Environment and Health in Urban Area: Analysis of Mosquito Density in Kuala Lumpur, Malaysia

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ABSTRACT

This study examines the relationship between mosquito density, as determined by the Breteau Index (BI), and the elements of environment in urban areas, specifically Kuala Lumpur, and identifies hotspots of BI by applying Geography Information System (GIS), Remote Sensing, and Geostatics method. Weekly BI data from the Ministry of Health Malaysia, monthly rainfall data and the type of land use in 300 meter square for each locality are utilized in this study. The third data are classified into five areas - water, plinth, devoid of vegetation, sparse vegetation, and dense vegetation. The findings reveal that there is a significant relationship between the number of locality with high BI and the total rainfall ($r = 0.64$, $p = 0.024$). On the other hand, there is no significant relationship between BI and the type of land use (built-up area: $r = 0.162$, $p = 0.118$; cleared area: $r = -0.107$, $p = 0.304$; dense vegetation area: $r = -0.206$, $p = 0.046$; sparse vegetation area: $r = 0.023$, $p = 0.823$; and water area: $r = 0.246$, $p = 0.016$). Using Kernel Density, the value of BI for the whole of Kuala Lumpur can be mapped and several hotspots can be identified. The identification of these hotspots is important as part of the effort to reduce the statistics of dengue cases in Malaysia or Indonesia as it can assist the health authority to plan and implement the prevention and control of mosquito breeding.

Key words: mosquito density, urban area, environment, Kuala Lumpur.
Dengue, a major tropical and subtropical arthropod-borne viral disease, still remains as one of the major worldwide public health concern and problem (CDC, 2005; WHO, 2008). An arbovirus infection mainly affecting human population in endemic areas, dengue is transmitted by dengue viruses serotypes (DEN-1, 2, 3 and 4) carried by two common genus *Aedes* (subgenus of Stegomyia) infected female mosquitoes namely *Aedes aegypti* and *Aedes albopictus* (Rudnick et al., 1965; Gubler, 1998). Clinically, patients infected with dengue fever can be characterized as having severe fever and intense headache, prostration, leucopenia, myalgia, arthralgia, loss of appetite as well as serious pain in various part of the body (Vazquez-Prokopec et al., 2010).

In Malaysia, dengue fever was first reported in 1902 (Skae, 1902), whilst dengue haemorrhagic fever in 1962 (Rudnick et al., 1965). The incidence rate of DF and DHF in Malaysia showed an increasing trend from 44.3 cases/100,000 populations in 1999 to 181 cases/100,000 populations in 2007. Most of the dengue cases in Malaysia occurred more in urban areas than in rural areas. Human behaviour factors such as high population density, rapid development and increased population movement and lifestyle, provide conducive breeding conditions for the distribution and transmission of dengue *Aedes* (Aziz et al., 2012; MOH, 2010).

Control strategies such as continuous vector surveillance has been implemented in order to monitor the intensity and distribution as well as to reduce the emergence of adult mosquitoes especially the *Aedes* species. The utilization of Geographic Information System (GIS) and Remote Sensing can be implemented in order to understand dengue transmission. Vector control such as Container Index (CI), House Index (HI) and Breteau Index (BI) - also known as conventional indices - are frequently used as a statistical index for determining the transmission of dengue virus for immature stages of mosquito population (Hani, 2007). Among these three indices, Breteau Index (BI), defined as the number of positive containers (i.e. containing *Aedes* mosquito larvae) per 100 houses inspected (WHO, 2010), is most widely used. BI plays an important role in larvae surveillance, focusing on predicting the mosquito intensity in suspected localities. Thus, this study particularly aims to examine the relationship between the recommended hotspots and the environmental factor (rainfall), to determine the relationship between the utilization of Breteau Index (BI) and land use, and to estimate the spatial density of Breteau Index (BI) among hotspot areas.

**Methodology**

**Study Area**

This preliminary study was carried out in Kuala Lumpur during the period of January 2010 to December 2010. Located at 3°8'51"N and 101°41'35"E, the city, making up an area of 243 km² with an average elevation of 21.95 m, is located in the centre of Selangor state and has up to 1.6 million population. Statistically, the average maximum temperature of the city is 32.4°C whilst the average minimum temperature is 23.3°C. The city has received almost 2,600 millilitres
(mm) per year, with the months of June and July are relatively dry due to its tropical rainforest climate. In order to achieve the aims of this study, we divided the city into six zones - Kepong, Setapak, Damansara, City Centre, Klang Lama and Cheras (Figure 1). All zones are under the jurisdiction of Kuala Lumpur City Hall (KLCH).

**Data Sources, Integration and Management**

The 2010 weekly report data on Breetu Index (BI) were obtained from the Ministry of Health (MOH) and contained the list of hotspots localities throughout the six zones of Kuala Lumpur. The 2010 monthly rainfall data, on the other hand, were obtained from the Malaysia Meteorological Services Department. Initially, all the data including rainfall and hotspots localities data were entered into a Microsoft Excel to generate the vector program database. Later, these data were sorted out according to each zone, and then cleaned and processed. The locations for all suspected hotspot localities were also gathered using handheld Garmin GPSMAP 60CSx.

![Figure 1: Study Area](image-url)
Implementation of Remote Sensing and Spatial Statistical Tools

The Systeme Probatoire pour l’Observation de la Terre (SPOT) 5 satellite imagery of Kuala Lumpur was acquired in 2010 and the topography map with 1:50 000 scale and ground truth data were used as a basis for image classification. The digital image processing and classification were performed using the ENVI 4.5 software. A Region of Interest (ROI), Regions of Interest (ROIs) or the training area for image classification was selected according to the visual interpretation and the ground truth data. Each ROI classes was calculated using the Jeffries-Matusita and Transformed Divergence measures to obtain the information on how well the separability among each object class. Most of the object class have values of 2.0, indicating highly separable object class. Six objects were grouped in the ROI based on the ground truth campaign; Water, Built-Up, Vegetation Sparse, Vegetation Dense, Cleared Area. These six groups were used as the basis for land use classification in the study area. The percentage of each type of land use around 300 meters at each hot spots point was then calculated. Next, the Pearson correlation coefficient was used to determine the relationship between land use and BI.

The Kernel density estimation interpolation technique was utilized in order to analyze the hotspot localities. Kernel estimation, a technique involving the identification of high risk areas within point patterns of disease incidence; not only produces a continuous and smooth surface, but also provides information on the level of risk for particular area (Bithell, 1990). This technique has been proven to be a better hotspot identifier as compared to cluster analysis as the former can calculate density of point features around output raster cell (Levine, 2007).

Result

Using Pearson Correlation formulation, the number of hotspot localities with high BI obtained from the Ministry of Health (MOH) was correlated with the monthly rainfall data obtained from the Department of Meteorological, Malaysia. In this preliminary study, two variables - hotspot and rainfall - were used in order to assess the spatial density of BI within six zones particularly the six hotspot localities in Kuala Lumpur area (Figure 2). Generally, the number of hotspot localities with high BI and monthly rainfall data is strongly significantly positive with the r value less than 1 and p-value below 0.05 (r = 0.64 and p-value = 0.024) (data not shown).
Figure 2: Number of Hotspot locality and Rainfall

The results also show that the types of land use do not appear to influence the population of mosquito within the six zones in Kuala Lumpur area (Build-up: $r = 0.16$, $p$-value = 0.118; Cleared area: $r = -0.107$, $p$-value = 0.304; Vegetation dense: $r = -0.206$, $p$-value = 0.046; Vegetation sparse: $r = 0.023$, $p$-value = 0.823; Water: $r = 0.246$, $p$-value = 0.016). Kernel density estimation was also utilized in the study to determine the location of hotspot localities for dengue cases based on high number of BI among the six zones in Kuala Lumpur area (Figure 3). In Figure 3, the dark coloured areas show the hotspot localities with the highest number of BI, and are represented as H1 (Vista Angkasa Apartment, Klang Lama zone), H2 (Seri Selangor Flat, City Centre zone), H3 and H4 (Taman Setapak Jaya and Taman Setapak, Setapak zone), H5 (Desa Tun Razak, Kepong zone) and H6 (Taman Bukit Maluri, Cheras zone).

Discussion

The vaccine to treat both DF and DHF is unavailable; hence, the mosquito control measurement remains the ideal strategy to control the transmission of dengue virus by infected female Aedes mosquito and to reduce the statistical number of dengue cases within hotspot areas. Dengue is still considered as a priority and continuous effort from health authorities such as WHO, to define and
search for new control entomological strategies, in an effort to monitor the proliferation of *Aedes* mosquito throughout the urban areas (Farrar et al., 2007). In this study, routine surveillance such as conventional indices method incorporated with GIS advanced technique and spatial statistical tools analysis, was used to analyze the spatial density of mosquito population in several hotspot localities within Kuala Lumpur during the year 2010.

Figure 3
This study also utilized the Breteau Index (BI) as it is based on larval indices and combined the mean of monthly rainfall. BI is capable to predict the transmission of dengue based on larval indices (Sanchez et al., 2006). It was found that there is a strong correlation between the number of hotspot localities with high BI and monthly rainfall data. This could be due to the presence of high rainfall data with the high number of BI in certain months within the study period. The relationship between rainfall and BI can provide a useful guide for planning and implementing Aedes prevention activities in the study area. Generally, rainfall in the study area occurs throughout the year. However, monthly rainfall varies in each month and does not show a regular pattern (Figure 4). The months of March to April and November to December have a high amount of rainfall each year. Elimination of mosquito, particularly through the fogging activity should be further enhanced in these months. A study by Aziz et al (2012) found that the spatial distribution of dengue cases in Kuala Lumpur will show dispersed pattern in the coming months with highly rainfall. This suggests that rainfall has a strong relationship with BI and could influence the occurrence and spatial pattern of dengue cases. Hence, rainfall should be considered as one of the factors in planning and implementing the process for the prevention and control activities of DF and DHF in Malaysia and Indonesia.

The study also examined the influences of types of vegetation and ground cover using remote sensing analysis. However, the results showed that none of the criteria such as cleared area, built-up, vegetation dense, vegetation sparse and water correlates to hotspot localities of mosquito population within the six zones of Kuala Lumpur. This could be due to the study area being an urban area with almost uniformed pattern of land use. This pattern will reduce the variation of vegetation and ground cover to be associated with BI.
In this study, the used of Kernel density estimation is essential in designing and mapping the high risk of dengue incidence areas. Previous study in Hulu Langat developed the spatial mapping of dengue incidence for the area using Kernel density as the designed dengue density map could target specific area within points of highest dengue cases prevalence (Er et al., 2010). By incorporating a more detailed data such as humidity or temperature, this meteorological information could be considered as it contributes to the assessment of spatial distribution of dengue incidence or other vector-borne diseases (Aziz et al., 2012). The previous study (Rudnick et al., 1965; Gubler, 1998; Vazquez-Prokopel et al., 2010; Er et al., 2010 and Aziz, et al., 2012) also suggests not to simultaneously oversimplifying the relationship between meteorological information, distribution of mosquito population and dengue cases in targeted areas.

This study utilized three main elements namely the Breteau Index, Remote Sensing and Kernel density estimation. They will help the public health management to provide beneficial information as well as to reduce and overcome the risk of dengue infections throughout the suspected dengue cases areas. Coupled with a computerized GIS tools technologies and meteorological data such as rainfall, this study shows that there is a strong correlation between these

Figure 4: Total Monthly Rainfall from 2007 to 2010
elements, indicating a possible improvement in understanding the level of spatial density of dengue cases distribution together with the utilization of mosquito surveillance (i.e. Breteau Index). Using larval indices of BI, we can predict the dengue transmission in any hotspot areas. Furthermore, these data are supported by Kernel density which acts as a useful tool to identify the location of hotspot areas based on dengue cases activities. Besides that, the use of Remote Sensing provides another advantage as it investigates the influences of environmental factors such as built-up, vegetation dense, cleared area, vegetation sparse or water. These factors could be a major contribution in determining the dengue incidence pattern within the identified hotspot areas. All these advanced tools can create opportunities for public health sectors such as the Kuala Lumpur City Hall, the District Health Department or the Ministry of Health, to immediately plan effective dengue control strategies to reduce the statistics of dengue cases in Malaysia.

References


