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The area and index of diurnal dynamic of microclimate gradient as a mangrove – environment interaction parameter

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Abstract

Environment interactions with forest ecosystems including mangrove forests can be described by changes of the micro climate parameter quantity around the edge of the woods. This study describes the use of the dynamic area and index parameter of air temperature and humidity gradient. We formulate these parameters to characterize the mangrove forest microclimate and its interaction with the environment. Diurnal data collecting of the air temperature and humidity is conducted in ten transects which have different environmental conditions and ecosystem borders. The results show that the dynamic area parameter of the microclimate gradient may characterize the mangrove ecosystem and border environment.

Keywords: air temperature, air humidity, gradient dynamics.

1. Introduction

Diurnal microclimate change controls various biophysics process in forest ecosystem (De Siqueiran *et al.,* 2004; Godefroid *et al.,* 2006; Bunyan *et al.,* 2012), including mangrove forest (Medellu, 2012.a.; de Lima *et al.,* 2013). Microclimate variables that are often used by researchers in describing forest ecosystem microclimate are: radiation intensity of sun, air temperature, air humidity, wind velocity (Davies_Colley *et al*., 2000, Newmark, 2001; Hennenberg *et al,* 2008, de Lima *et al.,* 2013). Diurnal microclimate change is described in some quantities, i.e.: difference between the maximum number of microclimate variable inside and outside forest (Chen *et al.* 1993; Anderson and Leopold 2002), depth of edge effects (Gehlhausen *et al.* 2000; Stewart and Mallik, 2006; Medellu *et al.,* 2012; Ibanez *et al.,* 2012), microclimate variable gradient around the forest boundary (Chen *et al.* 1995; Williams-Linera *et al.* 1998; Gehlhausen *et al*. 2000; Newmark 2001; Cienciala et al. 2002). These parameters can characterize the forest ecosystem and boundary environment.

The diurnal microclimate gradient parameter in the forest edge is indicator of thermal diffusion through the boundary ecosystems with environment. Microclimate gradient values at the edges are not fixed throughout the day (Medellu *et al.,* 2012.a., Ibanez, 2012). Gradient sign that indicates the direction of thermal diffusion can also change. During the day, the temperature gradient at the boundary of mangrove forest and the sea has a negative sign (air temperature above the sea level is higher than the air temperature under the mangrove canopy). At night the temperature gradient has a positive sign. During the day, the humidity gradient around the boundary of mangroves and the sea has a positive sign, while at night it has negative sign. Micro climate gradient value and sign changes at the edge depend on the condition of the ecosystem and the boundary environment (Medellu 2012.a; 2012.b).

In dissertation, I have formulated two new microclimate parameters, i.e.: (1) the diurnal dynamic area of microclimate gradient, and (2) the diurnal dynamics index of microclimate gradient. Both of these parameters are related and interpreted as a whole. The diurnal dynamic area of microclimate gradient is the area that is formed by the diurnal dynamics of microclimate gradient curve with thermal equilibrium line between the ecosystem and environment. The thermal equilibrium line shows the time when the quantity of micro climate variable on the inside and the outside of the border are same. When the thermal equilibrium is reached, the gradient value of microclimate variable is equal to zero. The time to achieve thermal equilibrium indicates the direction transition time of thermal diffusion between the forest ecosystem and the environment (Medellu, 2012.a). Diurnal dynamics index of microclimate gradient is a comparison between the diurnal dynamics area of microclimate gradient at night and day. This article demonstrates the use of diurnal dynamic area of air temperature and humidity gradient in grouping of mangrove forests which have different ecosystem conditions and environment borders. These groupings can prove that the gradient diurnal dynamic area parameters can be used as indicators of mangrove forest interaction with the environment.

2. Materials and Methods

The microclimate variable calculation (air temperature and humidity) is conducted in three research locations, i.e.: (1) mangrove forest in Talengen Village Sangihe Regency, (2) mangrove forest in East Ratatotok Village Southeast Minahasa Regency, and (3) mangrove forest in Arakan Village South Minahasa Regency. The number of transects at location (1) are three transects, location (2) are five transects and location (3) are two transect. Determination of transects based on border environment variation and structure of mangrove forest. Border environmental variation includes: open ocean, river, shrub vegetated coast, large wooded shore, the invegetated beach, and asphalt roads. Border environment differences such as sea, rivers, open beach (sand), thicket-overgrown-beaches, and trees-overgrown-coasts affect the amount of microclimate parameters (Medellu, 2012). Structure variations in mangrove forest include: stand high, canopy density, the existence of fragments and gap. Forest ecosystems where there are gaps, shows the quantity of edge gradient parameter and depth of edge gradient parameters that are different with homogeneous mangrove forests (Medellu, 2012.a.; Medellu et al., 2012.a.). The presence of fragments also affects the quantity of micro-climate parameters (Medellu, 2012.a). Canopy cover variations cause radiation energy transmission differences, thus it cause differences in the maximum value and the time-lag between the water/mud temperature changes under the canopy with irradiation intensity changes (Medellu *et al*., 2012.b). Location map and measurement transect coordinates is presented in Appendix. Measurements transect condition at three research sites are presented in Table 1.

Table 1. Transect condition

Location	Tran sect	Mangrove type	Forest structure	% canopy coveri	Environment condition
Talengen Bay (1)	1	Fringe	Homogeny, *Rhizophora*, gap at 36 m from the edge	72-85	sea, Talengen Bay
	2	Fringe	Homogeny, *Rhizophora*	75-85	Sea, Talengen Bay
	3	Riverine	Homogeny, *Rhizophora*	78-88	River/Talengen Bay
East Ratatotok village(2)	1	Ham- mock	Fragmented (12 m from the edge)	90-95 55-70	Aspalt strreet, mangrove at 8 m from edge
	2	Fringe	Homogeny, *Rhizophora*	75-80	Coast (shrub)
	3	Basin	Heterogeny in type, high and canopy cover.	40-65	Coast.shrub, sea infront
	4	Basin	Heterogeny, domination of *Avicenia*	35-55	Coast/shrub
	5	Scrub	heteerogeny, domination of *Avicenia*	50-60	Coast/shrub
Arakan village (3)	1	Fringe	Homogeny, *Rhizophora*, i	75-85	Sea
	2	Basin	Heterogeny, in mengrope type, high and canopy cover.	55-65	Coast, shrub and high trees

Source: Medellu, 2012

Data Collection

Data collecting at each transect is conducted for 24 hours. The measurement time interval is 1 hour. Data collecting use *moving station system*. The measurement is conducted at nine positions, i.e. 4 m and 2 m from the edge to outside mangrove forest, at the edge (as the reference position: x = 0), and at the distance of 1 m, 2 m, 4 m, 8 m, 16 m, and 32 m from the edge to inside of mangrove forest. The measurement at location 1 (Talengen Village) was conducted on May 2012. The measurement at location 2 (East Ratatotok Village and location 3 (Arakan Village) in 2012. At the measurement, the wind velocity is low, < 2 m/sec, and it is not raining. The used data format for the variables: sun radiation intensity, air temperature, air humidity, and water/soil temperature, as the following.

Tabel 2. Form of microclimate data measurement

Variable: ……………………....Location: ….……………………transect num: …..

Position	Time of measurement						
	06.00	07.00		t_i			06.00
- 4 m				$T(-4,t_i)$			
- 2 m							
0				$T(0,t_i)$			
1 m							
2 m							
4 m							
8 m							
16 m							
32 m				$T(32,t_i)$			

The measurement of the four variables for each position is performed simultaneously using the "four in one" equipment that can measure the four variables simultaneously. The variable of sun intensity was observed between 06:00 am to 06:00 pm, with one hour of observation time interval. This article presents a method of analysis and the determination of the value of the diurnal dynamic area parameter of air temperature and humidity.

The determining procedure of diurnal dynamic area and index of air temperature and humidity gradient parameter

1. The diurnal temporary changes modeling of air temperature, air humidity, and soil/water temperature variables.

The temporary changes modeling of micro climate variable use Fourier function modeling procedure. This modeling is performed per measurement position, so that it produces temporary change function for each measurement position. The Fourier function models for each measurement position are:

$$T(t) = T_0 + \sum_{m=1}^{N/2} a_m \cos \omega_m t + b_m \sin \omega_m t \quad \text{……………………………………(1)}$$

$$\omega_m = 2\pi m/N \quad \text{…………………………………… (2a)}$$

$$a_m = \frac{2}{N} \sum_{t=0}^{N-1} f(t) \cos \omega_m t \quad \text{…………………………………… .(2b)}$$

$$b_m = \frac{2}{N} \sum_{t=0}^{N-1} f(t) \sin \omega_m t \quad \text{……………………………………(2c)}$$

m is enumerator harmonic, and N is the number of data. N also shows the number of data pairs of time (t) variable with the micro-climate variable.

Measurements for 24 hours with one hour intervals for air temperature and humidity variable, result 24 data (N = 24). The number of harmonics is N/2, so for 24 observations data, the value of m is: 1, 2, …………., 12. Fourier function modeling steps are:

a.Determining the coefficients of a_m and b_m, using Equation (4-2b) and (4-2c).

b.Determine the coefficient of $c_m^2 = a_m^2 + b_m^2$.

c.Determine the contribution of diversity: $s_m = (c_m^2/(2.\sigma)).100$

σ is the standard deviation of the microclimate variable data. This stage produces the value of a_m, b_m, c_m and s_m for m = 1,2 , ... 12. The scale data of diversity donation (s_m), is made as determining reference of the needed harmonics number to construct the temperature and humidity function. Model data deviation on the measurement result data is the smaller if the harmonic is taken more. Temporal functions that cannot fluctuate greatly can be constructed from four to six harmonics, but if the temporal function fluctuates widely, then the entire harmonic will be used. This stage displays graphs and functions of the temporal changes in micro-climate variables for each measurement position.

2 . Data synchronize data inter-positions.

This synchronization must be done because the data were not measured simultaneously, but switching from one position to the next position, along the transects. Data synchronization is done by measuring the time difference between entering data from one position to the next position, to the modeling result function (stage 1). This synchronization does not alter the function but gives a new value for each position. The synchronization data results are used for spatial analysis and modeling so that the microclimate parameters that describe the spatial variations can be determined.

3 . Spatial modeling microclimate variables .

The researcher develops spatial function modeling techniques of thermal diffusion in the form of exponent, using three pairs of reference data and is controlled using another three or more data pairs. The development of this function modeling techniques is compatible and supports the measurement method on several positions near the edge (logarithmic distance). Spatial function modeling technique of measurement result on data six or more positions around the edges ensures the efficiency of field measurements and data analysis that result the quantitative parameters: edge effects depth, edge gradient, area and diurnal dynamic index of the microclimate gradient. This spatial modeling techniques is constructed from three pairs of field data, including the reference position data (x = 0), and three or more pairs of control data. A general model of diffusion exponential function is:

$$T(x) = k_1 + k_2.e^{k3 - k4.x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where x is the distance from the edge to the middle of mangrove (Medellu 2012.a.; 2012.b.). The constants k_1, k_2, k_3 and k_4 obtained by iteration techniques (computer). Usually it takes four pairs of data (x,T), but if it select the reference point data (x = 0), then the constants and coefficients can be determined by three pairs of data, for example: (0, T_0), (x_1, T_1), and (x_2, T_2). Stages of iterations to generate constants and coefficients of spatial functions are:

$$(T_0-T_1)/(T_0-T_2)=[(\exp(k_4.x_2).(\exp k_4.x_1-1)]/[(\exp(k_4.x_1).\exp(k_4.x_2-1)]$$

$$k_3 = (T_0 - T_1)/(1-1/\exp(k_4.x_1))$$

$$k_2 = (T_0 - T_1)/(\exp(k_3) - \exp(k_3 - k_4.x_1))$$

$$k_1 = y_0 - k_2.\exp(k_3)$$

Through the stages of spatial functions modeling, it generates special function and graphs for each measurement time. Spatial function and graphs can also be developed for any time by first determining the value of the variable at the position in question. The trick is to enter the time data on the temporal function at the measurement position. Example of microclimate (air temperature) function and spatial function graph for 07.00, 13.00 and 23.00 are presented in Figure-1 (source: Medellu, 2012.b).

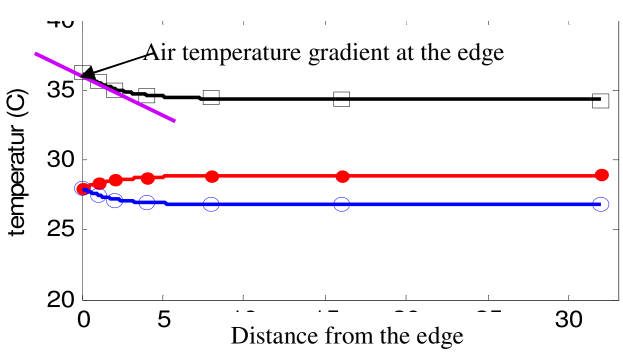

Figure 1. Spatial changes of air temperature at 07.00 a.m. (blue), 13.00 p.m. (black) and 23.00 p.m. (red)

Mathematic ... location, to 23:00 hours (Figure-1, t...

T(x) = 34.3...

Spatial function graph of the air temperature shows that during the day, the outside temperature is higher than in the forest, while at night (around 23:00 o'clock) the air temperature in the forest is higher than the air temperature outside the forest. The graph also shows the air temperature fluctuates more around the edges than in the forest.

4. Gradient determining at the edge of mangrove

The micro climate variable at the edge of mangrove forest is obtained from the relationship of G = dT(x)/dx for x = 0, or through the equation:

$$G = - k2.k4.\exp (k3) \qquad (4)$$

The value of k_2, k_3, and k_4 are obtained from the stage 3. T(x) is function (micro climate variable) that change all the time; so with the value of k2, k3, and k4. That means microclimate variables gradient at the edge of the mangrove forest is dynamic or change according to the time (Newmark, 2001; Medellu, 2012.a.; 2012.b.). Edge gradient in Figure 1 is shown by the tangent on the spatial function at the edge (x = 0) (purple line). Edge gradient value is the tangent slope angle of the tangent line at position x = 0. During the day the air temperature gradient at the edge has a negative sign (down), while at night it has a positive sign. The value and sign changes of the temperature gradient at the edge show amount and direction changes of thermal diffusion between the mangrove forest and environment. The changes pattern of the edge gradient (G (x = 0)) is sinusoidal to time as a result of thermal diffusion process between the environment and mangrove forest ecosystem. Mathematical modeling of the diurnal dynamics functions of the microclimate gradient use the same procedure with the stage 1.

5 . Determination of the diurnal dynamics area and index of microclimate gradient.

The area of microclimate gradient dynamics is obtained by integrating (numeric) the fields that are bounded by the gradient dynamics curve with thermal equilibrium line. The formula to determine the gradient dynamic area is:

$$A = \sum_{i=t1}^{t2} G_i \, . \Delta t \qquad (5)$$

G_i is the gradient value at time i = t + ½ Δt. t is the scale of time that is increased to Δt from zero. t_1 and t_2 are the intersection point of the diurnal dynamic curve of microclimate gradient with the thermal equilibrium line. Thermal equilibrium line is a flat line on a data plot vs. time which its gradient is zero. If the measurement result data shows gradient direction changes, then it produced two fields of gradient dynamic, the one is located above the thermal equilibrium line and the other one is located below the thermal equilibrium line (Figure-2). The area unit of gradient dynamic is the gradient unit is multiplied by the time unit. Gradient unit is the variable is divided by distance unit. Area unit of the air temperature gradient dynamics field is ^{o}C.hour/m. Area unit of the humidity gradient dynamic field is %.hour/m. Gradient dynamic index is the gradient dynamic area at night is divided by the gradient dynamic area at day. Gradient dynamics index has no units. To analyze the interaction of the environment with ecosystems forest, the gradient dynamics index is interpreted as a single entity with the gradient dynamic area.

3. Results

Sample graphs of microclimate gradient dynamics for air temperature and humidity variable are respectively presented in Figure 2, and Figure 3. Each graph shows the gradient change of air temperature and humidity variable for 24 hours, ranging from 07.00 to 07.00 the next day, on transect 1 in Talengen village.

Temperature gradient change at location 1, transect 1 shows the direction change of thermal diffusion. At the day, the air temperature above the sea surface is hotter than the air temperature under the mangrove canopy. At the day the direction of thermal diffusion is from the environment into the mangrove forest. At the day the air temperature gradient has negative sign (located below the thermal equilibrium line). At night, the gradient has positive sign which shows the air temperature under the canopy is higher than the air temperature at the surface of the open ocean. Diurnal dynamics of air temperature like this also occurs in forest ecosystems which borders with open land (*****************).

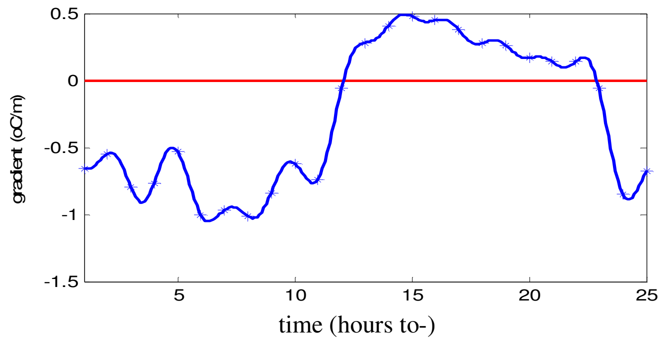

Figure 2. Graphics of diurnal air temperature dynamics of location 1, transect 1

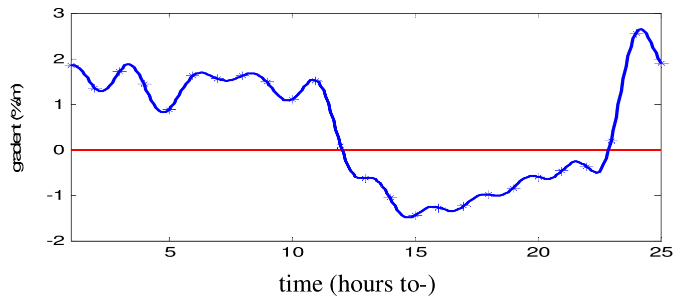

Figure 3. Graphics of diurnal air humidity dynamics of location 1, transect 1

The diurnal dynamic of air humidity gradient graph at locations 1 transect 1 shows the inverse changes with air temperature gradient. At the day, the humidity under the canopy is higher than the humidity above the sea level. At the day, the sign of gradient is positive (the graph is above thermal equilibrium line). At night, the sign of gradient is negative which indicates that the humidity above sea level is higher than the humidity under the mangrove canopy.

The mathematics function of air humidity gradient dynamic at location 1 transect 1 is:

G(t) = - 0.2874 - 0.2231 cos(2πt)/24 - 0.6480 sin(2πt)/24 - 0.0009 cos(4πt)/24 + 0.1643 sin(4πt)/24 - 0.1422 cos(6πt)/24 - 0.0763 sin(6πt)/24 - 0.0588 cos(8πt)/24 + 0.0440 sin(8πt)/24 - 0.0310 cos(10πt)/24 + 0.0100 sin(10πt)/24 - -0.0050 cos(12πt)/24 + 0.1056 sin(12πt)/24 - 0.0665 cos(14πt)/24 + 0.0471 sin(14πt)/24.

The gradient dynamic function above is generated from the first seven harmonic with the diversity donation total of the Fourier function is 97.663 percents. Mathematics modeling of microclimate variable data to the determining of micro-climate gradient dynamic area and index uses software that created by the researched for purpose of this analysis. The calculation result data of the gradient dynamic area at day and night and the gradient dynamics index for ten transects are presented in Table 3.

The analysis result data shows that for all transects, the air temperature gradient index is less than one which means that the area of gradient dynamic at night is less than the area of gradient dynamics at the day. These results indicate that the difference of air temperature outside and inside the mangrove forests at day is greater than the air temperature difference at night. This is due to the acceptance of solar radiation energy by the environment is greater than the penetration of radiation than under the mangrove canopy. The air temperature rise faster in the environment than under the canopy so the gradient area becomes larger than at night.

Tabel 3. The area of gradient dynamics (day and night) and index of gradient dynamics of air temperature and humidty for 10 transects

Location	Transect number	Variables/area and index of diurnal gradient dynamics					
		Air temperature			Humidity		
		Area of day gradient	Area of night gradient	Gradient index	Area of day gradient	Area of night gradient	Gradient index
		(^{o}C.hour/m)	(^{o}C.hour/m)	-	(%.hour/m)	(%.hour/m)	-
Talengen Bay	1	9.586	3.034	0.316	9.179	19.337	2.107
	2	9.696	3.140	0.324	10.028	20.013	1.996
	3	9.967	3.070	0.308	9.768	20.355	2.084
East Ratatotok village	1	8.994	2.842	0.316	8.445	17.838	2.112
	2	9.399	3.134	0.333	9.650	20.483	2.123
	3	7.828	2.747	0.351	8.355	16.760	2.006
	4	7.305	2.738	0.375	8.374	15.501	1.851
	5	7.436	2.510	0.338	8.069	18.446	2.286
Arakan village	1	9.688	3.172	0.327	9.887	19.481	1.970
	2	8.660	2.722	0.314	8.341	21.291	2.553

At night, the thermal energy under the mangrove canopy slowly down while in the environment faster. As a result, the air temperature at night under the canopy is higher than the outside, but the difference is not as big as the temperature difference during the day. The maximum air temperature difference between the inside and outside of mangrove edge at day for ten transects is ranging from 1.2°C - 3.8°C, while at night it is ranging from 0.5°C - 0.8°C (Medellu 2012.a).

The ratio of the air temperature gradient dynamics area inter-transect shows that the greatest gradient dynamic filed extent at day and night occurs at transect which is the cutting edge of the mangrove with dense canopy cover (rizophora type) and is adjacent to the open sea (location 1: transects 1, 2, 3; location 2 transect 2, and location 3 transects 1). During the day, the air temperature above the sea level rises faster than the air temperature above land surfaces of the coast that is vegetated or not vegetated. Gradient and the dynamic field area of the daytime at the edges of mangrove that is adjacent with open sea are greater than the air temperature around the edge of the mangrove coast that is adjacent with the vegetated or not vegetated coasts. The ratio of the air temperature gradient dynamic area at night inter-transects shows that for the mangrove forest which its canopy is dense and homogeneous is greater than the mangrove forest which its canopy density is low and has gaps or a fragment.

The influence of a crack on the dynamic area is shown by the dynamic area difference at transect 1 and transect 2 location 1. Mangrove forests where both transects are taken are from the same type (rizhopora) and has the same canopy density, but at transect 1 there are gaps that their wide is approximately 32 m, while in the second transect there is no gap. The dynamic area of air temperature gradient at day and night on transect 2 is higher than transect 1. The dynamic area of air temperature gradient at day and night on transect 1 is smaller because the thermal diffusion is two-way (from sea borders and from slit). Thermal diffusion through two limit field causes the air temperature difference under the canopy and outside the mangrove forests low (Medellu et al., 2012.a). At night, the thermal diffusion of the mangrove forest to the environment at transect 1 is faster than at transect 2 so that the area of air temperature gradient dynamic at night in transect 1 is less than in transek 2.

The influence of fragment on the gradient dynamic area of air temperature also relates to the sun radiation reception from the thermal diffusion over the edge of mangrove forest. The penetration of solar radiation under the fragmented mangrove canopy is larger than the dense and homogeneous mangrove. The release of thermal energy which is trapped beneath the mangrove canopy at night is faster at the fragmented mangrove forests than at the homogeneous mangrove forests. The dynamic area of air temperature gradient at day and night on the fragmented mangrove forests (location 2 transect 3) is smaller than the homogeneous mangrove forest (transect 2 location 2). The results are shown by the gradient dynamic area parameters which are consistent with the results shown by the maximum air temperature difference parameter between the environment and mangrove forests (Medellu, 2012.a).

The transect grouping based on gradient dynamic area of air temperature (abcissa) versus humidity (ordinat) at day is presented on Figure 4.

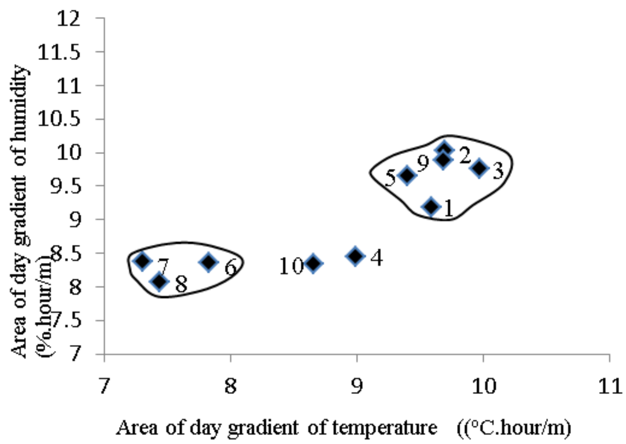

Figure 4. Transect grouping based on the area of gradient dynamic of temperature versus humidity at the day

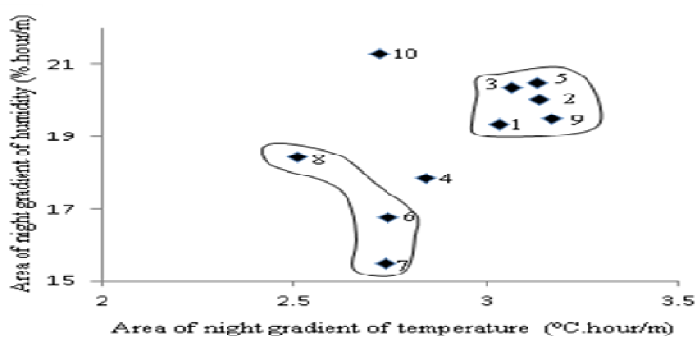

Figure 5. Transect grouping based on the area of gradient dynamic of temperature versus humidity at night

The transect grouping based on the dynamic area of night gradient is consistent with the grouping at day. Transect which has large dynamics area of air temperature and air humidity at day, also has large gradient dynamics area at night. Transect which has large dynamic area of air temperature and humidity gradient are transect 1 (location 1), transect 2 (location 1), transect 3 (location 1), transect 5 (or transect 2 location 2), and transect 9 (or transect 1 location 3). Table 1 shows that the transects are the cutting mangrove edge transect which are adjacent with sea (fringe-type) or wide river channel (riverine-type). The mangrove forests types on these five measurement transects are Rhizopora, with a canopy cover of more than 72%. Open environment and dense canopy cause the great air temperature and humidity gradient at the day and night.

The grouped transects at low air temperature and humidity are transect 6 (transect 3 location 2), transect 7 (transect 4 location 2), and transect 8 (transect 5 location 2). The mangrove forest type at transect 6 and 7 is basin type while at transect 8 is scrub. At the three transect, mangrove forest is adjacent with tree and bushes overgrowned beach. Mangrove forests are not homogeneous but consist of several types (*Avicenia* etc.), with the low canopy density (35%-65%). The boundary environment factor in the form of vegetated coast and low canopy density causes the low area dynamic of air temperature and humidity gradient at day and night. Transect

4 (or transect 1 location 2) and transect 10 (transect 2 location 3) do not show the consistent grouping at day and night. The mangrove forest condition at these both transects is different in type (hammock and basin) and environment (pavement and vegetated coast). At transect 4 there is fragment, where the forepart of mangrove forest (*Rhizopora*) has a width of 12 m, and canopy density of 90-95%. The back of mangrove at transect 4 is not homogeneous with canopy density variation of 55-70%. At transect 10, mangrove forest is various with the canopy density of 55-65%. The showed grouping result at Figure 4 and Figure 5 proves that dynamic area data of air temperature and humidity gradient can differentiate and characterize mangrove forest. The factors that affecting the dynamic area of air temperature and humidity gradient are the boundary environment and the condition of mangrove forest itself. The mangrove forest condition that significantly affects is canopy density, homogeneous and not homogeneous mangrove type, and the existence of fragment. Environment condition such as sea, pavement, vegetated coast is environment factor that affects the dynamic area of air temperature and humidity gradient. The diurnal gradient dynamic shows the thermal condition change in environment and ecosystem, so that this parameter is potential to monitor the changes in ecosystem structure and boundary environment. The usage research of dynamic area parameter of air temperature and humidity gradient and the other microclimate variable need to be followed up for more various mangrove ecosystem and weather condition. The use of this parameter also need to be investigated more to characterize the thermal interaction between the environment with the forest ecosystem, settlement etc.

4. Conclusion

The research result shows that the parameter value and mangrove forest grouping based on the diurnal dynamic area and index parameter of air temperature and humidity can characterize the mangrove forest and boundary environment. The diurnal change of this parameter value is associated with the change in ecosystem or environment, so that this parameter can be used for monitoring the ecosystem and environment condition.

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