 0.87         | 1.02          | 1.22         | 1.40           | 1.27  |
| November  | 0.61          | 1.20         | 0.73          | 0.56         | 1.25           | 0.87  |
| December  | 0.72          | 1.82         | 0.50          | 1.10         | 1.92           | 1.21  |
| January   | 1.55          | 2.15         | 1.36          | 1.64         | 2.33           | 1.81  |
| February  | 2.21          | 2.53         | 2.12          | 1.89         | 2.72           | 2.29  |
| March     | 1.72          | 2.41         | 1.98          | 1.22         | 2.53           | 1.97  |
| Mean      | 1.58          | 1.43         | 1.33          | 1.34         | 1.60           | 1.46  |
The MLR is exception in September, when occur increasing of MLR, can explain that higher temperature and lower humidity, MLR will increase but its transmission rate is low. High transmission is occur when higher rainfall, lower temperature and higher humidity [6], as occur in December until February.

3.2. Prediction DHF Cases Based on Model of Environmental Factors

Based on Figure 2, there are for related subsystem by occurrence process of DHF that is climate subsystem, Aedes subsystem, human subsystem, and DHF subsystem. Four subsystems are interrelated and inter influencing.

First subsystem is climate. In this subsystem, there is rainfall, temperature, and relative humidity. Second subsystem is the life cycle of Aedes mosquito. Connecting factor to climate and mosquito subsystem is location of breeding places (BP). BP is more influenced by rainfall [7]. Other connecting factor from climate subsystem is environment, which influence Extrinsic Incubation Period (EIP). The EIP is influenced by environment temperature, humidity, viremia rate in human, and virus strain. Increasingly in temperature can minimized EIP and increase the transmission process [8]. The temperature can increase until 34°C will influence water temperature of BP and also can influence hatching egg become the larva. DHF occurrence is determined by contact between mosquito and human[6]. Human activities are indicated by how much using fosil fuel. Impact from this is emission of CO₂. Based on statistic analysis is known that there is significant correlation between MLR, temperature and humidity, by p-value :0.000.

Figure 1. Correlation of MLR, temperature and humidity in Jakarta, April 2015–March 2016.
4. Conclusion
From the finding and discussion above can be concluded as follows:
1. Mean of man landing rate 1.46, temperature 33.09°C and relative humidity 65.66% in Jakarta.
2. There is significant correlation among man landing rate, temperature (p: 0.000), and relative humidity (p:0.000).
3. The climate factor, which influence man landing rate, is temperature, outdoor humidity, and which influence the man landing rate of Aedes mosquitoes.
4. To anticipate the spread of Dengue Hemorrhagic Fever cases, there should be early warning system through temperature and humidity as the environmental factors.

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