Makalah Ballroom

PRELIMINARY STUDY OF WATER TEMPERATURE CHANGES TO IDENTIFY THE HYDROLOGICAL DYNAMICS AT SITU CIBUNTU

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ABSTRACT

Water temperature is one of the important parameters in the aquatic systems, and it remains as the interesting subject of world-wide environmental research. Water temperature has a vital role in various processes that determine whether an aquatic environment is suitable for fish and other organisms. The objective of this study is to identify the parameters of hydrological, meteorological and topological those influence water temperature and its change at Situ Cibuntu site based on data from April 2008 to April 2009. In addition, the changes in water temperature during rainfall events could identify the mechanism that generates the initial response as direct inputs of rainwater. In order to gain insight on water temperature fluctuations, water temperature data for one year were statistically analyzed using root mean square (Rms) and harmonic methods. From our analysis, the largest of air (Ta) and water temperatures (Tw) were 30.6oC and 30.9oC, respectively. To the contrary, the smallest of those were 21.1oC and 23.0oC, respectively. In addition, the highest values of Rms 7-days for Ta and Tw on September were 1.51 and 1.57, respectively. Next, based on hourly Tw changes during rainfall events, it seemed that subsurface flow influenced water temperature changes. In addition, the management of Situ influenced the flow paths differently through the changes of infiltration rate, surface runoff, interflow/subsurface flow and groundwater percentage. Further, we expect that using Tw could trace the water sources and that it would be good tracer of basin hydrology as easily observable indicator.

Keywords: water temperature – air temperature - root mean square – harmonic method – rainfall even

ABSTRAK

Temperatur air merupakan salah satu parameter penting dalam sistem akuatik dan sampai sekarang masih menjadi kajian menarik untuk riset di berbagai wilayah belahan dunia. Temperatur air merupakan salah satu faktor penentu layak tidaknya suatu lingkungan perairan bagi keberlangsungan hidup ikan dan organisme lainnya. Tujuan dari studi ini adalah identifikasi awal parameter-parameter biologi, meteorologi, topologi dll yang mempengaruhi temperature air dan perubahannya pada lokasi Situ Cibuntu berdasarkan data pengukuran dari April 2008 sampai April 2009. Selanjutnya, perubahan temperatur air selama kejadian hujan dapat dipakai untuk mengidentifikasikan mekanisme respon awal dari perubahan temperatur tersebut dan pengaruh input air hujan yang masuk. Dalam rangka mengidentifikasikan fluktuasi temperatur air selama setahun, digunakan statistik analisis berupa root mean square (Rms) dan metoda harmonik. Hasil analisis, temperatur maksimum untuk udara (Ta) dan air (Tw) adalah 30.6oC dan 30.9oC, sedangkan temperatur minimum untuk udara dan air adalah 21.1oC dan 23.0oC. Selanjutnya, nilai tertinggi untuk Rms Ta dan Rms Tw terjadi pada bulan September sebesar 1.51 dan 1.57. Berdasarkan perubahan Tw dalam interval jam-an selama kejadian hujan, dapat diasumsikan bahwa aliran bawah permukaan terindikasi mempengaruhi perubahan Tw. Lebih lanjut, manajemen tata ruang dan pemanfaatan Situ dapat pula mempengaruhi prosentase pola aliran yang melalui infiltrasi, aliran permukaan, aliran bawah permukaan dan aliran air tanah. Diharapkan, temperatur air sebagai indeks parameter dapat menjadi indikator untuk menganalisa pola aliran dan sebagai alat penelusuran proses hidrologi yang terjadi didalamnya.

Kata Kunci: temperatur air - temperatur udara - root mean square - metoda harmonik – kejadian hujan

INTRODUCTION

Most physical properties of water and the rates of many chemical and biological processes in water are expressed as functions of water temperature (Bogan *et al.*, 2004; Caissie 2006). In addition, most aquatic species have respective specific ranges of water temperature that they can tolerate (Jensen *et al.*, 1989; Eaton and Scheller, 1996; Dunham *et al.*, 2003). Some studies showed that the meteorological (air, solar radiation, humidity, rainfall) and hydrological parameters (water discharge, groundwater percentage) were important ones that influenced water temperature changes (Sinokrot and Gulliver 2000; Gu and Li 2002; Sophocleous 2002; Becker *et al.*, 2004; Lambs 2004; O'Driscoll and DeWalle 2006).

Generally, air and water temperatures have a strong relationship. It was supported by some scientific researches in which water temperature often had been related to air temperature and meteorological conditions as yearly or longer time-scale fluctuations (Mohseni *et al.*, 1999; Fukushima *et al.*, 2000; Ozaki *et al.*, 2003; Webb *et al.*, 2003; Hannah *et al.*, 2004; Tung 2006; Subehi *et al.*, 2009; Subehi 2010).

In addition, during rainfall event, water temperature changes were influenced by different characteristic of flow paths (Subehi *et al.*, 2010). Related to rainfall events water flow paths at watersheds continue to be interested in water temperature analysis. Changes in water temperature during rainfall events help to identify the mechanism that generates the initial response as direct inputs of rainwater, surface/subsurface flow or discharge of groundwater. An understanding of the processes driving water temperature dynamics is fundamental for assessment and prediction of thermal response to climatic variability and change.

The objectives of this study are: (1) to examine water temperature characteristics at Situ Cibuntu; and (2) to elucidate the hydrological dynamics from water temperature changes. We analyzed water temperature at Situ Cibuntu from April 2008 to April 2009.

METHODS

Situ Cibuntu as a small and shallow lake has surface area about 15,83 m^2 with average depth 0.88 m and volume about 13,55 m^3 (Tarigan 2001; Sulawesty *et al.*, 2000). Situ Cibuntu is located at Kabupaten Bogor which lies $06^0$29'S, $103^0$51'E and 103 m dpl (Fig. 1).

The data on air and water temperatures were taken at the interval of 5 minutes from April 2008 to April 2009 by sensor, Global Water GL 500. In addition, rainfall was also measured by a tipping bucket rain gauge at the interval of 5 minutes during those periods.

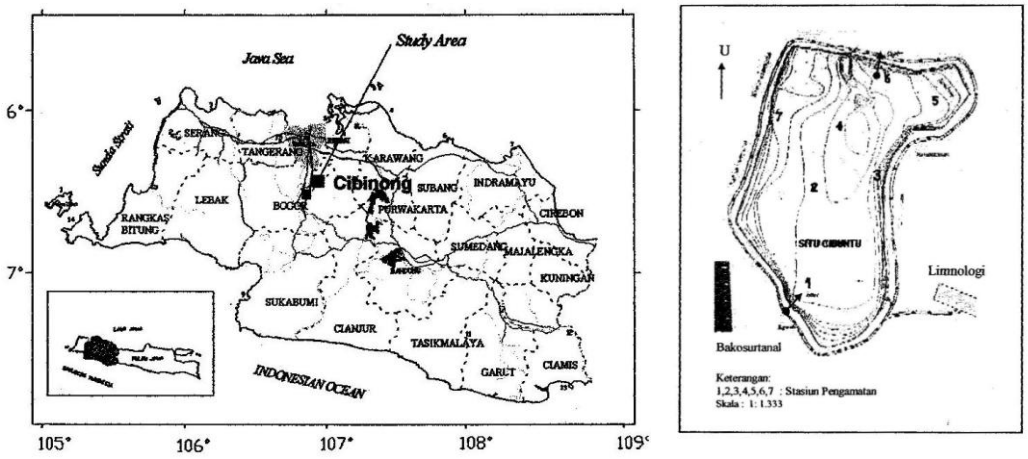

Figure. 1 Location of study area

For fluctuation temperature analysis, we used not only the standard deviation (σ) but also the root mean square variation over 7 days (*Rms 7-days*). The equation can be described in the following manner:

$$\text{Rms 7-days} = \sqrt{(1/n)\sum_{i=1}^{n}(x_i - \bar{x}_i^m)^2} \qquad (1)$$

where n represents the number of days analyzed (monthly: 28-31, yearly: 365), x_i is the daily average temperature (^{0}C), and $\bar{x}_i^m$ is the m-day moving average of daily temperature. We used 7 days for m. The weekly average temperature is commonly used to quantify stream temperature changes (Bogan *et al.*, 2004) because the weekly (7 days) timescale gives a good correlation between air and stream temperatures (Pilgrim et al. 1998; Mohseni and Stefan 1999) and also

eliminates most transient variations, including diurnal effects of solar radiation and air temperature.

We also employed harmonic method, the representation of functions or signals as the superposition of basic waves. The equation is defined as follows:

$$yT = A \sin (c\ (t + \varphi)) \qquad (2)$$

where y_T represents the sine curve of temperature T; t is the time (day); A is the amplitude of temperature fluctuations; c equals $2\pi/L$ (L = time period = 365 days) and φ represents the phase shift (day).

Next, analysis during rainfall events, we had selected the rainfall events of which the intensity rainfall more than 5.0 mm/hour. The changes of water temperature (ΔTw) and air temperature (ΔTa) during those events were observed.

RESULTS AND DISCUSSION

Daily air and water temperatures were observed (Figure. 2) from April 2008 until April 2009, indicated that air and water temperature changes were not so close. The largest of air and water temperatures were 30.6°C and 30.9°C, respectively. Contrary, the smallest of those were 21.1°C and 23.0°C, respectively. Figure 3 shows the changes in air and water temperatures more clearly by harmonic method. The larger air temperature was observed from May to August. On the other hand, that of water temperature was observed from September to December. It was suggested that the seasonal variations influenced air and water temperature changes.

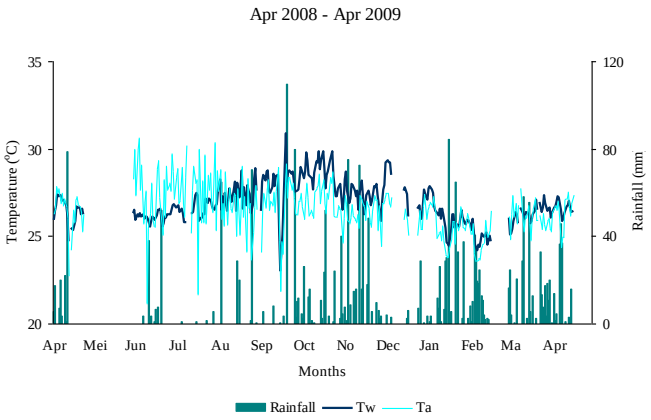

Figure. 2 Daily air and water temperatures at Situ Cibuntu

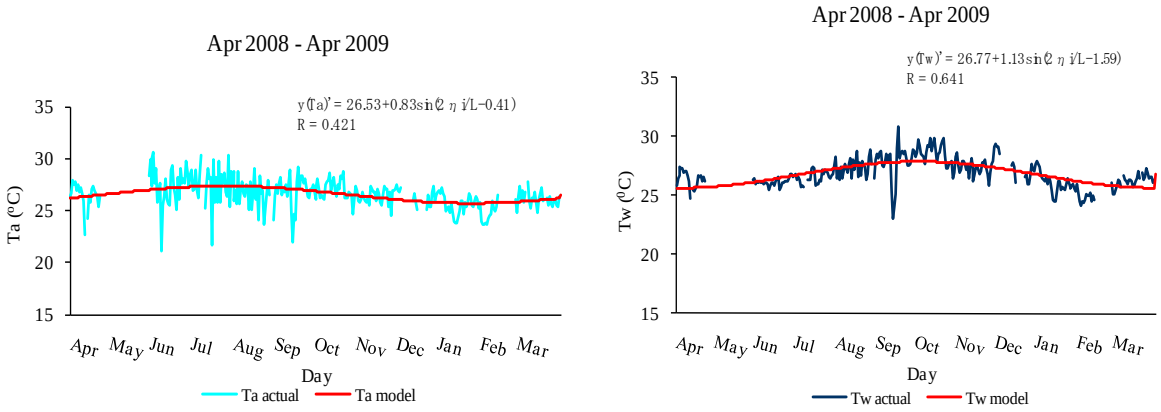

Figure. 3 The changes in air and water temperatures by harmonic method analysis

Based on fluctuations in air and water temperatures, expressed by Rms 7-days, those both fluctuations change proportional from March 2008 to March 2009 (Fig. 4). It could be explained that water temperature changes seasonally. In addition, the highest values of Rms 7-days for Ta and Tw were observed on September (1.51 and 1.57, respectively).

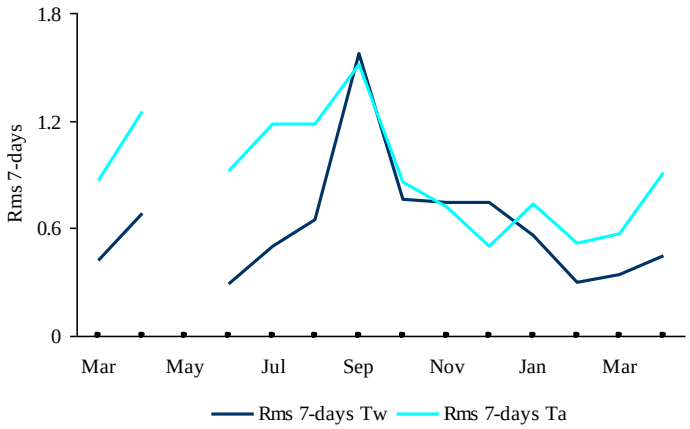

Figure. 4 Monthly changes in *Rms 7-days* of daily air and water temperatures

In order to know the hydrological dynamics, air and water temperatures changes were analyzed during rainfall events which the intensity rainfall more than 5.0 mm/hour (Figs. 5 & 6, respectively).

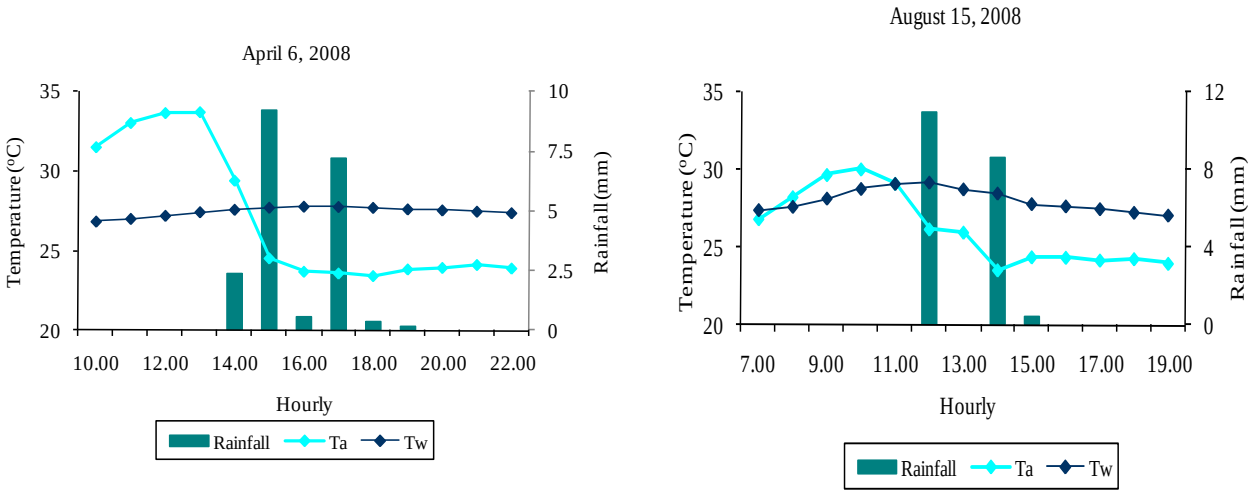

Figure. 5 The changes in air and water temperatures on April and August

Based on figure 5 and 6, the air temperature decreased with increasing water temperature during rainfall events. It was suggested that subsurface flow or groundwater flow probably influenced water temperature conditions. Similarly, those on September, December and February (Fig. 6), probably large flow paths contributed from deeper pathways (subsurface and groundwater flows).

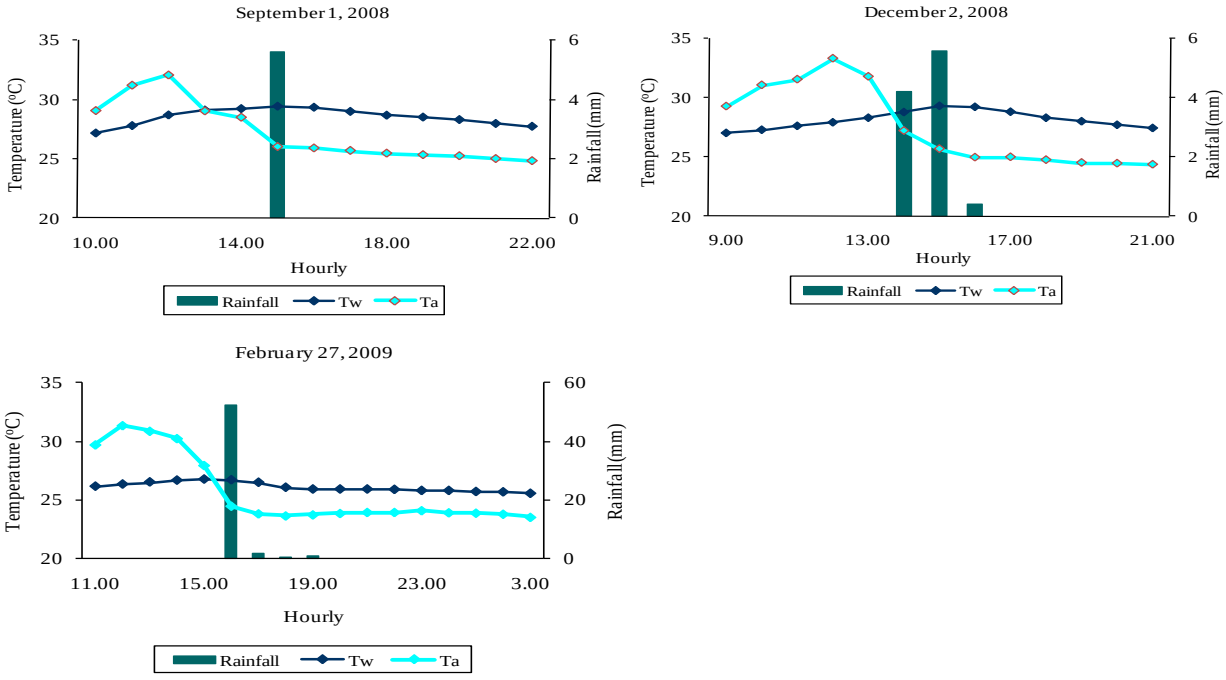

Figure. 6 The changes in air and water temperatures on September, December and February

Besides meteorological, geological and topological (steep slope) should be considered as key parameters influenced the proportion of flow paths. Water temperatures are predominantly related to weather and lake morphometry (Hondzo M and Stefan HG, 1993a; Hondzo M and Stefan HG, 1993b). In addition, solar radiation forces stable density stratification and reduces vertical mixing resulting in shallow mixed layer depths (Herb W and Stefan HG, 2004). It could be explained that air temperature fluctuations related to solar radiation affected water temperature.

CONCLUSION

Water temperature fluctuations are very important because every aquatic organism has a preferred temperature range for its life. A hypothesis on how water temperature changes in yearly and during rainfall events at Situ Cibuntu was developed and tested.

Based on the analyses, not only meteorological parameter but also geological and topological conditions affected water temperature. Interactions among surface, subsurface and groundwater flows during rainfall events were indicated from this study. Next, soil temperature and groundwater analysis, combined with geological and topological at Situ Cibuntu are important to understand the water temperature dynamics in the future research.

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DISKUSI

Penanya : Tugiyono, Biologi FMIPA, Universitas Lampung
Pertanyaan : Bagaimana karakteristik temperatur air?
Jawaban : Karakteristik suhu air berbeda antara hulu dan hilir, hal ini akan mempengaruhi biota karena terdapat spesies biota khusus yang hanya dapat hidup pada temperatur badan air tertentu.

CATATAN

Tampilan peta lokasi kajian sebaiknya dibuat lebih detail dengan insert peta Jawa Barat.