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PROFILING OF DENGUE VECTORS BREEDING HABITAT AT URBAN RESIDENTIAL AREAS IN SHAH ALAM, MALAYSIA

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ABSTRACT

Dengue fever is an urban vector-borne disease transmitted by *Aedes aegypti* and *Aedes albopictus*. Both species lay their eggs in favourable breeding containers either in natural or artificial containers. Thus, an understanding of *Aedes* species habitat characteristics is important in combating dengue fever outbreaks. A minimum of 100 houses were inspected the peridomestic area for *Aedes* species in central zone of Shah Alam. Larval surveillance and water analysis were conducted to determine water breeding characteristic while larval species identification was conducted used to determine dominant species in Shah Alam. *Aedes* immatures were identified by using standard entomological procedures. *Aedes albopictus* easily found throughout the localities while plastic container become most preferences breeding container and paint cans were the favourable breeding container. pH and sodium are considered as the water parameters that enhanced the development of *Aedes* larvae with p-value of 0.001 and 0.000 respectively. By identifying the key of habitat characteristic of *Aedes* species through larval surveillance, the vector control can be implemented efficiently throughout the central zone of Shah Alam.

Keywords: *Aedes*, breeding habitat, water characteristics, urban, Malaysia

ABSTRAK

Demam denggi adalah penyakit berjangkit bandar yang di bawa oleh *Aedes aegypti* dan *Aedes albopictus*. Kedua-dua *Aedes* spesies ini bertelur di dalam bekas yang disukai sama ada bekas semulajadi atau bekas buatan manusia. Oleh itu, pemahaman berkaitan dengan sifat air bagi tempat pembiakan nyamuk *Aedes* ini penting bagi mengatasi penularan demam denggi. Sekurang-kurangnya 100 buah rumah di zon tengah Shah Alam telah diperiksa persekitarannya untuk mengenalpasti kehadiran nyamuk *Aedes*. Pengawasan jentik-jentik dan analisis air telah dilakukan untuk mengenalpasti sifat air tempat pembiakan nyamuk *Aedes* dan pengecaman spesis jentik-jentik juga dilakukan untuk mengetahui spesis utama di Shah Alam. Pengecaman jentik-jentik dilakukan dengan menggunakan kaedah piawai prosedur entomologi. *Aedes albopictus* sangat mudah di jumpai di semua kawasan pengawasan terutama di dalam bekas plastic yang merupakan bekas pilihan manakala tin cat merupakan bekas kesukaan nyamuk untuk bertelur. pH dan natrium merupakan parameter yang menggalakkan pembesaran

jentik-jentik dengan masing-masing mencatat nilai-p 0.001 dan 0.000. Dengan mengenalpasti sifat-sifat utama air tempat pembiakan nyamuk *Aedes* melalui pengawasan jentik-jentik, kawalan vektor dapat dijalankan dengan lebih berkesan di sekitar zon tengah Shah Alam.

Kata kunci: *Aedes,* tempat pembiakan nyamuk, sifat air, bandar, Malaysia

INTRODUCTION

Water-associated diseases account for approximately 10% of the global disease burden, representing a significant source of morbidity and mortality worldwide (Dom et al., 2016a). Dengue is classified as one of water-associated disease as the water acts as a media of transmission, although occurs indirectly (Dom et al., 2016a). The role of *Aedes aegypti* and *Aedes albopictus* in the transmission of dengue viruses is well documented (Lambrechts et al., 2010). Human ecology, habits and behaviour greatly influence mosquito distribution, species relative abundance and survival (Chatterrjee et al., 2015). Locations of probable breeding sites and water body conditions often lead mosquito groups and subgroups and species to choose their preferred habitats. Generally, mosquitoes lay their eggs in a wide range of habitats with different physicochemical characteristics (Abai et al., 2016).

There are many factors that influenced mosquitoes to adapt with a wide range of artificial container habitat such as heavy deforestation, climate change and increase in global trade (Rao et al., 2011). Both *Aedes* species had the habits to breeds in a specific type of container with specific preference characteristics of the water that attract them for oviposition (Chatterrjee et al., 2015). Some of the commonly used cues that attract the mosquitoes are colour and optical density of water, oviposition substrate, temperature, olfactory cues, and chemical cues provided by *Aedes* immature (Chatterrjee et al., 2015). Thus, knowledge in habitat selection of dengue vectors (DVs) mosquitoes is vital in order to implement vector control program. In dengue active area, it is crucial to monitor DVs mosquitos' abundance and its distribution to predict the dengue epidemics. Water conditions, presence of larval food, location, and shades are the determining factors or cues of breeding sites of DVs (Bashar et al., 2016).

Dom *et al*. (2013) reported that environmental changes have contributed a big influenced to the pattern of dengue incidences distribution. Highly developed as well as high density population areas are reported with a high dengue incidence throughout the year. Previous studies showed that there are other factors that made an impact on the dengue outbreak such as inadequacies in urban infrastructure as in improper solid waste disposal system (Dom et al., 2013). In addition, the fluctuating number of dengue cases also has been heavily correlated with rapid population growth as well as increasing number of domestic and international travellers. A study by Dom *et al*. (2013) stated that *Aedes* mosquitoes breed in both artificial and natural containers inside and surrounding the residential area as well as in construction sites. Recently, rapid infrastructure development changes and economic developments had created favourable man made breeding habitat.

It is crucial to eliminate the DVs mosquito from the larval stage by several anti-larval measures. In order to execute that strategy, knowledge on larval habitat characteristics of DVs mosquitoes is important and vital. Therefore, this study was conducted in providing a better input on the knowledge in habitat selection of DVs mosquitoes. The technique of measuring larvae and adult mosquito population requires enormous effort and time, and this has to be done continuously. Ecological data on physicochemical factors of larval habitat is an important role in understanding the aquatic stages of mosquitoes and thus can help in developing the appropriate control measures through environmental manipulation and modification.

METHODOLOGY

Study Site and Study Population

Shah Alam is capital city of Selangor which located in Petaling District and part of Klang District of Selangor and it is located 25 km from Kuala Lumpur. Shah Alam covers an area of 290.3 sq. km and being divided into three zones which is north zone (NZ), central zone (CZ) and south zone (SZ). Figure 1 shows the number of DF cases in Shah Alam cumulatively from 2012 to 2014 and indicates that CZ recorded higher DF cases as compared to other zones. Moreover, CZ has a clustered DF cases and the main landscape characteristic of this area is an urban area with rapidly developed. The major land area in this study area is residential, commercial, and industrial area. Besides that, the forested areas and construction area also has shown a rapid changes trend, and this might influence the trend of DVs distribution.

Study Design

A series of cross-sectional ecological survey was conducted in sixteen selected localities in central zone of Shah Alam from October 2015 to December 2015. The selection of the localities is based on the constant occurrence of DF cases in Shah Alam for 3 years (2012-2014). A house to house and peridomestic area survey was carried out in order to detect mosquito larval breeding sites which reflect the infestation level with *Aedes* larvae in the localities. A team of 5 persons were employed to conduct larval surveillance in each locality starting from 8.00 am to 12.00 pm. *Aedes* surveyed was conducted with a minimum of 100 houses per locality to which covers dengue

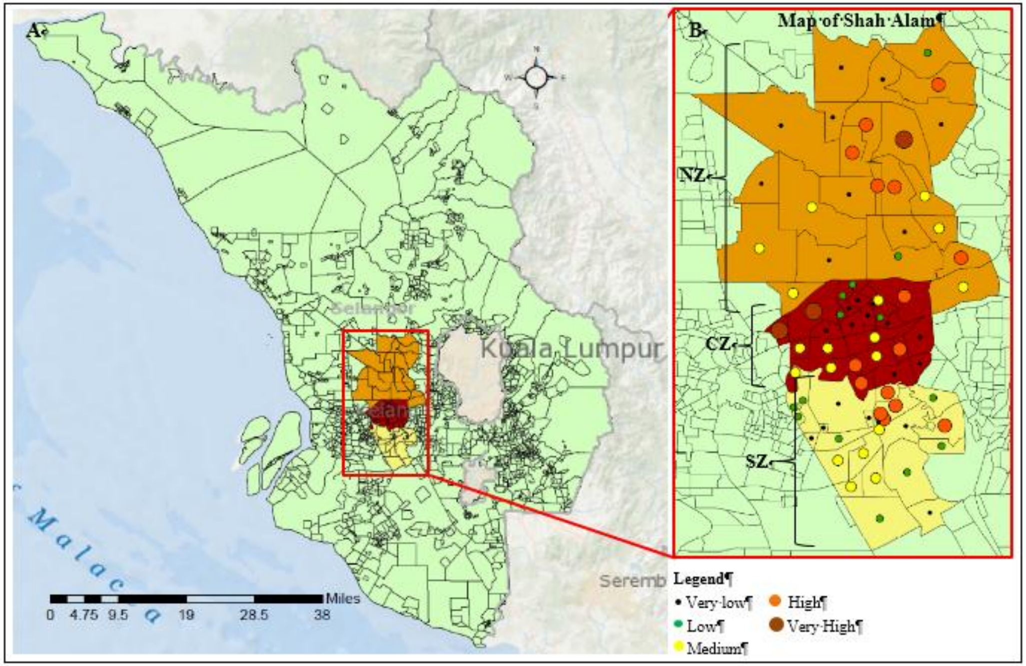


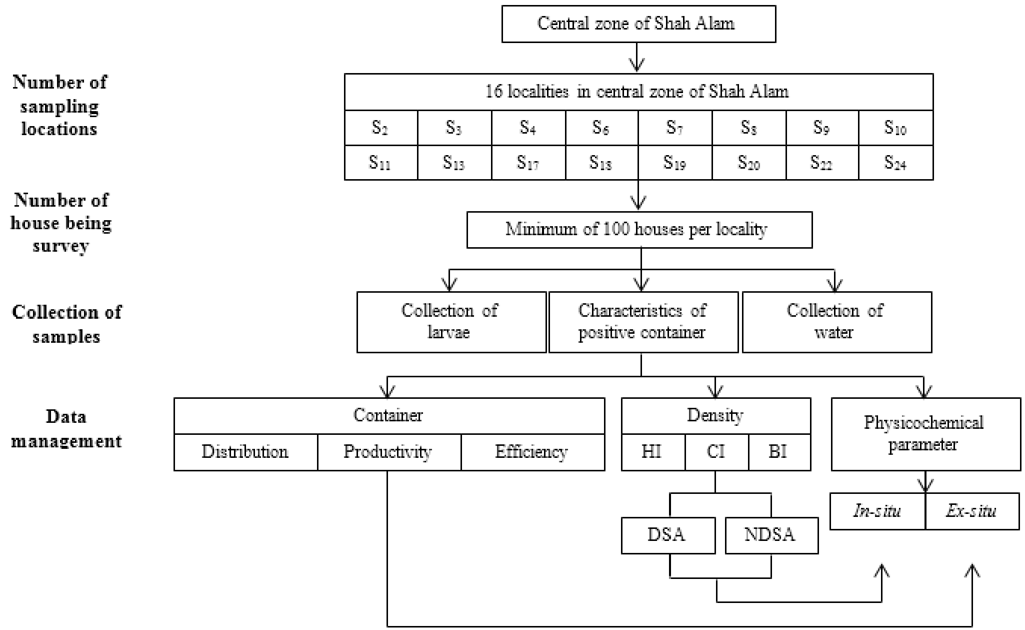
Figure 1. A] Map of Selangor highlighted Shah Alam in different colour from top; north zone (NZ), central zone(CZ) and south zone(SZ). [B] Distribution map in term of number of DF cases in Shah Alam cumulatively from 2012 to 2014

sensitive area and non-dengue sensitive area (Saifur et al., 2013; Rozilawati et al., 2015). Volume of water required for each sample is 200 ml per sample. The volume of the water taken was dependent on the type and numbers of water analysis parameters. At least ten positive containers were aimed to be collected in each locality and if the objective had not been fulfilled upon reaching 100 houses be, surveillance will be continuing until ten positive containers were located. Conversely, if ten positive containers were found before reaching 100 houses, the survey would continue until 100 houses were inspected. The overall study design of the research is summarized in flowchart (Figure 2)

Collection of Samples

During larval surveillance, possible wet containers were inspected and recorded in the form. Once positive container was identified, type of container, volume and physical analysis of water were conducted and recorded. The larvae were collected within the residential area by using standard larvae collection procedure (Su et al., 2016). The containers are inspected thoroughly using a flashlight and immature mosquitoes are collected (Manrique-Saide et al., 2008). The immature collection was collected by using standard dipper that varied in size according to the breeding habitat size (Chatterjee et al., 2015). Dipper and pipette is the most commonly used tools for collecting mosquito larvae from a wide variety of habitat (Vikram et al., 2016). As there is no recommended method in collecting *Aedes* immature, dipper with different size was used for different habitats, pipettes and white plastic pan (Chatterjee et al., 2015).

The collected immature is being kept in falcon tubes and the tubes are also labelled with house identification, container code, area code, and date of collection. Both water and *Aedes* immature were collected concurrently and send back to



Note: A minimum of 200 ml of water per breeding container

Figure 2. Study design being used in this study represents the study localities, sample size of the study, basic methodology and the management of the data collected

laboratory for analysis. The immature collection is possibly being avoided after a heavy rain because it might affect the results by having lower number of immature collected as it can be washed away by the rain water (Paramanik et al., 2012; Selvan et al., 2015).

The samples were carried to the laboratory and transferred into standard larval rearing bowl (30 cm x 30 cm). The larvae and dead pupae were counted and identified to species under a compound microscope according to the standard keys (Maheswaran et al., 2008). Live pupae were allowed to emerge into adults and then identified the species. The number of larvae and pupae were recorded along with the container types and added to a database for subsequent statistical analyses.

Characteristics of Positive Container

All containers will be given an identification container identity (CID) based on the operational guidelines in assessing the productivity of *Aedes aegypti* breeding sites (WHO, 2011). Eight CID has been determined where CID 1: Plastic container, CID 2: Drum and water reservoir, CID 3: Flower vases and pots, CID 4: Metal and tin pots, CID 5: Paint can, CID 6: Leaf and natural container, CID 7: Tyre and CID 8: Ceramic.

Determination of Physicochemical Characteristics

The physical properties of breeding water characteristics such as pH, water temperature (^{0}C), turbidity (NTU) and dissolve oxygen (DO) were recorded by conducting *in-situ* measurement whereas for hardness *ex-situ* measurement are conducted at laboratory using DR5000. Water samples (200 ml) were collected from the breeding habitat which showed the presence of immature mosquitoes. For chemical properties, the dissolved micronutrient such as calcium (Ca), sodium (Na), potassium (K) and magnesium (Mg) was measured by standard methods. The collected samples of water were preserved by adding 1 ml of analytical grade concentrated HNO_3 (acidified pH less than 2.0) for the analysis of dissolved micronutrients (USEPA, 2015; Agilent, 2015). This preservation was done to prevent chemical adsorption into the container walls as well as to inhibit the activity of microorganism, which might cause changes in chemical characteristic levels in the water samples. All these analyses were done in the Research laboratory, Department of Environmental Health and Safety, University Teknologi MARA.

Data Management and Analysis

Traditional indices are being used to evaluate the population densities of the DVs mosquitoes such as house index (HI), container index CI) and Breteau index (BI). HI is defined as percentage of positive houses per total number of house inspected. CI is defined as percentage of positive containers per total number of container inspected while BI is defined as percentage of total number of positive container per total number of house inspected. These methods are widely used as standard empirical parameters in developing countries (Petric et al., 2014). HI and BI commonly used to prioritize risk area for control measure while CI was used to draw vector control strategies. When HI>5% and/or BI>20% for any locality thus will be classified as dengue sensitive area and therefore adequate preventive measures should be taken. Depending on potential outbreak, an area can be placed in following categories. A locality will be classified into Priority I group when there is death due to dengue confirmed. Priority II group or being labelled as dengue sensitive area (DSA) is when HI>5% and/or BI>20% for any locality. Priority III group or non-dengue sensitive area (NDSA) when HI<5% and/or BI<20% for any locality and a locality will be classified into Priority IV group when despite active search already conducted, there are no positive breeding sites found (Minhas & Sekhon, 2013; Patel et al., 2015).

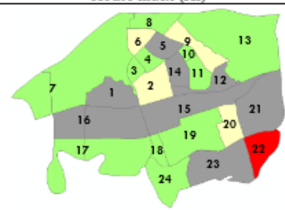
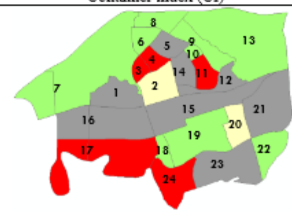
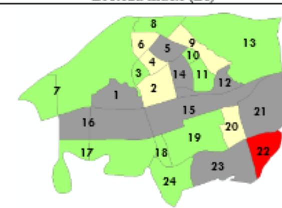
In order to study the abundance of larval mosquitoes found, the larval density need to be calculated, by using method by Gopalakrishnan *et al*. (2013); Larval density; (Total number of larvae collected/Total number of positive containers). Finding of the survey were analyse using Microsoft Excel 2013 spread sheet and Social Sciences (SPSS) version 21. Descriptive analysis was conducted which is data from the surveillance consists of number of house, number of containers and number of larvae and its species in order to obtain the *Aedes* indices. One-way ANOVA and *Kruskal-Wallis* statistical analysis test were conducted in order to determine the significant relationship between the habitat characteristics with references to containers types.

RESULTS

Dengue Vector Breeding Locations Classification and Distribution of *Aedes* indices

Through the larval surveillance, 153 positive containers was collected and it is found that *Aedes albopictus* is the dominant species (*n:* 4703; 90.7%) followed by *Aedes aegypti* (*n:* 482; 9.3%). A few indices were also calculated such as house index (HI), container index (CI) and breteau index (BI). Table 1 shows the distribution of dengue vectors in central zone of Shah Alam based on HI, CI and BI. From all the locality, the highest number of positive house were recorded at Seksyen 17 (*n*=13) followed by Seksyen 19 (*n*=12). In term of HI, Seksyen 22 has recorded the highest HI (15.34%) which indicates that this area is likely to be the most risk area for dengue transmission in central zone of Shah Alam also support by the BI reading with Seksyen 22 (19.23%) are the closest BI reading to 20% as it is the indicator for the classification for DSA.

Table1. Distribution of *Aedes* indices (HI, CI and BI) in central zone of Shah Alam which covers 16 localities. Different colour represents different level of *Aedes* indices; red colour indicate high, green indicate medium and yellow indicate low level while grey indicates the localities that are not included in the data collection

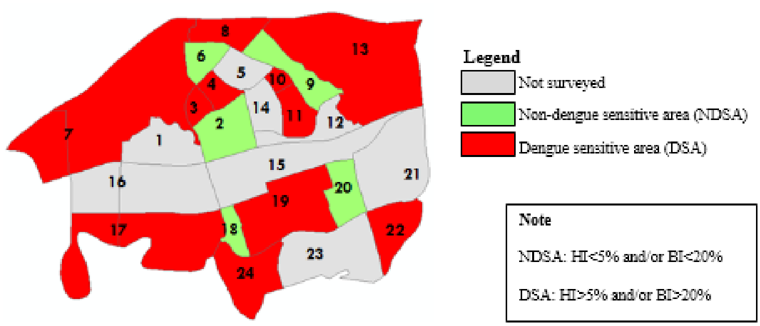
Locality	House index (HI)			Container index (CI)			Breteau index (BI)		
									
	Total House(a)	Positive house(b)	HI (%) (b/a)	Total container(c)	Positive container(d)	CI (%) (d/a)	Positive container(d)	Total House(a)	BI (%) (d/a)
S_2	180	6	3.33	55	8	14.55	8	180	4.44
S_3	111	8	7.21	23	11	47.83	11	111	9.91
S_4	170	9	5.29	14	10	71.43	10	170	5.88
S_6	112	4	3.57	21	6	28.57	6	112	5.36
S_7	98	7	7.14	28	9	32.14	9	98	9.18
S_8	103	10	9.71	59	11	18.64	11	103	10.68
S_9	75	2	2.67	5	2	40.00	2	75	2.67
S_{10}	84	7	8.33	41	11	26.83	11	84	13.10
S_{11}	120	8	6.66	23	10	43.48	10	120	8.33
S_{13}	145	9	6.20	34	12	35.29	12	145	8.28
S_{17}	137	13	9.49	26	15	57.69	15	137	10.95
S_{18}	106	5	4.72	34	10	29.41	10	106	9.43
S_{19}	136	12	8.82	43	13	30.23	13	136	9.56
S_{20}	120	3	2.50	105	5	4.76	5	120	4.17
S_{22}	52	8	15.34	49	10	20.41	10	52	19.23
S_{24}	87	7	8.05	20	11	50.00	11	87	11.49
Distribution	$S_{22}>S_8>S_{17}>S_{19}>S_{10}>S_{24}>S_3>S_7>S_{11}>S_{13}>S_4>S_{18}>S_6>S_2>S_9>S_{20}$			$S_4>S_{17}>S_{24}>S_3>S_{11}>S_9>S_{13}>S_7>S_{19}>S_{18}>S_6>S_{10}>S_{22}>S_8>S_2>S_{20}$			$S_{22}>S_{10}>S_{24}>S_{17}>S_8>S_3>S_{19}>S_{18}>S_7>S_{11}>S_{13}>S_4>S_6>S_2>S_{20}>S_9$		

Note: HI=(b/a)×100; CI=(d/c)×100 ; BI=(d/a)×10

Grey area was not included in the data collection due to lack of residential area which most of the areas are industrial and commercial area

The highest receptacle or wet container were found at Seksyen 20 (*n*=105). This suggest that the local municipal need to take a closer look at this locality although the positive container is among the lowest (*n*=5) but the risk is still there. Seksyen 17 have the highest CI with 57.69% which is consider as a very high CI and the specific key container of dengue transmission at this locality need to be identified. The distribution of HI and BI shows that Seksyen 22 recorded the highest reading and indicates that this locality is a susceptible locality for dengue transmission. However, in term of CI, Seksyen 22 has a low CI which located at fourth last in the CI distribution. This shows that even with low number of receptacles for mosquito to breed is available in Seksyen 22 but the HI and BI are still high. Based on HI and BI, the indices indicate that most of residential areas in central zone of Shah Alam were categories as DSA (68.75%) as showed in Figure 3 which represents the value of HI and BI in the study locality and thus determined the DSA and NDSA cluster.

A **Central Zone of Shah Alam**



B

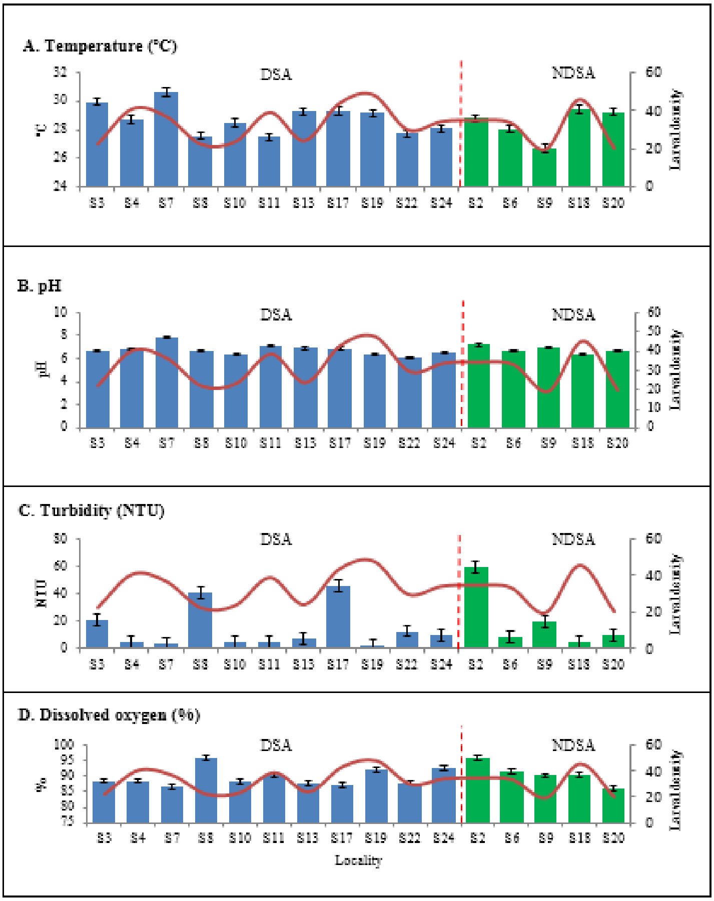
No	Locality	Abbreviation	House Index	Breteau Index	DSA	NDSA
1	Seksyen 1	S_{1}	-	-	-	-
2	Seksyen 2	S_{2}	3.33%	4.44%		/
3	Seksyen 3	S_{3}	7.21%	9.91%	/	
4	Seksyen 4	S_{4}	5.29%	5.88%	/	
5	Seksyen 5	S_{5}	-	-	-	-
6	Seksyen 6	S_{6}	3.57%	5.36%		/
7	Seksyen 7	S_{7}	7.14%	9.18%	/	
8	Seksyen 8	S_{8}	9.71%	10.68%	/	
9	Seksyen 9	S_{9}	2.67%	2.67%		/
10	Seksyen 10	S_{10}	8.33%	13.10%	/	
11	Seksyen 11	S_{11}	6.66%	8.33%	/	
12	Seksyen 12	S_{12}	-	-	-	-
13	Seksyen 13	S_{13}	6.20%	8.28%	/	
14	Seksyen 14	S_{14}	-	-	-	-
15	Seksyen 15	S_{15}	-	-	-	-
16	Seksyen 16	S_{16}	-	-	-	-
17	Seksyen 17	S_{17}	9.49%	10.95%	/	
18	Seksyen 18	S_{18}	4.72%	9.43%		/
19	Seksyen 19	S_{19}	8.82%	9.56%	/	
20	Seksyen 20	S_{20}	2.50%	4.17%		/
21	Seksyen 21	S_{21}	-	-	-	-
22	Seksyen 22	S_{22}	15.34%	19.23%	/	
23	Seksyen 23	S_{23}	-	-	-	-
24	Seksyen 24	S_{24}	8.05%	11.49	/	

Figure 3. [A] Boundary between NDSA and DSA in central zone of Shah Alam based on HI and BI indicator (Patel *et al*. [21]) [B] HI and BI reading based on all 16 localities in central zone of Shah Alam and the classification between NDSA and DSA

Role of Physicochemical Characteristics in Different Localities

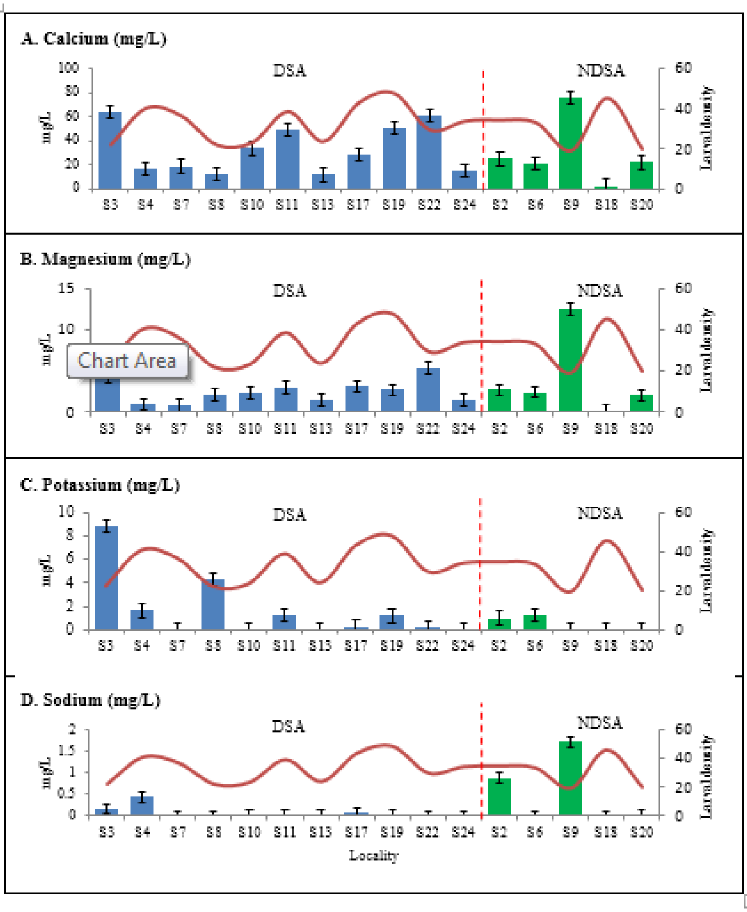
Figure 4 shows the physical characteristics of positive breeding water in residential area of central zone of Shah Alam with the larval density (LD) for each locality. The highest temp erature was recorded at Seksyen 7, (30.64±0.32°C), while the lowest temperature recorded is at Seksyen 9, (26.7±0.00°C). Apart from that, LD also the lowest in Seksyen 9 (LD: 19.5) which describe that less larvae were found in lower temperature of breeding water. In term of pH, the breeding water recorded reading range between pH of 6.11 to 7.89. This shows that mosquito prefer to breed in either slightly acidic, neutral or slightly alkali water. For turbidity (NTU), the highest reading was recorded at Seksyen 2 (59.06±22.49NTU), while the lowest turbidity reading is at Seksyen 19 (2.76±0.39NTU). As expected, highest LD was also recorded at Seksyen 19 and has proven that larvae are more prone to infest in less turbid water. The highest reading of dissolved oxygen (%) is at Seksyen 2, (95.95±0.49%) and the lowest reading is at Seksyen 20, (86.04±1.41%) hence this shows that mosquito prefer to breed in water that has high oxygen level (>80%).

For chemical parameter as showed in Figure 5, larvae were found in water that has specific characteristics with certain ranges of chemical parameters. (i) calcium (2.66 to 75.71 mg/L), (ii) magnesium (0.25 to 12.46 mg/L), (iii) potassium (0.00 to 8.83 mg/L) and sodium (0.00 to 41.69 mg/L). The highest reading of calcium, magnesium and sodium in positive container were recorded at Seksyen 9 but vice versa in term of the value of LD which shows the lowest in Seksyen 9. This shows that mosquito less preferred to breeds in high level of calcium, magnesium and sodium containers or the survival rate of larvae is low that particular container.



Note: Blue and green histogram represent value for dengue sensitive area (DSA) and non-dengue sensitive area (NDSA) respectively while red line indicate the value of larval density

Figure 4. The comparison of reading of physical parameters between DSA and NDSA with the reading of larval density in central zone of Shah Alam



Note: Blue and green histogram represent value for dengue sensitive area (DSA) and non-dengue sensitive area (NDSA) respectively while red line indicate the value of larval density

Figure 5. The comparison of reading of chemical parameters between DSA and NDSA with the reading of larval density in central zone of Shah Alam

Distribution of Positive Containers Based on the Types of Containers with Their Efficiencies

Table 2 shows the number of positive container in each study locality. Based on the result, S17 recorded the highest number of positive container found with 15 containers (9.8%) followed by S19 with 13 containers (8.5%). As showed in Table 2, CID 1 has the highest number of containers collected with 93 containers (61%). In term of the variation in different locality, most all of the locality recorded CID 1 as the highest positive container found except for S2(CID3) and S22(CID7). In this study, the profile of container efficiency was also being observed. Table 3 shows the larval productivity and efficiency of dengue vector breeding container in the residential area of central zone of Shah Alam. For larval productivity, the most productive container is CID 1 with 59.41% followed by CID 2 (12.85%), and the least productive container is CID 6 (1.3%). The most efficient container for source reduction to reduce the number of larvae in population is CID 5 with efficiency of 1.47% followed by CID 7 (1.35%) while the least efficient container was CID 6 (0.54%). Even though, CID 1 has high productivity, but in term of efficiency of larval production, CID 1 had recorded a low efficiency (0.93%) which is the third lowest efficiency among the containers.

Table 2. Percentage of different types of containers in each locality and the distribution of containers based on localities in central zone of Shah Alam

Locality	Number of containers (%)								Total (%)	Distribution of containers based on localities in central zone of Shah Alam
	CID 1	CID 2	CID 3	CID 4	CID 5	CID 6	CID 7	CID 8		
S_2	2 (25%)	2 (25%)	3 (38%)	1 (12%)	0	0	0	0	**8 (5.2%)**	CID 3 > CID 1 = CID2 > CID 4 > CID 5 = CID 6 = CID 7 = CID 8
S_3	9 (82%)	0	2 (18%)	0	0	0	0	0	**11 (7.2%)**	CID 1 > CID 3 > CID 2 = CID 4 = CID 5 = CID 6 = CID 7 = CID 8
S_4	6 (60%)	3 (30%)	0	0	0	1 (10%)	0	0	**10 (6.5%)**	CID 1 > CID 2 > CID 6 > CID 3 = CID 4 = CID 5 = CID 7 = CID 8
S_6	4 (66%)	0	0	0	1 (17%)	0	0	1 (17%)	**6 (3.9%)**	CID 1 > CID 5 = CID 8 > CID 2 = CID 3 = CID 4 = CID 6 = CID 7
S_7	6 (67%)	1 (11%)	2 (22%)	0	0	0	0	0	**9 (5.9%)**	CID 1 > CID 3 > CID 2 > CID 4 = CID 5 = CID 6 = CID 7 = CID 8
S_8	8 (73%)	1 (9%)	1 (9%)	0	0	1 (9%)	0	0	**11 (7.2%)**	CID 1 > CID 2 = CID 3 = CID 6 > CID 4 = CID 5 = CID 7 = CID 8
S_9	1 (50%)	0	0	0	0	1 (50%)	0	0	**2 (1.3%)**	CID 1 = CID 6 > CID 2 = CID 3 = CID 4 = CID 5 = CID 7 = CID 8
S_{10}	6 (55%)	0	0	3 (27%)	0	1 (9%)	1 (9%)	0	**11 (7.2%)**	CID 1 > CID 4 > CID 6 = CID 7 > CID 2 = CID 3 = CID 5 = CID 8
S_{11}	7 (70%)	1 (10%)	1 (10%)	0	0	0	0	1 (10%)	**10 (6.5%)**	CID 1 > CID 2 = CID 3 = CID 8 > CID 4 = CID 5 = CID 6 =CID 7
S_{13}	10 (83%)	0	2 (17%)	0	0	0	0	0	**12 (7.8%)**	CID 1 > CID 3 > CID 2 = CID 4 = CID 5 = CID 6 = CID 7 = CID 8
S_{17}	6 (40%)	3 (20%)	0	0	3 (20%)	0	3 (20%)	0	**15 (9.8%)**	CID 1 > CID 2 = CID 5 = CID 7 > CID 3 = CID 4 = CID 6 = CID 8
S_{18}	8 (80%)	0	0	0	0	0	0	2 (20%)	**10 (6.5%)**	CID 1 > CID 8 > CID 2 = CID 3 = CID 4 = CID 5 = CID 6 = CID 7
S_{19}	6 (46%)	6 (46%)	0	0	0	0	0	1 (8%)	**13 (8.5%)**	CID 1 = CID 2 > CID 8 > CID 3 = CID 4 = CID 5 = CID 6 = CID 7
S_{20}	3 (60%)	0	1 (20%)	0	0	0	0	1 (20%)	**5 (3.5%)**	CID 1 > CID 3 = CID 8 > CID 2 = CID 4 = CID 5 = CID 6 = CID 7
S_{22}	4 (40%)	0	0	0	0	0	6 (60%)	0	**10 (6.5%)**	CID 7 > CID 1 > CID 2 = CID 3 = CID 4 = CID 5 = CID 6 = CID 8
S_{24}	7 (70%)	1 (10%)	0	0	0	0	1 (10%)	1 (10%)	**10 (6.5%)**	CID 1 > CID 2 = CID 7 = CID 8 > CID 3 = CID 4 = CID 5 = CID 6
Total	**93 (61%)**	**18 (11%)**	**12 (8%)**	**4 (3%)**	**4 (3%)**	**4 (3%)**	**11 (7%)**	**7 (4%)**	**153**	**CID 1 > CID 2 > CID 3 > CID 7 > CID 8 > CID 4 = CID 5 = CID 6**

Note: (>): more than; (=): equal to

Table 3. Percentage of productivity, prevalence and efficiency of each type of container with the distribution of the container's efficiency

CID	Container types	Number of Larvae (*n*)	Number of Wet Container	Productivity (%)[1]	Prevalence of container (%)[2]	Efficiency (%)[3]	Distribution on efficiency based on different types of container
1	Plastic container	3015	107	59.41	64.08	0.93	CID 5 > CID 7 > CID 2 > CID 3 > CID 8 > CID 1 > CID 4 > CID 6
2	Drum	652	18	12.85	10.78	1.19	
3	Flowerpot	429	12	8.45	7.19	1.18	
4	Metal pot	75	4	1.47	2.39	0.62	
5	Paint cans	178	4	3.51	2.39	1.47	
6	Natural	66	4	1.3	2.39	0.54	
7	Tyre	451	11	8.89	6.59	1.35	
8	Ceramic	209	7	4.12	4.19	0.98	

Note:

1. Productivity = number of larvae/all larvae x 100
2. Prevalence of container = number of wet container/all container x 100
3. Efficiency = productivity/prevalence of container

Role of Physicochemical Characteristics in Different Localities and Types of Containers

The water characteristics of breeding habitat can be determinant factor of female *Aedes* mosquito to breed and different types of container may contribute to a differ characteristics of water. The comparison on different types of container with the physicochemical characteristics of breeding habitat is tabulated in Table 4 and Table 5. The results show that pH (*p-value*=0.001) and sodium (*p-value*=0.000) have a significant variation in term of difference breeding habitat. This shows that different mosquito breeding habitat have a differ water characteristics and; pH and sodium was detected as the characteristics that attracts female *Aedes* mosquito to breeds in that particular container. From the surveillance, it was found that plastic container (CID1) recorded the highest number of positive container (*n*=93). This indicates that plastic container has a big influenced in determining the median reading of pH and sodium which lead to be the parameters that have a significant difference in term of differ types of containers. The interpretation of pH value is different when comparing to other parameters because of the sensitivity and indicator whether it is in acidic, neutral or alkali group. Even a small gap can make a difference in term of the classification of the pH unlike other parameters where it is broader.

Table 4. The comparison of physicochemical characteristics in different types of containers across central zone of Shah Alam (Non-parametric test)

Parameters	Median (IQR)	*X_2 statistic(df)*	*p-value*
Number of larvae	25.00(40.00)	5.569(7)	0.591
pH	6.73(0.69)	24.183(7)	0.001*
Turbidity (NTU)	6.08(12.03)	7.908(7)	0.341
Calcium (mg/L)	21.04(25.18)	6.625(7)	0.469
Magnesium (mg/L)	1.52(2.46)	7.344(7)	0.394
Potassium (mg/L)	0.00(0.00)	13.186(7)	0.068
Sodium (mg/L)	0.00(0.03)	26.383(7)	0.000*

Note: The calculated median and interquartile range (IQR) were based on sample size of CID1, *n*=93; CID2, *n*=18; CID3, *n*=12; CID4, *n*=4; CID5, *n*=4; CID6, *n*=4; CID7, *n*=11; CID8, *n*=7. *Kruskal-Wallis* test applied. **p-value* <0.05

Table 5. The comparison of physicochemical characteristics in different types of containers across central zone of Shah Alam (Parametric test)

Parameters	Mean (SD)								*F-stats(df)*	*p-value*
	CID 1(*n=93*)	CID 2(*n=18*)	CID 3(*n=12*)	CID 4(*n=4*)	CID 5(*n=4*)	CID 6(*n=4*)	CID 7(*n=11*)	CID 8(*n=7*)		
Temperature (ºC)	28.98 (1.44)	29.02 (2.50)	28.86 (1.15)	29.35 (1.17)	29.03 (0.98)	28.20 (1.04)	28.44 (1.18)	28.51 (0.77)	0.435(7)	0.879
DO (%)	89.66 (5.15)	92.03 (4.85)	90.60 (3.86)	89.20 (5.74)	86.75 (3.21)	88.88 (8.00)	89.46 (5.44)	90.11 (4.55)	0.78(7)	0.605

Note: One-way ANOVA test applied
**p-value* <0.05

DISCUSSION

Previous studies show that several physicochemical properties and biotic characteristics have a great impact to the abundance of immature in the population (Higa, 2011). This study demonstrated that the density of *Aedes species* larvae were significantly influenced by some of the physicochemical environmental factors that are associated with mosquito breeding ecologies. *Aedes albopictus* is a dominant species in central zone of Shah Alam followed by *Aedes aegypti* in the peridomestic area surrounding the residential areas. The dominancy of *Aedes albopictus* species were also being observed in each locality that being surveyed. This is supported by the study conducted by Vijayakumar *et al*. (2014) where *Aedes albopictus* was found to be the most common species distributed equally at outdoor environment in urban and rural areas.

From the surveillance, majority of *Aedes* species larvae were found in plastic container (CID 1) with productivity of 59.41% thus it becomes most preference container for mosquito to breed and the least productivity of container was natural container (CID 6) with productivity of 1.3%. The result of productivity highlighted that the gap between plastic container and other containers was high which shows that plastic container had a big influence in the dengue transmission in the study area. The usage of plastic container particularly in residential area was very varied. The types of houses also heavily correlated with the social status have been found affected the cleanliness of surrounding area (Chandren et al., 2015). Other variables that should be considered is the efficiency of the solid waste management system of the residential area which is play an important role as all the receptacles especially plastic container can be found scattered at the waste collection point near the residential area (Banerjee et al., 2013). In term of efficiency, paint cans (CID 5) and tyres

(CID 7) prove to be the most efficient container for *Aedes* mosquito to breed with the efficiency of 1.47% and 1.35% respectively. This indicates that paint can specifically is the most favourable container for female *Aedes* mosquito to breed in and had supply the optimum condition for the larvae development. Although plastic container has the highest productivity, the efficiency of breeding containers is more crucial. It has been proven that not necessary a high productivity container will have a high efficiency. Study by Dom *et al.* (2016b) shows that recyclable containers have a high productivity, but rubber material type of container are the one that recorded as the highest efficiency which is align with the result of this study. The result also supported with the study by Mudin, (2015) where polystyrene food container, plastics bottles and tyres contribute the highest percentage of breeding places. It also reported that *Aedes species* less often breed in natural containers such as plant leaf axils, bamboo stumps, tree cavities and coconut shells (Hai et al., 2015). The same pattern was also observed at Philippines where the most productive breeding sites for *Aedes aegypti* found consistently were artificial container such as plastic and metal drum, while *Aedes albopictus* were found in bamboo stumps, plastic drums, and rubber tires (Edillo et al., 2012).

From the surveillance, Seksyen 22 recorded the highest HI and BI which shows that this locality has a higher tendency of infested by *Aedes* mosquito compared to another locality in central zone of Shah Alam. Seksyen 22 would be considered as high-risk area based on the BI and for residential area that has high BI and HI, local authority need to carry out preventive action to prevent new emergence of dengue fever in the area and to control spread of dengue fever in the area (Saleeza et al., 2011). In term of CI, by identifying the key of habitat characteristic of *Aedes species* through larval surveillance, the vector control can be implemented efficiently. Based on the findings of this study, majority of *Aedes species* were found in plastic container (CID 1) such as plastic based-materials and only small distributions of *Aedes species* were found in natural container (CID 6) such as leaf axil and coconut husk. Thus, vector control such as search and destroy in Shah Alam should be carry by focusing more on the key breeding container which is more cost effective and time saving.

Based on the results, pH and sodium has a significant difference in term of physicochemical parameters for every type of containers. By focussing on the value of pH and sodium for paint cans (CID 5) (highest efficiency), the most optimum conditions for *Aedes* mosquito to breeds can be identified. Study by Thangamathi *et al*. (2014) indicates that pH, calcium and phosphate show a positive correlated with the number of larvae. These results shown clearly that *Aedes species* larvae favoured a neutral pH environment. Hence, pH manipulation from the larval aquatic habitat by spraying of bio pesticides such as neem oil can be one of management tool to combat the risen of mosquito population. Apart from that, study by Chatterjee *et al*. (2015) have indicates that sodium and potassium are the only parameters that can be associated with the number of larvae thus considered as the water parameters that enhanced the development of *Aedes* larvae.

CONCLUSION

This study has provided information on the profile distribution of *Aedes* species by container with detailed characteristics. The most preferred breeding habitat for *Aedes* mosquitoes was plastic containers with 59.41% container productivity while the most favourable container was paint cans with 1.47% container efficiency. These reflected by the abundance of *Aedes* species in the study area which indicates a prominent density of mosquitoes. From using *Aedes* indices, BI was the most sensitive and reliable index and Seksyen 22 has recorded the highest BI which indicated that this area is the most susceptible area in central zone of Shah Alam. The local authority could then give a special attention to the key containers at specific locality in managing the risk of mosquito infestation. The key determining factors of *Aedes* breeding characteristics associated with the larval density and container preferences of dengue vectors species are pH and sodium. This study also observed that irregular garbage collection and poor sanitation contribute to potential sources of breeding sites for dengue vectors. Therefore, it is suggested that environmental management should be carried out to reduce *Aedes* mosquito infestation, with social participation was recommended to provide proper management of backyards.

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