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# EMISSION FACTORS OF BLACK CARBON (BC) FROM RICE STRAW OPEN BURNING SPECIFIC TO DISTRICT CIANJUR, WEST JAVA, INDONESIA.

Hafidawati[1], Puji Lestari[2] and Asep Sofyan[3]
[1,2,3]Departement of Civil and Environmental Engineering, ITB, Indonesia

*pujilest@indo.net.id, received: 01July 2016, Revised: 22 July 2016, Accepted: 03 Dec 2016

ABSTRACT : Open burning of rice straw, common practice in Cianjur, West Java, to eliminate rice residues after harvesting. However, the common practice of post-harvest burning of rice straw emits particulate material , greenhouse gases, and short lived climate force to the atmosphere. Open burning of rice residues in the field releases a large amount of Black Carbon (BC). In this context, this work aims to determine rice straw burning emission factors for Black Carbon on particulate material smaller than 2.5 μm ($PM_{2.5}$) in the field open burning in Districts Cugenang, Cianjur, West Java, Indonesia. Samples of airborne particulate matter ($PM_{2.5}$) from open burning of rice straw were collected at seven locations in District Cugenang for eight varities of rice straw, from June through October 2015. The samples were collected using a minivol air sampler. Black carbon was analyzed using an EEL smoke stain reflectometer. Excess mixing ratios for $CO_2$, CO, BC in $PM_{2.5}$ were measured, allowing the estimation of their respective emission factors. The average of BC emission factor for eights varieties (Mekongga, Hibrida, Ciherang, Inpari, Cintanur, Sarangue, Inul dan Pandan wangi ) was 0.501, 0.817, 0.749, 0.973, 0.794, 0.847, 0.928, 1.099 g/kg respectively. Average estimated values for emission factors (g kg−1 of burned dry biomass) were 0.939 ±0.417 for BC in $PM_{2.5}$. These emission factors presented provide useful information for the development of local emission factors for Black Carbon from open burning of rice straw in Cianjur.

Key Word : Black Carbon, Emission factor, Field Open Burning, Rice Straw,

## I. INTRODUCTION

Paddy is the most popular plants in Indonesia which is rapidly increasing annual production to meet domestic demand. Indonesia has a large population, 46% of which lives in rural areas. Because of the large use of crop residues the burning of rice straw in the fields, this become important type of biomass burning open in Asia which is open combustion residues of rice on the ground. Intensive open burning activities generally take place during the dry season when stagnant atmospheric conditions [14]. It is releasing a number of aerosols cause atmospheric phenomena regional implications strong climate such as Atmospheric Brown Clouds [8].

Open burning of agricultural residue is one of the major source of aerosol emissions. Results of rice straw combustion emits types of particulate matter ($PM_{2.5}$) [3] the pollutant emissions from the combustion, such as BC in PM and CO, have contributed substantially to the regional environmental pollution problem [8].

Black Carbon (BC) contributes directly and indirectly to the earth's radiative balange change, and consequently, has impact on global warming as the second largest contributor after Carbon Dioxide ($CO_2$)[8]. Only a few studies on emissions of pollutants from open burning of waste is done post-harvest rice in Indonesia. Where one of the potential sources of emissions of pollutants BC in $PM_{2.5}$. Therefore, the main purpose of this study is: 1) To asses emission factor of Black Carbon from the burning rice straw in the filed open burning. 2) To investigated the characteristic Black Carbon emitted net burning smoke concentration from the burning of rice straw in the field open burning with different varieties in the Cianjur District. This study provides useful information on pollutant emission, which way lead to air quality management for both local and regional scales.

## 2. EXPERIMENTAL WORK

### 2.1. Crop residue collection

Burning straw experiments conducted in the District Cugenang, Cianjur on eight varieties of rice. Straw was collected from seven villages in the districs Cugenang Mekongga varieties collected from Sukamanah, ciherang and cintanur varieties collected from Giri Harja, hybrid varieties from the Babakan Imbangan, Inpari from Panumbangan, varieties inul and sarangue collected from Pangkalan Benjot, Varieties of Pandan wangi collected from Ranca Picung. Sampling was carried smoke from burning straw during the rice harvest in June-October 2015 by 8 field burning in rice harvested in Cianjur**.** Sampling location presented at Fig.1

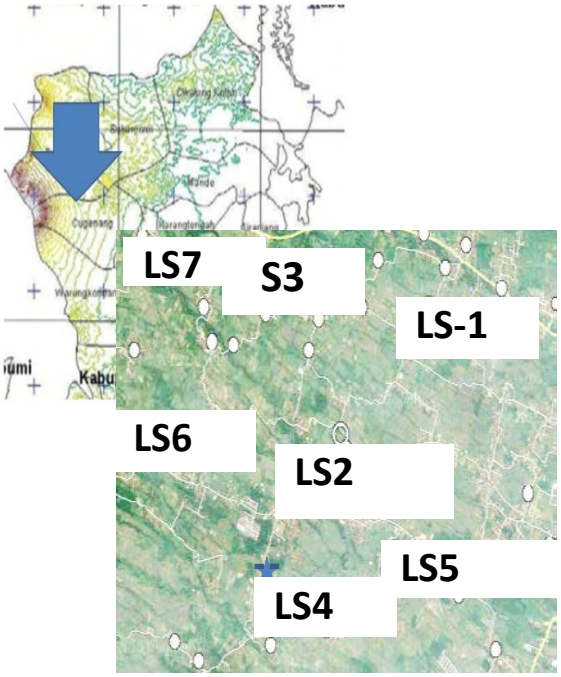


Fig.1 The location of Study Area

### 2.2. Processing Open Burning

Experimental field is the part that is harvested by farmers. Experiments in the field of combustion follow local practice of burning straw. Base on our survey at the seven villages in the Districts Cugenang shows that straw burning is done 4-10 days after the rice harvest in between the hours of 11:00-16:00. Each field experiments on rice varieties performed well every background sampling prior to combustion. Sampling background lasts for 6-8 hours. After completion of sampling the background conditions, the burning of rice straw begins to sample. Smoke sample measurement starts as soon as the fire becomes stable (smoldering) and continue until the fire stops.

### 2.3. Sampling of Black Carbon

Measurements of pollutants (BC, CO and $CO_2$) carried by air quality monitoring equipment comprising from minivol sampler, and CO and $CO_2$ analyzer.

Measurement of Black Carbon from field burning experiments was collected by two samplers minivol (Anderson 214 series) on the Teflon filter, collected by the flow rate of 5 $Lmin^{-1}$. Sampling equipments was placed at two points downwind in each experiment the combustion is at a distance of approximately 5 m from the edge downwind of the combustion field, to avoid damage from fire and heat. equipment is positioned at 1.5 m above the ground. Two minivol sampler located about 1-1.5 m from each other. At this distance, samplers considered close enough to capture the same piece of pollutants from smoke and far enough away to minimize disruption inlet flow. Figure of sampling equipment presented at fig.2.

Fig.2.Field Burning Sampling Equipment

All measurement in the field is also done recording meteorological conditions and CO and $CO_2$ over a period of combustion takes place in the field.

Parameters monitored meteorological conditions consist of wind speed, wind direction, temperature, pressure, and humidity. This parameter measurements carried out in order to see the influence of meteorological conditions on emissions BC. Continuous data from $CO/CO_2$ analyzer is used to measure the concentration of gas near the fire, and this data is primarily used to determine the combustion deficiency. Both of $CO/CO_2$ analizer at a height of 1.5 meter long stick close to the source of combustion.

Air quality monitoring is done before trial to get background ambient air concentrations and during open burning for measuring emissions from open burning of rice straw. Burning time from the start of combustion from the burning conditions (smoldering) until the fire dies. After burning, the ash and unburned straw collected for analyze the water content and to get dry mass to determine the fraction of combustion.

### 2.4. Black Carbon Analysis

Black carbon concentration level on Particulate Matter samples collected on filter media were analysed gravimetrically. To determined mass of Black carbon by an EEL Smoke Stain Reflectometer.

(Model 43D, Diffusion Systems Ltd, London) at the Laboratory of air quality environmental engineering Institute Technology of Bandung.

Analysis of Black Carbon by optical methods, by comparing the transmission of light through a filter that contains suspended particles with the transmission of light through a filter that is still clean. It is possible to estimate Black Carbon (BC) concentrations in the atmosphere by simply measuring light absorption or reflectance.

Air is drawn through the filter and then the density of the particles retained on the filter was measured using a reflectometer. Particulate density can be converted using a calibration curve to obtain the mass concentration of Black Carbon.

### *2.5. Calculating Methods*

The emission BC were measured in form of concentration (mg/m$^3$ BC). The concentrations of BC on $PM_{2.5}$ from the smoke emision were calculated as the following equation :

1). Calculation of carbon black weight per unit area of filter

$$BC = 4{,}37638\ x\ \{-ln(\bar{R})\} + 21{,}199 \qquad (1)$$

Where, BC is weight of black carbon per unit area of filter (mg / m$^2$). R is average reflectance samples.

2) .Calculation of carbon black mass

$$M = BC\ x\ A_{filter} \qquad (2)$$

Where, M is mass of carbon black (g), A filter is ½ filter area (m$^2$).

### 2.6. Emission Factor Calculation

Emission factors (EF) for BC are calculated after analysis of the concentration of BC on $PM_{2.5}$. BC in the results obtained with the unit mg / m$^3$. The derivation of emission factors with direct method [9]. Emission factor from open burning of rice straw in the field was obtained by following equation.

$$EF = Ci/BR \qquad (3)$$

where, Ci is emission concentration of pollutant i (mg/m$^3$) and BR is burned rate (g/s). The units of BC concentration were changed from μg/m$^3$ and ppm to mg/m$^3$.

## 3. RESULT AND DISCUSSION

In this research, estimation of emission factor BC from open burning in the rice field is the target. Other pollutants ($PM_{2.5}$, $CO_2$, and CO) are also considered to investigate combustion characteristics and efficiency combustions (EC).

Emissions of BC from open burning of rice residues were measured in form of concentration (μg/m$^3$ BC) by real time monitored equipment. Emission factor of BC in form of gr/kg (dm). Emission factor from open burning of 8 varieties of rice straw results are presented in Table 1.

Table. 1 Emission factor of BC from Field Open Burning of Rice Straw.

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| Rice Straw Varieties | EF BC (g/kg)dm |
|---|---|
| Mekongga | 0.501 |
| Ciherang | 0.749 |
| Hibrida | 0.817 |
| Inpari | 0.973 |
| Cintanur | 0.794 |
| Inul | 0.928 |
| Sarangue | 0.847 |
| Pandan Wangi | 1.099 |

Table 1 shows the average value of local emission factors for Black Carbon varied for each variety. Fluctuations in the value of emission factors among these varieties reflect variations in combustion conditions, biomass conditions and the meteorological conditions [10].

Differences of emissions factor from burning straw with different varieties influenced by the characteristics of the straw (moisture content, ash content, carbon content) and also influenced by the efficiency of combustion.

For this experiment, moisture content of the Ciherang varieties (19,03%) was bigger level and lower carbon content than other varieties. Based on this it can be explained that the bigger the moisture content of the straw, the emission factor will be low. Conversely, if the high emission factors from burning the straw will be high [13]. Overall, BC Emission Factor correlated with the characteristics of the straw (moisture content, ash content, carbon content) and by the efficiency of combustion presented at Figure 3.

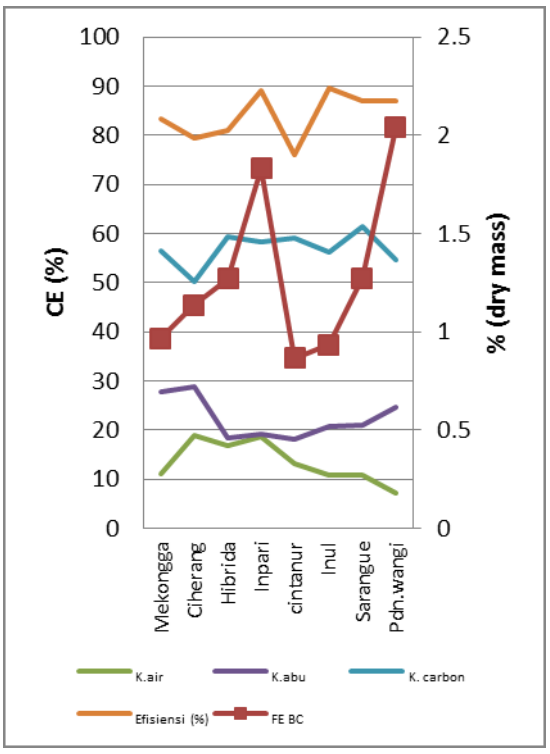


Fig 3. BC Emission Factors vs Characteristic rice straw.

Variations BC emission factors also influenced by the efficiency of combustion. Functions combustion efficiency in the field against BC in the $PM_{2.5}$ concentration is described by the linear regression equation y = -0.0813x+93.8 correlation value is negative ($R^2$ = 0.763).

Averaged value emission factors for BC from open burning straw without distinguishing varieties, in the district of Cianjur Cugenang can be compared with other studies. Comparison with some research can be seen in Table 2.

Table 2. Result and another research comparison.

| Result | EF BC (g/kg) dm |
|---|---|
| Hayashi et. All (2005) | 0.069 ±0.013 |
| Andreas Merlet (2007) | 0.47 |
| Kanokkanjana (2011) | 0.06 ±0.02 |
| This research (2016) | 0.939 ± 0,417 |

The Emission Factors reported in this study were much bigger than those of previous study [3], [6], [8], due to many factors as previously mentioned. This is expected because the characteristics of rice straw in Cianjur which has a higher carbon content (56.91%) when compared with the carbon content of the straw research [4] amounted to 35.4%.

Comparisons using inferential statistical analysis needs to be carried out using SPSS statistical 20. In this analysis the data inputted into the program is BC emission factor data from experiments in the field. Furthermore, the significance of the data is analyzed by comparing the average value using one-way ANOVA test (one way ANOVA) and t test-Two Sample at 95% confidence level. One-way ANOVA test is used to test the significance between varieties of the BC concentration. To answer the question whether the average value of the concentration of BC between varieties there are significant differences. The results of the analysis are summarized in Table 3.

Table 3. Result of the SPSS analysis

| FE BC Lapangan | Anova (Tukey test) |
|---|---|
| MKGA(0.301) | A |
| CHRG (0.044) | A |
| CNTR (0.047) | A |
| SRNG (0.508) | A |
| INUL (0.056 ) | A |
| INPR (0.058) | A |
| PDNW(0.129) | B |
| HBRD(0.131) | B |

Figures followed by the same letter in the same column are not significantly different according to Tukey test at 5% significance level (α =95%).

## 4. CONCLUSIONS AND RECOMMENDATION

This study involved the assessment of Black Carbon Emission Factor in $PM_{2.5}$ from rice straw open burning in the field in District Cugenang, Cianjur, West Java Indonesia. Field experiments were conducted to quantify eight varieties rice straw, which is main fuel for combustion. The sample were collected using miniVol sampler and for Black carbon was measuremend using an EEL smoke stain reflectometer.

Result of BC emission factors for eight varieties Mekongga, Hibrida, Ciherang, Inpari, Cintanur, Sarangue, Inul, Pandan wangi was Emission Factor of BC from open burning of rice residues in the field is 0.939 ± 0.417 μg/$m^3$. Variations of this value is influenced by the efficiency of the combustion simulation and the characteristics of the straw (moisture content, ash content, carbon content).

The results of this study presented provide useful information for the development of local emission factors for Black Carbon from open burning of rice straw in Cianjur. This research paved the way for more accurate estimate of emissions that have an impact on air quality and climate impacts in Indonesia. Measurements of Emission factor for local sources should be conducted to provide a better estimate of amount of black carbon emission in all same typical rural areas in the country.

## 5. ACKNOWLEDGMENTS.

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