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Mapping Cumulative Carbon Dioxide Concentrations at Two meters Above the Ground for Greenspace Assessment in Surabaya

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Abstract: This paper presented the cumulative concentration of carbon dioxide in ambient air of Surabaya to assess the presence of greenspace. Time series within 24 hours data of carbon dioxide concentration was applied to measure the results of CO_2 emission and uptake. A total 137 sites were set to take air samples for the each season, dry and rainy. The cumulative concentration was negative for CO_2 uptake of more than emission, which occured in the greenspace and coastal area. Negative and positive values also differ over the season and landuse. As for the results of the whole city there were negative and positive values, which differ by the season and landuse. There was about 33-37% of the city area that absorbed CO_2 from the air for a year.

Key words: Cumulative concentration · Carbon dioxide · Greenspace · Land use · Season

INTRODUCTION

Cities in the world produced carbon dioxide. The flux of carbon dioxide used for indicator levels of carbon dioxide emission, which was positive at major cities, revealing carbon dioxide moving towards ambient air [1-16]. The flux value of carbon dioxide was significantly related to vegetation fraction [17]. Urban garden could uptake carbon dioxide [18]. There was an uptake of carbon dioxide by greenspace when there was sunlight for photosyntesis [19]. Thus the flux value was an indicator for time instantaneous ($\Delta t \approx 0$). In a greenspace within 24 hours, there was CO_2 uptake and emission that was affected by meteorology the prevailing weather conditions.

Previous proposal used cumulative concentrations levels of carbon dioxide within 24 hours in ambient air to determine the level of CO_2 uptake and CO_2 emission in the city area [20, 21]. However, height of measurement significantly influenced the carbon dioxide concentration [22]. Therefore, this research used the measurement concentration carbon dioxide at 2 meters height to provide a map for assessment the existing greenspace in Surabaya.

MATERIALS AND METHODS

Location and Time: The research location was the city of Surabaya, covering an area of 340 km^2. Surabaya is the second largest city in Indonesia, located on the coast of the island of Java. The focus of this research area was the urban area where there were a lot of activities.

This research carried for the dry and rainy season, and its transition periods. The period of April-May 2012 was dry season and January 2013 was rainy season.

Sample Size: Sample size was determined from the wide of the city, wind, time lapse of concentration changes, the level of significance of results and the level of sampling error [21]. For the city of Surabaya in this study used the results of 90% significance level, the sampling error of 5%, the average wind = 2 m/sec, an interval of minute changes. This defined 137 sampling sites in each season of measurement.

Time Series Data of Carbon Dioxide Concentration: Concentration measurement for CO_2 used infrared method. The concentration of carbon dioxide was 1 minute average from the scanning of every 6 seconds,

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so there were 10 times scanning with the following equation:

$$C_{(\Delta t=minute)} = (C_{(t=6\ sec)} + C_{(t=12\ sec)} + \ldots + C_{(t=60\ sec)}) /10 \quad (1)$$

Measurements carried out during 24 hours. When midnight was in stable meteorological conditions there would be evenly concentration. Almost all researchers used the night to be starting time for concentration of carbon dioxide in 24 hours. At night, carbon dioxide derived from natural sources including vegetation. During the day occurred in the reduction of carbon dioxide by vegetation in greenspace,

Interpolation techniques were used to obtain carbon dioxide concentration curve within 24 hours. Concentration curve within 24 hours of carbon dioxide formed the data series of carbon dioxide.

Cumulative Concentration Value of Carbon Dioxide Within 24 Hours in Ambient Air (Net_C0$_2$ - Con): Carbon dioxide after the 100-200 would accumulate in the ambient air [20,21,23]. Cumulative concentration within 24 hours determined the integration of the rate of concentration (dC/dt). The rate concentration was formed from the difference concentration to the time series [20, 21]. Graphical presentation for the determination of cumulative concentration value of carbon dioxide within 24 hours was in Figure 1.

Net_CO_2-Con Map: The cumulative concentration value of carbon dioxide within 24 hours (Net_CO_2-Con) of the 137 sites of sample was analyzed by finite difference to generate a map of Net_CQ -Con at city of Surabaya.

RESULTS AND DISCUSSION

Net_CO_2- Con Map for the Dry Season: Net_CO_2-Con Map for the dry season was presented in Figure 2.

In dry season, Net_CO_2-Con negative value was found in coastal area (north to east) and low ground level. However, west Surabaya has no effective greenspace that may be due to lack of availability of water in vegetation media. The availability of water significantly with affected the rate of photosynthesis [19, 24]. Net_CO_2-Con positive value was found in industrial area, commercial area, residential area, drainage and roads. In dry season, it was only 36.7% of the city has negative value of Net_CO_2-Con. An average Net_CO_2-Con value was 9.55 ppm.

Net_CO_2- Con Map for Rainy Season: Map Net_CO_2-Con Map for the rainy season, in Figure 3.

In the rainy season, Net_CO_2-Con negative value was found in coastal areas and west Surabaya. In the rainy season, the greenspace in west Surabaya was effective to uptake CO_2, revealing the area has sufficient water in vegetation media. It was identified that Net_CO_2-Con was positive value in industrial area, commercial area, residential area, drainage and roads. In rainy season, the city area of 37% has negative value of Net_CO_2-Con. An average Net_CO_2-Con value was 25.03 ppm.

Net_CO_2- Con Map for Transition Periods: Net_CO_2-Con Map for transition periods, both the dry to the rainy and vice versa was presented in Figure 4.

In transition periods, Net_CO_2-Con negative value was found in coastal area and the greenspace area. Totally, the city area of 33.3% has Net_CO_2-Con negative value. An average value of the net CO_2 was 17.29 ppm.

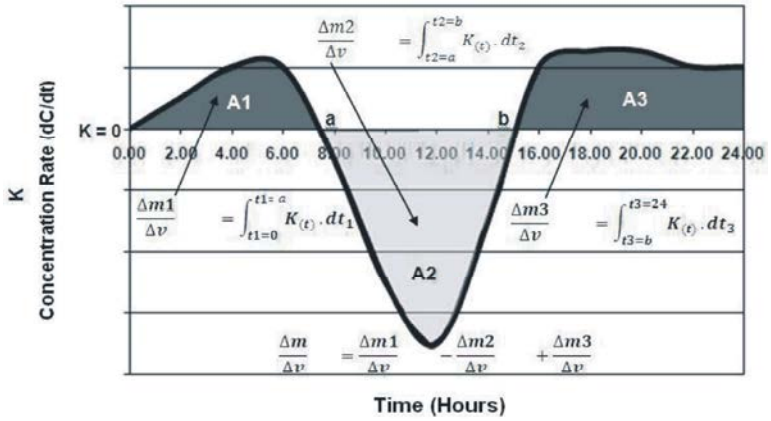

Fig. 1: Concentration Rate curves of carbon dioxide (Net_CO_2-Con) [21]

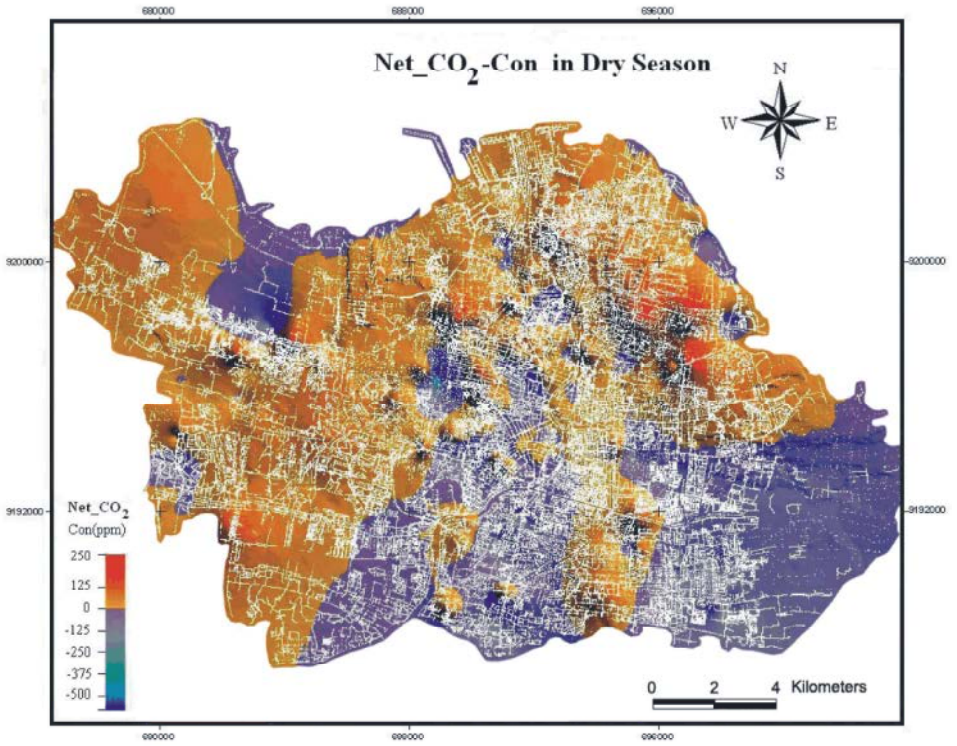

Fig. 2: Net_CO_2-Con Map for dry seasons

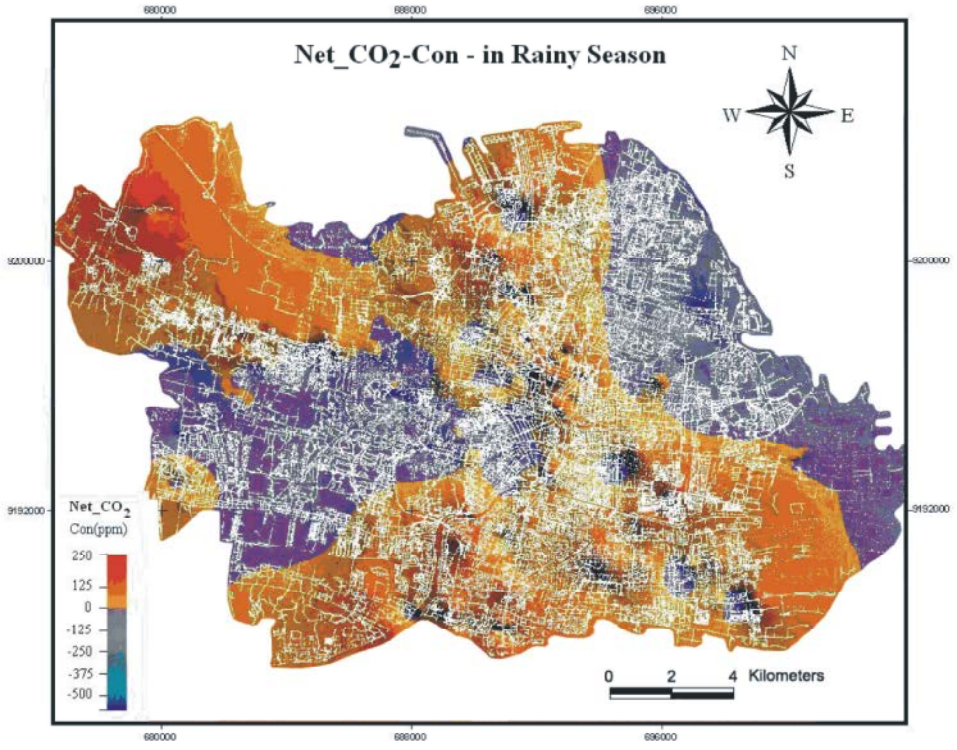

Fig. 3: Net_CO_2-Con Map for Rainny Seasons

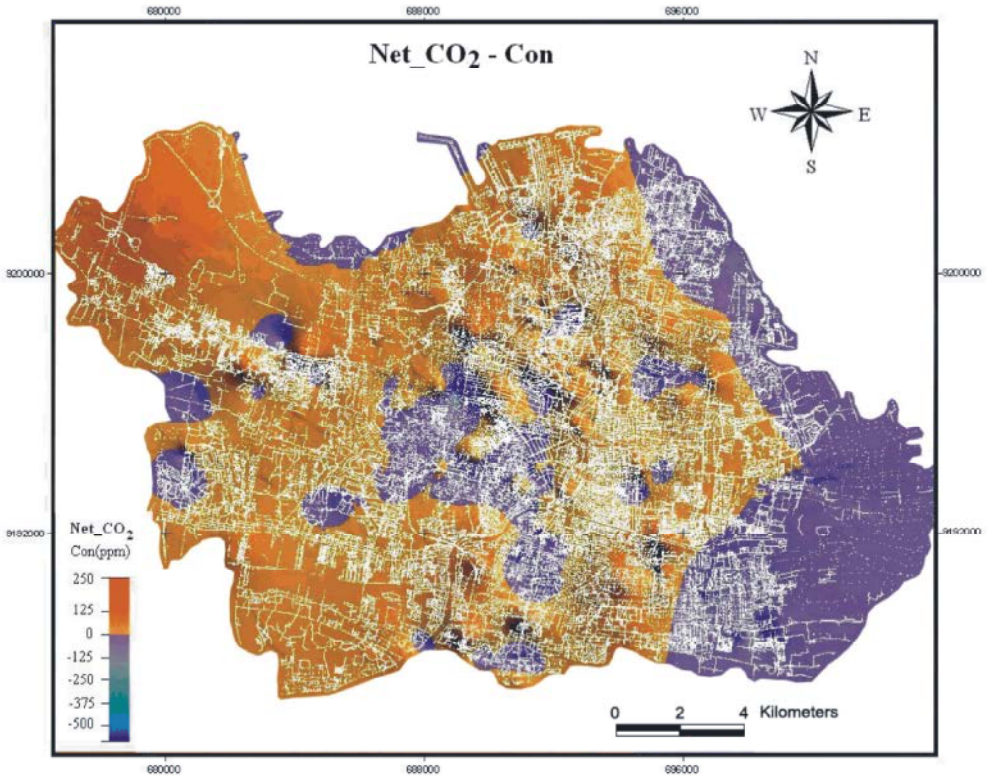

Fig. 4: Net_CO_2-Con Map for Transition Periods

CONCLUSION

The cumulative concentration value of carbon dioxide within 24 hours was significantly different with landuse and season. Net_CO_2 values were negative at coastal area and greenspace area, revealing CO_2 uptake was higher than CO_2 emission. Net_CO_2 values were positive at industrial area, commercial area, settlement area, drainage and roads. Moreover, the cumulative concentration values of carbon dioxide within 24 hours was significantly different to season. Carbon dioxide in general, CO_2 uptake in the dry season was higher than the rainy season.

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