Environmental Variability and Habit at Suitability of Malaria Vector in Purworejo District, Central Java Indonesia

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ENVIRONMENTAL VARIABILITY AND HABITAT SUITABILITY OF MALARIA VECTOR IN PURWOREJO DISTRICT, CENTRAL JAVA INDONESIA

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ABSTRACT

Background: Purworejo's landscape was composed the coastal and hilly regions, endemic malaria diseases, influences of global climate change. Characteristic of environmental determines a species Anopheles distribution in space and time. Understanding the ecological habitat of mosquito disease vectors can, therefore, be a powerful control or of the risk of exposure to the pathogens they transmit. However, research of the geographic distribution and ecological requirements of these species is to date still inadequate.
Methods: Breeding and resting quality, indoor-resting mosquitoes were sampled from 34 villages covering of ecological settings available in Purworejo, Central Java. Using a water and air quality parameter, species density on presence records, habitat suitability maps were constructed for habitat suitability index (HSI). Environmental variables as key to mosquito geographic distribution were assessed by cluster and discriminate techniques.
Results: Nine *Anopheline* species were collected, of which 2 are known as vector to transmit malaria in Purworejo. Discriminant factor for *Anopheles* dynamic were Total Dissolve solid (0,737), Chloride (0,943), turbidity (0,733), salinity (0,949), hardness (0,755), conductivity (0,523), dissolved oxygen (0,867), pH (0,796), air temperature (0,837), humidity (0,578), wind speed (0,799). The suitable region of mosquito life, base on Habitat suitability index (HSI) pre-dry season 41%, dry season 65%, pre-rainy season 79%, rainy season 79%
Conclusions: The distribution of major *Anopheles* species in Purworejo is strongly affected by the environmental characteristic dynamic. Habitat Suitability Index (HSI) should help improve malaria vector control interventions by targeting places and time
Keywords: vector malaria, habitat suitability index, Purworejo

BACKGROUND

Climate change impacts various aspects of life [1]. Based on report of the United National Development Project (UNDP) 2007, Indonesia is a country that influenced by climate change [2]. IPCC report (2007) shows the influence of global climate change on the biological and social systems. Extreme weather increases the risk of spread of infectious diseases including diarrhea, vector-based diseases (vector-borne diseases), including malaria, non-communicable diseases, and floods [3]. Several studies have tested the relationship between variations in weather and the occurrence of infectious diseases. Changes in weather due to El-Nino (ENSO) affects the spread of disease vectors or non-vector-based like malaria, dengue fever, cholera, hantavirus [4,5].

The process of transmission of disease (including malaria), involves three components: the host (host), agent (parasite) and the environment [6-8]. WHO in the "Manual On Practical Entomology in Malaria", adding 2 components in the transmission process, compose it 5 components: 1.parasit; 2.vektor; 3. host; 4. physical environment; 5. factor ot her biological [9]. The environmental factors can be projected in space and time, respectively, periodic and continuous. Therefore transmission of malaria can be predicted periodically [10].

In 2011 the Central Java province experience and outbreak, where the number of Annual Parasite Incidence (API) in several districts has increased. Purworejo is the only region that experienced outbreaks during the period 2009-2011. Three districts namely Loano, Bagelen and Bener have been designated as areas experiencing extraordinary events. At least 311 residents were in the care of hospitalization due to malaria cases [11].

Macro mapping results indicate spread of malaria in coastal areas, surrounding farm land, the region in the hills Menoreh belt. Temporal fluctuations in malaria cases occur in addition Purworejo from year to year, it also happens from month to month. Environmental change and the vulnerability of the population is strongly suspected as a contributing factor of the condition. Fluctuations in malaria cases occur due to an accumulation of various factors that cause the interaction between sp (vector), parasites, and human environment changes from time to time. Increased incidence of malaria was considered related to climate change, as well as environmental changes, such as changes in land use, changes in behavior, and socio-economic changes [12].

Institute of Medicine (IOM) in 2003 conveyed the Convergence model, linking the various causal factors of disease transmission, which were: 1. man; 2. microbe; 3. ecology factors; 4. descent and biological factors; 5. physical environment factors; 6. socio-political and economic factors. Convergence models incorporate various factors by concentric (centered) to support the emergence of malaria cases [13].

Anopheles sp. found in Purworejo recorded more than 5 species [14]. The 2012 study found species 9 species, namely: *An. balabacensis*; *An. aconitus*; *An. maculatus*; *An. vagus*; *An. kochi*; *An. barbirostris*; *An. subpictus*; *An. indifinitus*; *An. annularis* [15]. Each species has its own characteristics, habitats, distribution patterns and bionomic [16]. Bionomic vector of malaria is influenced by various environmental factors. There are significant changes in weather to bionomic malaria vectors [17].

METHOD

Location and sampling

The study was conducted in Purworejo, which is geographically located at 3°23’20”-4°9’35” east longitude and 5°43’30”-6°47’44” south latitude. Purworedjo district consists of 494 villages, has a specific landscape, coast and mountains in the zone of ecosystem. Malaria endemic areas in Purworejo include 233 villages with a height of 0-723 mdpa. Last ten years (2000-2012) there were 171 villages have been cases of malaria, 22 villages of Low Case Incidence (LCI), 18 village as Middle Case Incidence (MCI), and 22 village as High Case Incidence (HCI) [11].

The research of environment quality, type and density of vectors was done in 34 villages in the region Purworejo. Sample grouped and defined by height class interval region with 100 mdpal and endemicity areas with proportional random sampling. Five villages in the sample to represent the region have been no cases of malaria at an altitude of 0-100 mdpal. Region with MCI category, HCL, LCI at altitude 0-100 mdpal represented each 1 sample. Areas with no cases of malaria category at an altitude of 100-200 and 200-300 mdpal, each represented by two samples, while the other categories, namely category regions with LCI, MCI, HCI height for each sample is represented by 1 sample (Figure 1).

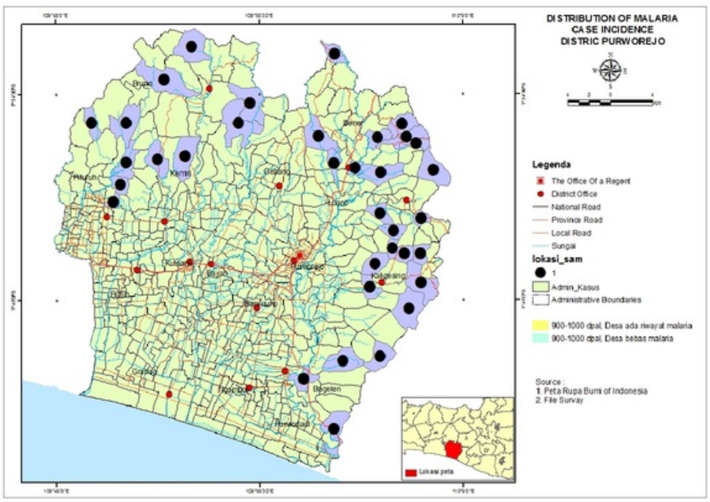


Figure 1 Sampling location

Vector data and environmental quality

The study was conducted during the fourth period:transition of rainy-dry season (May), dry season (July), transition of dry-rainy season (October), and rainy season (December). Type and density of malaria vectors was the parameter in this study. The other parameter were culture, water quality, air quality, breeding places. Vector density was observed by the method of MHD and MBR, whereas the identification of vectors in parasitological laboratory. Observation of the type and density of vectors was done annualy 06:00 pm to 06:00 am. In every village, 2 houses were selected. Each house consisted of 2 catchers, for indoor and outdoor. Confirmatory test was done with ELISA.

Water quality analysis consisted of 9 parameters: pH, turbidity, total dissolved solids (TDS), total suspended solids (TSS), Dissolved Oxygen(DO), chloride, electrical conductivity (EC), salinity and hardness. Air quality parameters on resting place consisted of air temperature, humidity and wind speed. The hourly temperature variation by placing a thermometer in each sample village along with vector density measurements .

Environmental Variability analysis results

Environmental variability analysis is done with graphical trend analysis of the dynamics of environmental quality. Range of water quality parameters and the air density is used as a vector for analysis to determine the effect of neighborhood characteristics and density of the vector.

Environmental variabilityand malaria vectors bionomic

Analysis to determine the effect of changes in the environmental characteristics of the malaria vector abundance was conducted by cluster analysis. Cluster and discriminant analysis to determine which parameters influence significanly. Cluster analysis was performed to determine the distribution of classes of water and air quality. Analysis used cross-tabulation (cross tab), and chart dendrogram. Results of both approaches were the similarity of data that can be formed into 5 groups, 4 groups or 3 groups. Members of the group have been shown in the table cluster analysis and dendogram. Discriminant was used to determine the factors that have a dominant influence. The analysis method was a hierarchical method, because the number of clusters has not been determined. It was assumed that these variables contribute to forming the group in vector abundance. Test of equity analysis of group means, resulting Wilks lambda to a variable rate. Using the F test significance>0.05 would result in a significant discriminant. This matrix structure will provide information which variables had a significant role as a discriminant deskriminan and magnitude of each variable.

RESULT

Species diversity and distribution of Anopheles

Observation in transition of dry to rainy season (May) found 9 species of *Anopheles* at 27 locations. The species were as follows: *An. balabacensis*; *An. aconitus; An. barbirostris; An. vagus; An. anularis; An. kochi; An. maculatus; An. indifinitus; An. subpictus*. The most dominant species was *An. vagus* (209 sp), followed by *An. barbirostris* (84 sp) and *An. aconitus* (49 sp). *An. vagus* was found on a wide range of areas, including 17 villages, with a height range < 100 mdpal up to > 700 mdpal. Other species that hadwide distribution was *An. aconitus* and *An. barbirostris*, scattered in 11 (eleven) villages observations. *An. aconitus* found at an altitude of 200-300 and 400-600 mdpal. At a height of < 200 and > 700 mdpal the species was not found. *An. barbirostris* species are found in areas with height range < 100-600 mdpal, while more than 700 mdpal height of the species was not found. Other species found in low populations was *An. indifinitus*. They found in Somoleter and Cepadak (300-500 mdpal). *An. subpictus* species were found at low densities in areas with an altitude of 100-400 mdpal. The highest number of species was found in Wonosido, a location with a height of 400-500 mdpal. At Wonosido we found six species of the *An. aconitus; An. barbirostris; An. vagus; An. anularis; An. kochi; An. maculatus*. However, *Anopheles* was not found in 7 rural areas: Dadirejo (< 100 mdpal); Kapiteran (< 100 mdpal); Ngandagan (< 100 mdpal); Sokoagung (100-200 mdpal); Tepansari (100-200 mdpal); Durensari (300-400 mdpal); Puspo (300-400 mdpal).

Observation in dry season (July) found 8 Anopheles species at 30 locations. Anopheles were not found in four areas: Dadirejo, Bagelen, Kedunggubah and

Hardimulyo. Eight species found were as follows: *An. balabacensis; An. aconitus; An. barbirostris; An. vagus; An. anularis; An. kochi; An. maculatus;* and *An. subpictus*. *An. indifinitus* did not match any arrests in the dry season. The most dominat species caught was *An. barbirostris* (362 sp), followed by *An. aconitus* (216 sp) and *An. vagus*. Spatial distribution of spesies, *An. aconitus* found in a wide range of areas, included 20 villages, with a height range < 100 mdpal up to > 700 mdpal. Other species that widely distributed was *An. barbirostris*, *An. vagus* and *An. maculatus*. *An. barbirostris* found at an altitude of 100-600 mdpal. *An. vagus* species was found in area with a height range < 100-> 700 mdpal, together with *An. maculatus*. Species found in low populations were *An. subpictus* (Ngandagan with a height < 100 mdpal); *An. anularis* (Wonosido, 500-600 mdpal). We also found four areas with the highest number of species: Wonosido (500-600 mdpal), Kaliharjo (100-200 mdpal), Bleber (200-300 mdpal), Kaliglagah (mdpal 200-30). Five species were found in the four areas.

Observation in transition of dry to rainy season (October) found 8 species at 26 locations. The eight species found were as follows: *An. balabacensis; An. aconitus; An. barbirostris; An. vagus; An. anularis; An. kochi; An. maculatus;* and *An. indifinitus*. *An. subpictus* did not match any arrests in the transition of dry-rainy season (October). The most dominant species was *An. vagus* (353 sp), followed by *An. aconitus* (63 sp) and *An. barbirostris* (53 sp). The range of distribution area of *Anopheles vagus* < 100 mdpal up to > 700 mdpal, inlcuded 16 villages. Other species that had wide distribution is *An. aconitus* and *An. barbirostris*. *An.indifinitus* found at less area, this species found at altitude of 300-400 mdpal (Puspo), although, on previous observations of this species was not found. *An. anularis* was found of 100-200 mdpal (Tepansari). *An. kochi* found only at altitudes of 500-600 mdpal (Wonosido, Watuduwur, and Ngadirejo).

Observation on the rainy season (December) found 7 species at 30 locations. We did not find Anopheles species in four rural areas: Kedung Pom Kulon, Pekacangan, Durensari and Puspo. The seven species found were as follows: *An. balabacensis; An. aconitus; An. barbirostris; An. vagus; An. anularis;* and *An. kochi*. *An. subpictus* and *An. indifinitus* did not match any arrests in this season. Dominan species were *An. vagus* (196 sp); *An. aconitus* (77 sp) and *An. balabaensis* (60 sp). Distribution of habitat of *An. vagus* was found on a wide range areas, included 15 villages, with a height range < 100 mdpal up to > 700 mdpal. Other species that have broad distribution is *An. aconitus* (14 observation villages), *An. balabacensis* (13 villages). *An. indifinitus* and *An. maculatus* were not found in the observations of the rainy season. Other species that were found in low populations consisted of *An. anularis* (Kaliglagah, 200-300 mdpal) and Cacaban Lor (300-400 mdpal). Other studies found the area with the highest number of species Kaliglagah observation locations (200-300 mdpal), found as many as 5 species. The species distribution of four survey periode as the Table 1.

Table 1. Malaria species distribution base on elevation of 4 survey periode

No	Lokasi/Desa	Ketinggian	Jumlah Spesies Anopheles																																			
			balabaensis				aconitus				barbirostres				vagus				anularis				kochi				maculatus				indifinitus				subpictus			
		mdpal	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1	Bagelen	<100		0											1		3	13																				
2	Dadirejo	<100	0	0	0													1																				
3	Kaliwader	<100			2			1	4	2	14	25			11	12	1	1					3	4						6								
4	Kapiteran	<100	0							1		5	1				9	9										1										
5	Ngandangan	<100	0		0			2				2						2																		1		
6	Bleber	< 100	1					65	3	11	1	85	1	3		2	4							3		1		7	1	1								
7	Kaliharjo	<100		2	0	9		1			27	80			1									2				2										
8	Kaliurip	<100					1		1			1		1	1																							
9	Kaligondang	100-200					5	10	5						21	1							1				5	10	1	1					2			
10	Somoleter	100-200		3	1			1	3	4	1	2	5	2	7		11	3					1						3	26	1				3			
11	Kedunggubah	100-200	1	0	3	2																																
12	Sokoagung	100-200	0			3		8									10	12										3										
13	Tepansari	100-200	0					39	6	21				7		8	79	43			2								4	3								
14	Medono	200-300				1		13		4					18	3	40	27					1															
15	Kaliglagah	200-300	2	2	1	14		45		4		15			6	5	94	52				1						4	2	3								
16	Kedung Pom kulon	200-300		1		0							1		1		9												1									
17	Pekacangan	200-300				0			1						6													3										
18	Sendangsari	200-300			0		2			1	1	1			1	1																						
19	Cacaban Lor	300-400		1	1			2	3		13	1			4	11	10	3				1								2								
20	Durensari	300-400	0	5		0			4																													
21	Cepedak	300-400				1		2	2	4	1	18					1							1							1							
22	Puspo	300-400	0			0		1	1																								1					
23	Ngaran	400-500	3				5	1			1						1									1	1		1	5								
24	Guntur	400-500			0	1	1	3		1						5												1										
25	Hardi mulyo	400-500		0		9	2								5		1	1									1		1									
26	Wonosido	400-500					21	7	3	2	14	35	1	1	113	7	55	17	18	14			15	10	1	1	4		7									
27	Ngadirejo	500-600	1				2	2	1	3	9	12	4	6	10		18	11					2		1	3		1										
28	Ngasinan	500-600			1	1			1	3					1		1							1			1											
29	Purbowono	500-600	1	1	0	5	4																															
30	Watuduwur	500-600					5	1	13	16	2	80	40	12			2								2	1			10									
31	Benowo	600-700	2			1	1		12							1	3	1											2									
32	Donorejo	600-700	1		3	8											1											1										
33	Gunungwangi	600-700		4	0			8							2													1		1								
34	Tlogoguwo	>700			0	5		4																			1											
	Jumlah Spesies	1781	11	14	9	55	49	166	52	55	84	355	52	25	209	48	255	129	18	14	0	2	23	21	4	7	13	30	29	45	2	0	0	0	5	0		

Note : A : observation on May ; B: obseravtion on July; C : observatiom on October
D : observation on December

Analysis ELISA

ELISA test is used to determine the content/levels in the body sporozoites sp. This test refers to ELISA sporozoites detection, as a reference in the test. The test showed Anopheles species acted as transmitting Plasmodium (malaria vectors). Species found during the arrest in rainy-dry transition period (May), dry season (July), dry-rainy transtition (October) and rainy season (December) were as follows: 1. *An. balabacensis*; 2. *An. barbirostris*; 3. *An. vagus*; 4. *An. maculatus*; 5. *An. aconitus*; 6. *An. kochi*; 7. *An. indifinitus*; 8. *An. anularis*; 9. *An. supictus*. ELISA test results showed as table 2.

Table 2. Spesies Anopheles as vector malaria

No	Observation location	Periode	Malaria vector	plasmodium
1	Kedunggubah	October	An. balabaensis	P.falciparum
2	Ngaran	October	An.maculatus	P.falciparum
3	Kaliharjo	December	An.balabaensis	P.vivac
4	Kedunggubah	Descember	An. balabaensis	P.falciparum

Environmental Quality Data
Water quality(breeding place)

1. The degree of acidity (pH)

Results of water quality measurements at 34 locations showed in transition from dry to rainy season (May), pH ranged 4.3 to 8, with an average of 6.63. In the dry season (July) pH ranged 6-8.5, with an average of 7.12. In the dry season pH ranged 4.8 to 8.5 with an average of 6.84. In the rainy season pH ranged 4.3 to 8 with an average of 6.63.The data also showed the rainy season the average degree of acidity (pH) equal to 6.63 lower than 7.12 in dry season and the rainy to dry transition of 6.84. The average pH of rainy with rainy-dry transition was 6.63. This suggested that pH during the rainy to dry transition and dry season were unchanged. pH increased in dry season and rainy season before entering transition. Figure 2 showed the amount of variation in the average pH of 0.49 is the average difference between the rainy and dry seasons.

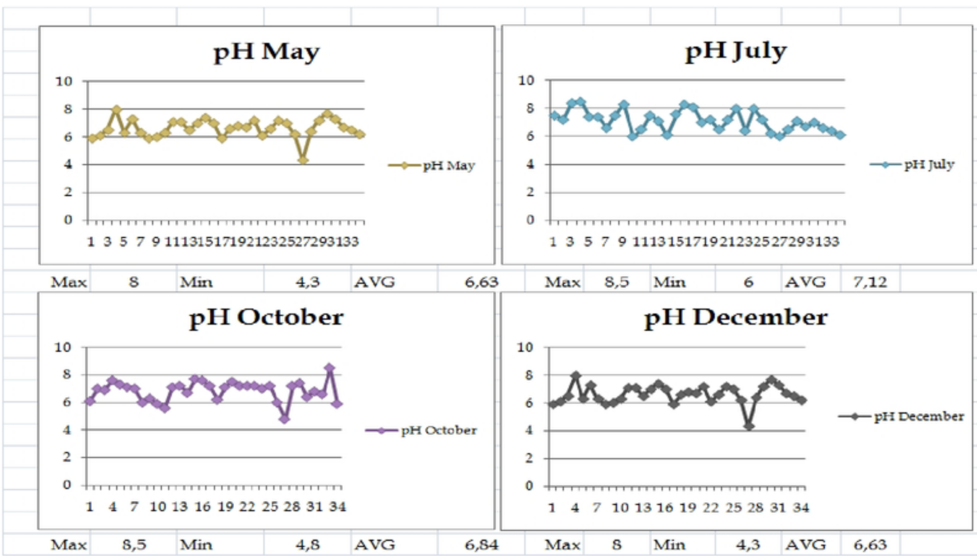


Figure 2. Variability of pH of 4 survey periode

2. Turbidity (NTU)

Our result showed turbidity variation between seasons. The highest mean turbidity (10.3) was found in transition of dry to rainy season (May),while the lowest (4.8) was found in dry season (July).

3. Total dissolved solid (TDS)

In general, a chemical compound derived from the surrounding environment. Our result showed variability of dissolved material (TDS) between seasons. The mean TDS was as follow: 123.4mg/l (May), 154.5mg/l (July), 147.8 mg/l (October) and 102.7 mg/l (December).

4. Suspended solid (TSS)

Measurement in wet-dry transition season (May) showed average TSS was 26.44 mg/l, ranged of 1-87 mg/lt. At follow-up measurements in the dry season (July) the average TSS values decreased to 3.76 mg/l, ranged of 1-31 mg/lt. Deviation between the transition and dry season of 22.68 mg/lt. TSS measurements on dry to rainy transition season (October) produces an average value of 13.06 mg/l, in the range of 1-36 mg/lt. The value increases with the value of 9.3 mg/l compared to the period of the previous season. In the rainy season (December) average TSS 11.94 in the range of 1-104 mg/l. The decrease in the rainy season due to the suspended material has been reduced by rainfall in the transition season.

5. Salinity

Salinity varied between seasons in Purworedjo. Measurement in rainy to dry transition (May) obtained average salinity of 0.0052‰, ranged 0.0009-0.0173‰. Salinity decreased during dry season (July) to 0.0037‰, in the range of 0.001-0.03‰. Deviation between the two seasons was 0.0015‰. Further measurement in dry to rainy transition (October) showed salinity of breeding places decreased slightly to an average of 0.0033 ‰, with a range of 0.0009-0.0173 ‰. As well as in rainy season (December) salinity has decreased by an average of 0.0023 ‰, with a range of 0001-0008 ‰. (Figure 3)

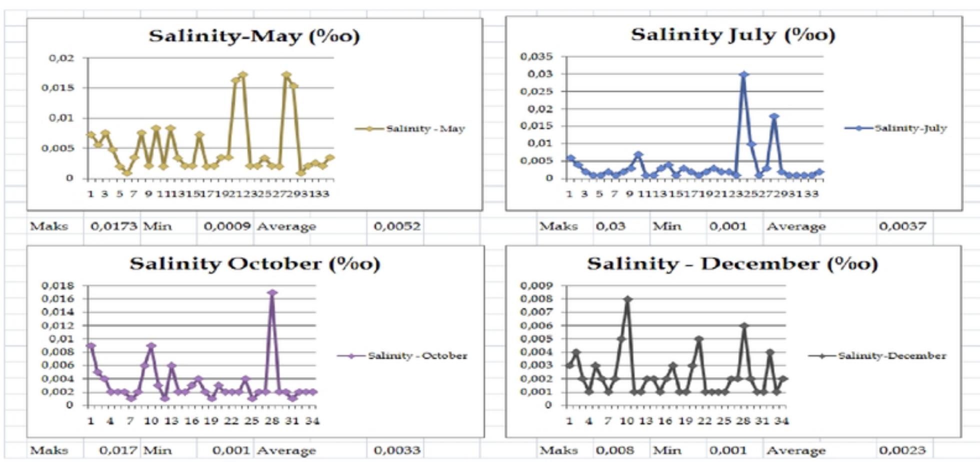


Figure 3 : variety of salinity of 4 survey periode

6. Dissolved oxygen (DO)

At the transition rainy to dry season (May) average DO was 3.7 mg/l, ranged 1-6.2 mg/lt. DO increased in the dry season (July) to 4.4 mg/l, ranged 2-6.8 mg/lt. There is a deviation of 0.7 between the two seasons. In transition of dry to rainy season (October) the average DO was 4.6 mg/l, ranged 2.1-6.6 mg/lt. The DO increased by 0.2. In rainy season (December) average DO was recorded at 5.2 mg/l, ranged 2.3-7.4 mg/lt. Deviation between transition and rainy season was 0.6 mg/lt.

7. Chloride (Cl)

Measurement in dry to rainy transition obtained average Cl concentration of 10.1 mg/l, ranged 1.7-30.8 mg/l. The average decreased to 6.15 mg/l in dry season, ranged 1.7-36.6 mg/l. Deviation of 3.95 was occurred between the two seasons. Further measurement in transition from dry to rainy season showed average of 7.8 mg/lt, ranged 1.7-40.9 mg/l. There was 1.65 difference between dry and transistion. Measurement in rainy season showed chloride concentrations declined by an average of 5.0 mg/l, ranged from 1.7-6mg/lt. Deviation of 2.8 occurred between the transition and the rainy season.

8. Electricconductivity (EC)

Our study showed an EC variations between seasons. Measurement in rainy to dry transition showed average EC 234.8 µmhos/cm, ranged of 91-604 µmhos/cm. In dry season average EC 249.41 µmhos/cm, ranged 57-567 µmhos/cm. There was 14.61 difference between transition dry to rainy with dry season. In dry to rainy transition EC increased the average of 279.41 µmhos/cm, ranged 126-488 µmhos/cm. Deviation between the periods was 30. In the rainy season EC decreased to 192.94 µmhos/cm, ranged 64-458 µmhos/cm. Deviation of 86.47 occured between the transition season and the rainy season.

9. Hardness

Our result showed hardness varied between seasons during the observation. Measurement in rainy to dry transition showed an average hardness of 88.18 mg/l CaCO3, with a range from 26.8-184.01 mg/l CaCO3. Measurement in dry season showed hardness increased to an average of 108.03 mg/l CaCO3, ranged 25.74-240.57 mg/l CaCO3, which was an increase of 19.85. Measurement in dry to rainy transition obtained hardness average of 116.68 mg/l CaCO3, ranged 24.88-254.52 mg/lt. Deviation compared to previous season was 8.08. Measurement during rainy season showed an average hardness of 81.27 mg/l CaCO3, ranged 28.86-197.99 mg/lt. Deviation occured was 35.41.

Air quality (resting place)

1. Air temperature

There was variation of air temperature during seasons. On May we obtained an average air temperature 28.3ºC, ranged 23.5 to 31 ºC. At follow-up measurements On July temperatures decreased to 26.9 ºC, ranged 23-32 ºC. There was 1.4 ºC difference between rainy-dry transitions with dry season. On October the average air temperature was 29.1 ºC, ranged 26.5-33 ºC. Deviation was 2.2 ºC between the two seasons. On December average temperature was 26.29 ºC, ranged 22.5-30.5 ºC. The average temperature decreased 2.81 ºC (Figure 4).

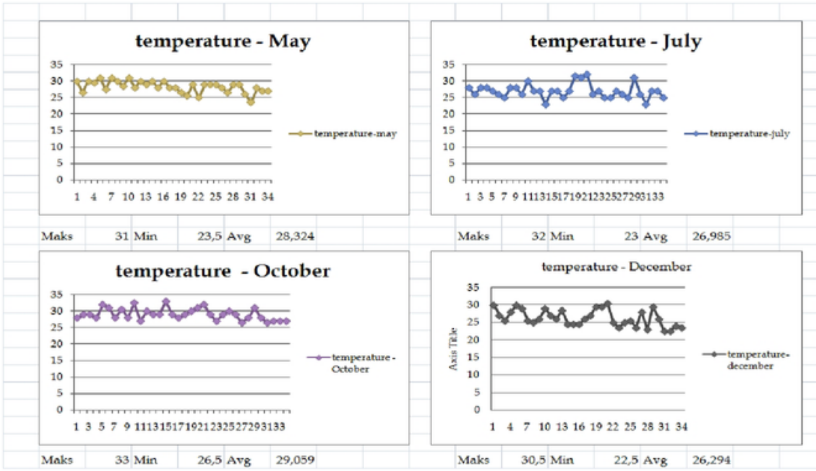


Figure 4. variability of air temperature of 4 survey periode

2. Humidity

Measurement on May found average relative humidity was 80.6%, ranged 71-96%. Measurement on July obtained an average humidity of 79.8%, ranged 61-89%. Humidity changed about 0.8%. Measurement on October obtained an average humidity of 68.41%, ranged 52-79%. The humidity changed 11.3% from previous season. Measurement on December obtained an average humidity of 86.3%, ranged 70-100%. This changed 11.4% from previous season.

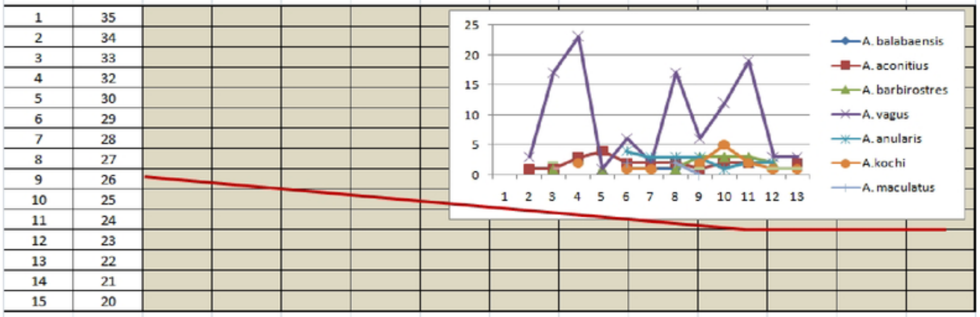
3. Wind speed

Average wind speed in transitiondry-rainy season was 1.6km/h, ranged 1.08-2.88 km/h. In dry season the average wind speed was 1.86 km/h, ranged 1.08-3.96 km. The wind speed in dry season was 0.26 km/h faster. In transition dry-rainy season we obtained average wind speed of 3.42 km/h, ranged 1.25-8.57 km/h. This was 1.56 faster compared to previous season. In rainy season the average wind speed was 2.35 km/h, ranged 1.05-5.56 km/h. This was 1.07 km/h slower compared to the previous season.

Bionomic of malaria vector

Mosquito catching was conducted at 06:00 pm-06:00 am. Air temperature decreased from 26.5 ºC at 06:00 pm to 23 ºC at 03:00 am, after that the temperature was relatively constant until 05.00 am. *An. balabacensis* have intermittent movement pattern, found from 08:00-09:00 pm, and found again in low density at 11:00 pm to 01:00 am. *An. aconitus* was consistently found throughout 06:00 pm to 06:00 am, only paused between 04:00-05:00 am. *An. barbirostriss* was started to catch at 07:00 pm until 00:00 am, the activity continued at 00:00-05:00 am. *An. vagus* was a dominant species, was found throughout the night, and had 2 density peaks, at 08:00-09:00 and 00:00 am. *An. anulari s*was started to catch at 10:00 pm until 05:00 am in a medium density. Activity of *An. kochi* was started at 08:00 pm until 06:00 am with a relatively constant density. *An. maculatus* had activity around 10:00 pm-01.00 am. *An. indifinitus* found at 07:00-08:00 pm, when all other species were not found (Figure 5).

Uraian		18 -19	19 - 20	20 -21	21 - 22	22 - 23	23-24	24 - 01	01-02	02-03	03-04	04-05	05-06
Suhu	° C	26,0	25,5	25,0	24,5	24,5	24,5	24,0	23,5	23,5	23,0	23,0	23,0
	° F	78,8	77,9	77	76,1	76,1	76,1	75,2	74,3	74,3	73,4	73,4	73,4



A. balabaensis			2			1	1					
A. aconitius	1	1	3	4	2	2	2	1	2	2		2
A. barbirostres		1		1			1	3	3	3	2	
A. vagus	3	17	23	1	6	2	17	6	12	19	3	3
A. anularis					4	3	3	3	1	2	2	
A.kochi			2		1	1		2	5	2	1	1
A. maculatus					2		2					
A.indifinitus		1										

Figure 5 : Bionomic of Anopheles of endemic area of Purworejo

Analysis of environmental variabilityand vector density

Discriminant factor analysis generated variables that affect the interests of the vector density on May were TDS (0.737), chloride (0.943), turbidity (0.733), air temperature (0.837), humidity (0.578), and wind speed (0.799). In the dry season (July) the discriminant variableswere TDS (0.903), chloride (0.889), salinity (0.949), air temperature (0727), humidity (0.792), and wind speed (0.894). Dry to rainy transition season had TDS (0.682), salinity (0.648), hardness (0.755), conductivity (0.523), DO (0.867), air temperature (0.726), humidity (0.777), and wind speed (0,665) as discriminant variables. In the rainy season the variables consisted of chloride (0.854), turbidity (0.319), hardness (0.705), DO (0.817), pH (0.796), air temperature (0.626), humidity (0.721) and wind speed (0,678).

Table 3 showed habitat for each species. *An. balabaensis* found in areas with an altitude of 50-500 mpdal, pH 4.3-8.3, DO 1.3-7.4, conductivity (44.78-604), hardness 24.88-206.91), salinity (0001-0.018), turbidity (1-48), chloride 1.7-36.6), TDS 39-239. Habitat of *Anopheles aconitus* was areas with altitude 0-750 mpdal, pH 4.3-8.5, DO 1.7-7.4, conductivity 57-488, hardness 24.88-254.52, salinity 0.0009-0.018, turbidity 1-58, chloride 1.7-40.9, and TDS 37-890. Distribution of species base of elevation showed at figure 6.

Table 3. Habitat characteristic of species Anopheles

No	habitat characteristic	malaria species								
		An.balabaensis	*An.aconitus*	*An.barbirotres*	*An.vagus*	*An.anularis*	*An.kochi*	*An.maculatus*	*An.indifinitus*	*An.subpictus*
1.	elevation, mdpal	50-100	0-750	0-500	0-800	350-500	0-500	50-500	150-400	50-300
2.	breeding place quality									
	TDS (mg/lt)	39-239	37-890	54-890	37-890	54-229	37-230	42-310	55-230	51-268
	Chlorida (mg/lt)	1,7-36,6	1,7-40,9	1,7-30,8	1,7-40,9	1,7-20	1,7-30,8	1,7-29,9	2-30,8	2-10
	turbidity (NTU)	1-48	1-58	1-58	,1-58	1-48	1-48	,1-48	1-31	2-31
	salinity (‰)	0,001-0,018	0,0009-0,018	0,0009-0,0163	0,0009-0,03	0,0009-0,009	0,0009-0,0163	0,0009-0,03	0,001-0,0163	0,0009-0,0035
	hardness (mg/lt)	24,88-206,91	24,88-254,52	31,84-172,26	24,88-254,52	44,78-119,18	24,88-175,12	28,86-240,57	48,24-152,51	42,21-254,52
	conductivity (µmhos/cm)	44,78-604	57-488	91-481	57-488	109-471	57-481	64-481	116-481	106-488
	DO (mg/lt)	1,3-7,4	1,7-7,4	1,7-7	1-7,4	2,7-7	1,9-6,9	1,7-7,4	1-6,5	2,1-5,9
	pH	4,3-8,3	4,3-8,5	5,6-8,5	4,3-8,5	5,9-8,3	4,3-8,4	5,6-8,5	6,5-7,5	6,3-7,5
3.	resting quality									
	temperature (°C)	22,5-31	22,5-33	24,5-33	22,5-33	24,5-32,5	23,5-32	22,5-32,5	25,5-32	25.5-32
	humidity (%)	61-90	52-89	52-93	52-95	60-89	55-96	55-95	61-88	61-88
	wind velocity (km/h)	1,08-5,56	1,08-7,4	1,05-7,4	1,05-8,57	1,05-4,48	1,05-7,4	1,05-7,4	1,08-5,56	1,08-4,36

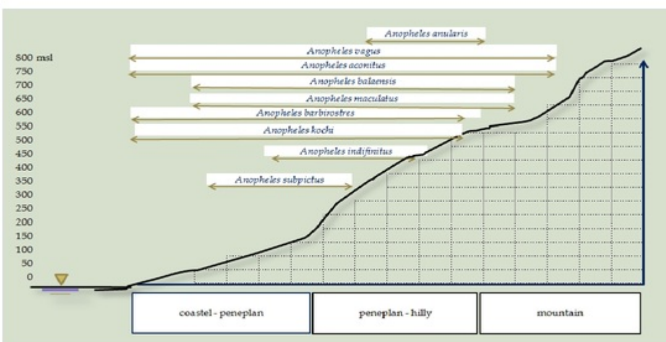


Figure 6. Distribution of species base of elevation at Purworejo

Our results showed habitat suitability index (HSI) experienced dynamic variation between seasons. In rainy to dry transition, regions were HSI medium (29%), high (9%), very high (3%), the corresponding overall (41%). HSI in dry season was medium (35%), high (21%), very high (9%), which corresponds to 65% overall. HSI in rainy to dry transition was medium (24%), high (24%), very high (32%), 79% overall. In rainy season the HSI was medium (38%), high (15%), very high (26%), 79% overall (Figure 7).

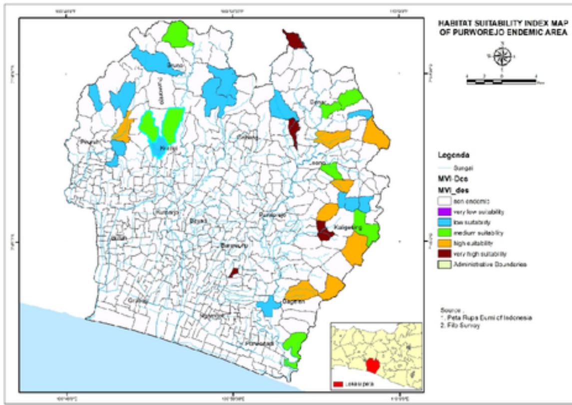


Figure 7. Map of Habitat Suitability Index of Purworejo Endemic Area

DISCUSSION

Malaria remains a health problem in Indonesia. Various factors conical and support each other (convergent) on malaria transmission [13]. Vector of malaria as one component of malaria transmission has ecological system [18]. Every landscape on earth has experienced characteristics and ecological processes of life on it [19,20]. Each region with its characteristic habitat for living beings has always experienced the dynamics of natural processes [21-23]. Weather changes that occur globally give life extensively, both to humans and disease patterns [24]. Malaria is a disease that is affected by global climate change [3,25-30].

Malaria habitat shifts in a wider space. Altitude regions that have not previously found malaria, it is currently found malaria and it vectors, Anopheles [31.32]. Mapping in malaria endemic areas, such as Purworejo, is a strategic step in the control of malaria. Knowing the characteristics of the region and spesific habitat was the key to controlling malaria vectors [33].

Our results showed *Anopheles* species experienced the dynamics of each season, consisted of 9 species in rainy to dry transition, 8 species in dry season , 8 species in dry to rainy transition, and 7 species in rainy season. This proves that the *Anopheles* species have dynamics over time from one season to another season in a year.[34]. The changes are caused by a variety of factors. One of which is the change in quality of habitat [35]. Our study showed habitat changes, which were mainly from the breeding place.

Characteristics of the breeding place changed in every season. In this study, we proved that acidity, turbidity, TDS, TSS, salinity, dissolved oxygen, chloride, conductivity, and hardness were all changed in accordance with seasons. Air quality also changed during observation, consisted of temperature, humidity, and wind speed. According to the law of tolerance Shelford, living beings will grow and develop in accordance with the betas tolerance [21]. Environmental characteristics provide materials and energy as a source of nutrients for optimal living beings to limit growth. At concentrations of less or excess of matter and energy it is precisely as a barrier to growth [19,22]. Each region has environmental quality, water and air, which is influenced by the interaction geosphere, biosphere, lithosphere, hydrosphere and atmosphere [23,36].

Every living being will choose a place to live (habitat) in accordance with the need to grow and develop optimally [37]. If there is a change there will be a migration of habitat, adaptation, mutation or extinction [38.39]. The distribution of malaria vectors in Purworejo is in accordance with nature of every living being. Living being always attempts to locate the material and the energy of the habitat in which to grow and develop optimally [40]. *An. vagus* and *An. aconitus*live in a range of 0 mdpal (coast) to 850 mdpal (hills) because both species have a high tolerance to grow and thrive. Tolerance is not shared by other species, so the species is more limited range distribution [41].

Distribution of Anopheles in Purworedjo according with height range region forms a particular pattern. *An. subpictus*, *An. anularis* and *An. indifinitus* have a limited distribution range. This result is consistent with studies in other parts of Indonesia [42-44] and parts of Africa, Brazil or Asia [32,45-51], indicating the existence of a certain range of the distribution of Anopheles species.

Environment as a limiting factor is for Anopheles was water quality (as a place to breed) and air quality (as a place to rest) [52]. Cluster and discriminant analyses revealed main parametersof environmental had seasonal dynamics. Season cycle as discriminant was TDS (0.737), chloride (0.943), turbidity (0.733), air temperature (0.837), relative humidity (0.578), wind speed (0.799), salinity (0.949), hardness (0.755), conductivity (0.523), dissolved oxygen (0.867), and pH (0.796). Our study suppported theory that parameters of water and air qualities experienced seasonal dynamics throughout the year [23,53]. Rainfall and surface water runoff will dissolve the chemical elements of rock and soil, thereby providing direct effect on changes in water quality parameters [54]. Air quality parameters are influenced by the movement of the sun that affects climate change. Topographically each region has distinct regional characteristics [36].

Dynamics of environmental quality (water and air) that occurs in each region will affect the breeding cycle of the vector [55]. Mosquito cycle of egg, larva, pupa, and adult mosquitoes is affected by the water composition suitable for growth. At good composition, accompanied with suitable energy and material for breeding, vector will occus in hight density [56]. Our results from 34 locations confirmed the dynamics of environmental quality and the dynamics of the vector density. The composition of air and water quality on every land, form a specific habitat for malaria vectors.Habitat suitability index (HSI) is an index that gives an overview about the suitability of any area for growing and breeding of malaria vectors [40]. Our result showed each species of Anopheles has specific environmental characteristics needed to breed. For example, *An. aconitus* and *An. balabacencis* have different need for altitude, pH, DO, conductivity, hardness, salinity, turbidity, chloride, and TDS. Similarly, other species also has a specific habitat. Our study showed similar results with other studies in Asia (Bangladesh and Vietnem) and Sudan, which also showed characteristics of a region served as determinant of malaria vectors [48,58,59,60]. Our result also showed HSI in Purworejo experienced dynamics in every season. This was similar to previous studies [26,46,64,70].

CONCLUSION

The environmental had dynamic characteristics and effect on life cycle ofmalaria vector. Species found during one year observation were *An. balabacensis, An. barbirostris, An. vagus, An. maculatus, An. aconitus, An. kochi, An. indifinitus, An. anularis, An. supictus*. ELISA test results showed *An. maculatus* and *An. balabacensis* served as malaria vectors. Environment as dynamics parameters for Anopheles are TDS (0.737), chloride (0.943), turbidity (0.733), salinity (0.949), hardness (0.755), conductivity (0.523), dissolved oxygen (0.867), pH (0.796), air temperature (0.837), relative humidity (0.578), and windspeed (0,799). Suitable habitat for Anopheles in Purworedjo based HSI was as follow: rainy to dry transition (41 %), 65% of the dry season, the dry yo rainy transition 79 % and rainy season 79 %. Further research needs to be done to measure the environment quality and vector density in other regions in Indonesia, so it can be used for mapping of areas with high HSI, as malaria vector control

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