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Mathematical Modeling of Daily Temperature and Moisture on City Forest at Megamas of Manado

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ABSTRACT

Mathematical modeling could describe the pattern of temperature and moisture changes either temporally or spatially. This model could be developed the planning and evaluation quality systems of thermal environment. This research intended to build dynamic model of daily temperature and moisture. Sample was collected from the city forest of green opened space (RTH) which was located in the back of Multimart, complex of Megamas. Result showed that temporal mathematical modeling for the changes of temperature and moisture at city forest was presented by fourier function, while spatial dynamic was expressed by exponential function. The different position of observation produced the difference of series coefficient of fourier and exponential function. City forest of RTH could reduced heat energy until 7.66%. Covering factor (tree canopy and soil surface) influenced temperature at the area of city forest. Number of trees at city forest were rather rare so that caused tree canopy was not too crowded and it gave chink of sunshine enter to city forest. This case caused the temperature at city forest was relative high but it was still lower than at outside of city forest.
Keywords: temperature, moisture, mathematical modeling

INTRODUCTION

Manado city was surrounded by hills and mountainous. The mainland area was dominated by hilly with part of them was low field at coast area. Manado would be as world tourism, so that development of city infrastucture was accelerated and in the recent years it was great increasing. Since the end of 1980, it was carried out coastal reclamation and great growing, Nowadays, the area was popular as Megamas area and it was part of Manado Boulevard area. Kawengian and Davy [1] expressed that coastal reclamation at Manado City was developed as functional area with super block pattern and in the way of performing Central Bussiness District (CDB). It caused the change of city view at coastal area.

Development of Manado city was more trended in the direction of coast so that Boulevard area was more opened and as one of in front parts of city which was oriented to the sea. Hence, human activity was more focussed in this area. They enjoyed the beauty of coastal as well as used by informal sector for finding income. This condition influenced public space at Boulevard area. Development of reclamation area surrounded this location showed a symptom that public space began lost. Human access due to coastal view began decrease with more developing structure at this area. Reclamation area of Megamas coast was as area of buisness and integrated tourism. This area was included of some storeyed buildings, hundreds unit of shops and apartments, and vegetated and non-vegetated areas. Since morning, the activity at this area began busy. There was passed by vehicles, activities of business and tourism, shoppings, etc.

Realizing that the public space was important, developer as well as city government made effort to create city forest in the back of Multimart Mall. The city forest was used as rest area and also anjoyed sea view, children play ground, and so far city forest was as one of green opened spaces. City forest had great function as hydro-orology system, creating micro climate, maintaining the balance between oxygen and carbon dioxide, decreasing pollutants, and muting noisy. Besides that, it would increase estetica and it was as comfortable city to live so that it gave positive impact to environmental quality and human life [2][3]. As public space with strategic function, condition of weather in this area had to give comfortable sense for the visitors. Tursilowati [4], Setyowati [5], and Anisha *et.al.*[6] presented that temperature and moisture of weather determined thermal comfortability of area.

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Change pattern of temperature and moisture either temporally or spatially could be more explained with mathematical modeling [7]. The equation of model was important mainly in measuring and analysis. In measuring, this method could use as sincronization of data or estimation of temperature at any time and position in the range of observed time. Because of the change of temperature and moisture followed the pattern of sinusoidal, so for producing model of mathematical equation and curve was used the approach of fourier series by applying the available software [8][9].

MATERIALS AND METHODS

Manado was city centre of North Sulawesi Province. It was located at the end of north peninsula of Sulawesi Island and fell between east longitude of 124°40' to 124°50' and north latitude of 1°30' to 1°40'. Number area of mainland was 15.726 ha and had coastal line along 18.7 km. Map of location was as in Figure 1 below.

Figure 1 City forest of Megamas Area of Manado

Data was collected from city forest area of Manado Boulevard by using intelligent meter EM-9200 and a tool namely four in one which was functioned as anemometer, humidity measuring, light meter, and thermometer. GPS used for determining location of research geographically. Location of research was selected purposively [5]. Transec of data was carried out as long section from coastal way to mainland or from western to eastern. Position of research locatioan was along transec that was at the position of 1 m, 2m, 4m, 8m, 16m, 20m, 26m, and 32m at city forest and one point at position of 40 m outside the city forest as the comparison. Observation or measuring of temperature and moisture was carried out mobilely beacause of the limitation of tool. Data was observed temporally from 07.00 WITA until 18.00 WITA with the time interval of 1 hour, but collecting data spatially was carried out from position-1 until the next position with time interval of 5 until 10 minutes.

Beverly [10] described that some environmental problem could be modelled using graphic, curve-fitting, or using technological programming of calculator graphically. Model and simulation of environment was functioned for planning, implementation, and monitoring next period of natural resources continuously.

Steps of modelling were begun from tabulating data of temperature {t(x,t)} and relative moisture {Rh(x.t)}. Because of change pattern of temperature temporally was followed the pattern of sinuzoidal, so the modelling was carried out using the approach of fourier series [9][10]. It was different with spatial data, its pattern was followed the pattern of complex exponential. Therefore it was carried out by using fitting data in the Tool Wolfram of Mathematic. Francois M. Hemez and Scott W. Doebling [11] explained that model of a system based on computer programming had to pass the step of validation. Validation test of field data was carried out based on the steps as follow:

1. To determine independent variable of modelling function:

$$g_m(t_m) = \sum_{m=0}^{N/2} a_m \cos\omega_m t_m + b_m \sin \omega_m t_m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

2. To determine the bias of data-m : $| g_m(t) - f_m(t) |$
3. To determine the bias of data mean:

$$\text{Mean of bias} = \frac{1}{N}\sum_{t=0}^{N-1}\left[f(t) - g(t)\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

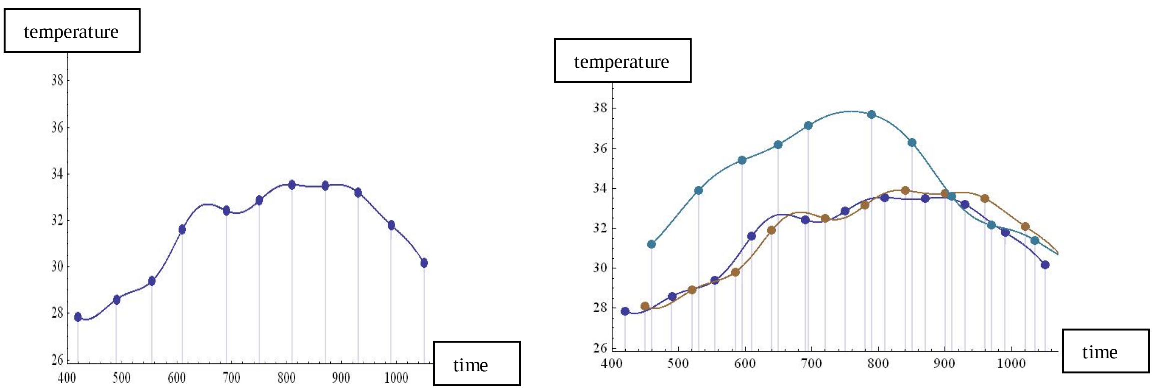
Model was assumed valid if mean of bias < 0.05. If there was not valid, fourier series was iterated again until reaching optimal value.

RESULTS AND DISCUSSION

Data of temperature and moisture was presented as in Table 1 below. Then, modeling was carried out by using mathematical software of Wolfram. Result of dynamic daily of temperature and moisture at city forest of Megamas was presented as in Figure 2 below.

Table 1 Data of temperature and moisture for the lowest, highest, and mean

Variable	Lowest value	Highest alue	mean	Time of observation
Temperatue ^{0}C	27,85	33,95	31,17	07.00 – 18.05
Moisture (%)	49,7	68,2	60,7	07.00 – 18.05
Temperature ^{0}C outside the city forest	31,2	37,7	34,12	07.40 -18.10
Moisture % outside the city forest	44,2	56	50,7	07.40 -18.10



(a) (b)

Figure 2:. a. Change pattern of temperature at position-2,
b.Change pattern of temperature at position-1, 26, and 40

Figure 2 a and b showed that at 07.00 am, the lowest measuring as 27.85^{o}C. The highest value was occured between 12.45 am until 01.50 pm, which position-40 reached 37.7^{o}C, while the highest temperature was 33.85^{o}C at position-20. Then, in the evening (after 01.45 pm), the temperature started up at the whole positions. The lowest temperature was 31.4^{0}C at 05.15 pm and position-26. The lowest temperature in the evening was 32.1^{0}C. It was seemed that in the evening the temperature outside city forest at position-40 which located at east city forest was lower than inside. Dynamic change of daily temperature which was started from the up temperature in the morning until afternoon then it was down again in the evening and followed the model equation of fourier series.

$$T(t)1 = ao + a_1\, Cos[\frac{n\pi Qt}{L}] + a_2\, Cos[\frac{n\pi Qt}{L}] + a_3\, Cos[\frac{n\pi Qt}{L}] + a_4\, Cos[\frac{n\pi Qt}{L}] + a_5\, Cos[\frac{n\pi Qt}{L}]$$
$$+ b_1\, Sin[\frac{n\pi Qt}{L}] + b_2\, Sin[\frac{n\pi Qt}{L}] + b_3\, Sin[\frac{n\pi Qt}{L}] + b_4\, Sin[\frac{n\pi Qt}{L}] + b_5\, Sin[\frac{n\pi Qt}{L}]$$

note : T(t)1 = temperature of temporal observation at position-1 and the fourier coefficients were as follow:

ao = 31.32897793933394 b1 = − 1.75107660549166604

a1=− 2.0038193011277343 b2 =− 0.6433437306714473

a2 = − 0.40570934865405467 b3 = − 0.04153986314834731

a3 =0.09423223331341957 b4 =− 0.03371052477408165

a4 = - 0.2208801927689541 b5 =− 0.27153956517741634

a5 = 0.08241479993229517

$$n\pi\frac{Qt}{L}=\frac{n\pi(630+10(-450+t))}{3465}$$

Absolute deviation = 0.

In general, the equation as above could be formulated as follow: T(t)1= a_0 +

$$\sum_{n=1}^{m}(a_n Cos[\frac{n\pi Qt}{L}]+b_n Sin[\frac{n\pi Qt}{L}])$$

With m = 5 and n = discrete number

Result of change pattern of daily moisture was presented as in Figure 3 below.:

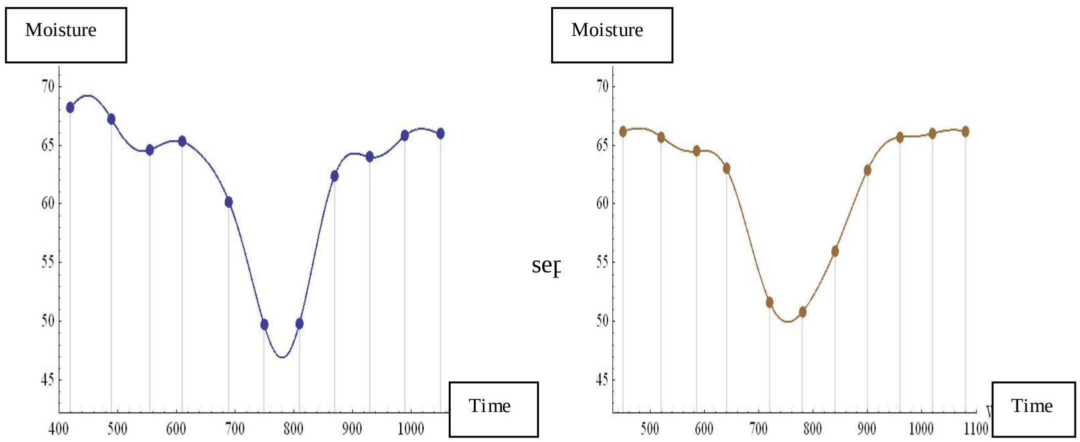


Figure 3 a. Change pattern of moisture at position-2
b. Change pattern of moisture at position-26

Change pattern of moisture at the whole positions were in the range of 49.2% to 68.2%. The changes showed decreasing pattern and reached the lowest value at 01.45 pm and it trended to increase until 06.50 pm. In general, change pattern of moisture had non linier and opposite comwas as follow:parison with change temperature. When temperature was up, the moisture would be down and if temperature was down, the moisture would be up. Equation of model which describe change pattern of moisture as in Figure 2 above

$$Rh(t)1=ao + a_1 Cos[\frac{n\pi Qt}{L}] + a_2 Cos[\frac{n\pi Qt}{L}] + a_3 Cos[\frac{n\pi Qt}{L}] + a_4 Cos[\frac{n\pi Qt}{L}] + a_5 Cos[\frac{n\pi Qt}{L}]$$
$$+ b_1 Sin[\frac{n\pi Qt}{L}] + b_2 Sin[\frac{n\pi Qt}{L}] + b_3 Sin[\frac{n\pi Qt}{L}] + b_4 Sin[\frac{n\pi Qt}{L}] + b_5 Sin[\frac{n\pi Qt}{L}]$$

with Rh(t)1 = relative moisture temporally at position-1 and coefficient of fourier was as follow:

$\mathbf{a_0}$ = 62.27983917380639	$\mathbf{b_1}$ = + 4.3636013379519225
$\mathbf{a_1}$ = 5.710647902378403	$\mathbf{b_2}$ = − 3.329376255594159
$\mathbf{a_2}$ = - 0.8908524966272969	$\mathbf{b_3}$ = 2.731873731439652
$\mathbf{a_3}$ = - 1.2974015163886117	$\mathbf{b_4}$ =− 0.6895054027826809
$\mathbf{a_4}$ = 0.7447923789926684	$\mathbf{b_5}$ =− 0.884694612159858
$\mathbf{a_5}$ = - 0.5470254421615726	

$$n\pi\frac{Qt}{L}=\frac{n\pi(630+10(-420+t))}{3465}$$

In general, the equation above could be formulated as follow:

$$R(t)1= a_0 + \sum_{n=1}^{m}(a_n Cos[\frac{n\pi Q}{L}t]+b_n Sin[\frac{n\pi Q}{L}t])$$

with $m = 5$, n = discrete number

Figure 4 below showed information about change pattern of temperature due to observed position. It showed that in the morning until afternoon, the graphic trended up, while at about 05.00 pm and 06.30 pm trended horizontal.

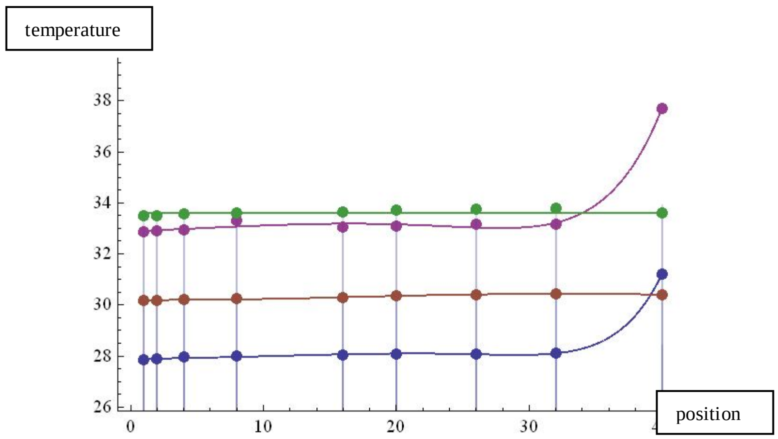


Figure 4 Spatial pattern of temperature as the result of measuring at the minutes of 420, 750, 870, and 1050

Equation model of temperature spatially at 07.00 am at the location of city forest with absolute deviation of 0.02 was as follow:

$$T(x)1 = 27.88969627381386 + e^{-9.77102604029756 9+0.11988686421727468x}$$
$$(-47.83956357013252 + 120.2548947689363x$$
$$-7.450059259185509x^2 + 0.11932786339894706x^3)$$

General equation could be formulated as follow:

$T(x)1 = k_0 + \mathbf{e}^{\mathbf{k1+k2x}}$ $(k3+k4x + k5\ x^2 + k_6\ x^3)$

with k_0, k_1, k_2, k_3, k_4, k_5 and k_6 were coefficients of exponential

Table 1 presented the comparison of temperature at RTH and non RTH at the area of city forest. Based on the mean value, it was seemed that temperature at RTH was lower than non RTH. The change of temperature at RTH was (34.13 – 31.51)/34.13 x 100% = 7.66%. It could be concluded that RTH (Green Opened Space) would reduce the temperature until 7.66% at the area of city forest.

Table 1 Comparison of temperature at RTH and non RTH at the area of city forest

Group	Mean	Standard deviation	$T_{calculation}$	Sig t	Conclusion
RTH	31.51	31.51	4.043	0.000	Significant
Non RTH	34.13	34.13			

$T_{table(db=97)} = 1.98$

If it was carried out to measure the temperature between 07.00 am to 06.00 pm, it was enough to take 5 data e,g at 07.00 am, 09.00 am, 03.00 pm, and 06.50 am. The other data in this interval could be found with interpolation. The same manner could be carried out too for analising the moisture.

Validity of model was expressed by absolute deviation and model equation generally had absolute value < 0.2. The value was relative small and it indicated that the equation was valid. The other important usage of model equation was sincronization of data. Sincronization of data was important when it would formulate spatial model, because collecting of data was carried not in the same time. It was caused by the limitation of tool. Sincronization of data was presented as in Figure 3 above.

Change pattern of temperature at the area of city forest was also determined by the density of vegetation canopy. At the RTH of city forest, there was only vegetation type of trembesi with the number of 86 trees, the height of 6-7 m, and the number area of 1200 m^2. It meaned that the density was 0.07. This condition was so rare, because ideally it filled 134 trees. Trembesi had small leaf and if the weather was rather hot, the leaf became small for reducing evaporation. The characteristic of leaf would give chink of sunshine for entering canopy. It caused the temperature inside of RTH was relative high. But the temperature at the area of city forest was lower than at the outside.

CONCLUSION

Based on the literature study and analysis of results as above, it was concluded:

1. Mathematical modelling of dynamic daily temperature (T) and relative moisture (Rh) at city forest temporally was formed as fourier function with the general formula was as follow:

$$\mathbf{F}(t) = A_0 + \sum_{n=1}^{M} \left[\left[a_n Cos\left(\frac{n\pi Qt}{L}\right) + b_n Sin\left(\frac{n\pi Qt}{L}\right) \right] \right]$$

   With F(t) was as the function of temperature (T) and the function of moisture (Rh), M = 5 and a_n, and b_n was as fourier coefficient which the value was different at each position and

$$\frac{n\pi Q}{L} t = \left[\frac{\pi n(630+10(-450+t))}{3465}\right] .$$

2. Mathematical modelling of dynamic daily temperature T(x) and kelembaban Rh(x) spatially was formed as exponential function with general formula was as follow:

$$f(x) = k_1 + e^{+k6 + k7x} (k_2 + k_3 x + k_4 x^2 + k_5 x^3)$$

   f(x) was as T(x) or Rh(x) and k was coefficient of equation
3. Temperature at RTH area of city forest was lower than at non RTH area. Therefore, RTH could reduce heat energy of sunshine. Temperature change at RTH area of city forest was 7.66%.
4. Mathematical modelling using software of Wolfram could be developed for some interests such as modelling of pollutant distribution at weather and sea, analysis of experimental result, data analysis of numerical calculation, etc.

REFERENCES

1. Kawengian, Davy Sancett.. 2003. *Dampak reklamasi pantai terhadap pemanfaatan Ruang Publik dan Strategi pengelolaannya*. Studi kasus: Kawasan Boulevard, Manado.Univ Gadjah Mada.

2. Dahlan, E. N., 2002. *Hutan Kota: Untuk Pengelolaan dan Peningkatan Kualitas Lingkungan Hidup*. Departemen Kehutanan Republik Indonesia. Http://www.w3.org/TR/REC-html40.

3. Sibarani, J. P., 2003. *Potensi Kampus Universitas Sumatera Utara Sebagai Salah Satu Hutan Kota di Kota Medan*. Fakultas Pertanian Program Studi Budidaya Hutan, Universitas Sumatera

4. Tursilowati, 2007.*Uses of remote sensing and Gis to compute suhu humi-dity index as human comfort indicator relative with land use - land cover change (LULC) in Surabaya*. LAPAN

5. Setyowati, D., 2008**.** Iklim mikro dan kebutuhan ruang terbuka hijau di kota Semarang. *Journal Manusia dan Lingkungan*, Vol.15, No.3, November 2008: 125-140

6. Anisha, N.K. M. Nobuo, S.Kojima and T.Yoko. 2010. Assessment of thermal comfort in respect to building height in a high-density city in the tropics. *American J. of Engineering and Applied Sciences* 3. ISSN 1941-7020

7. La Zakaria. 2009. Penggunaan matematika untuk penyesuaian kurva sinusoid dan perolehan bentuk deret Fourier sebagai model matematis. http://deretforierunila.blogspot.com/

8. Beverly et al., 2000. *Mathematical Modeling, Technology, and the Environment*. California State University.USA

9. Ling Wai Kung, 2006. *Modelling and Pricing the Weather Derivative*. University of Nottingham.

10. François M. Hemez and Scott W. Doebling. 2002. *Uncertainty, Validation of computer models and the myth of numerical. Engineering Analysis Group (ESA-EA) Los Alamos National Laboratory*