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Research Article

Analysis of the Physical and Chemical Properties of Peat Fires

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Abstract: Forest fire and peat fires in Indonesia is an important factor air pollution in Southeast Asia. Emissions from peat fires cause extraordinary impact for human health, visibility, the economy and affect global climate. The low intensity of peat fires can produce large particulates emission, CO and other gaseous compounds. Analysis of physical and chemical properties of smoke from peat fires took samples of peat in the village of Kuala Sekampung, District Sragi, Lampung province, Sumatra-Indonesia, to conduct laboratory scale combustion. The purpose of this analysis is to determine the physical and chemical properties of the smoke from peat fires and lasting drop in visibility and air quality deterioration. Chemical properties in researched is CO, NO, NO_2, CO_2, SO_2, and H_2S and physical properties in researched is dustfall, TSP and dust particles. Preparation of Simulation peat fires made for laboratorium scal. Process of cultivation of grass for 6 months. Burning grasses are used as fuel placed on the furnace which is positioned on a closed tunnel so there is no influence of the wind outside. Combustion carried out for 1 hour for each repetition. Instrument for physical properties measurement are dustfall canister and filter whatman 41 for dustfall parameter, High Volume Air Sample and filter Staplex tipe TFAG41 for TSP and petri dish, filter whatmann 41 and digital microcope for calculation of total dust particles. The results showed that from the physical and chemical properties are associated with decreased visibility and air quality deterioration.
Keywords: Peat Fires, Physical properties, Chemical Properties, Visibility, Dustfall, Air pollution, Size Distribution.

INTRODUCTION

Forest fires and peatland in Indonesia is an important caused of air pollution in Southeast Asia. Particles inflicted by fire dominated majority by pollutants which exceeded the limit of ambient air quality on a regional scale [1, 2]. Peat fires are a source of greenhouse gases in the atmosphere [3]. From several countries in Asia, Indonesia is the country with most experience peat fires and deforestation [4]. Forest fires and peatland in 1997 and 1998 in Indonesia burnt more than 11 million hectares of forest are not only an economic loss but also poses a threat to biodiversity, water supplies and other ecosystems [5-7].

In 1997, the major contributor of smog pollution that spread to Singapore, Malaysia and Sumatra was peat fires from Jambi, Riau and South Sumatra. The land clearing forest fires in Sumatra expected to continue along with the opening of new plantations [8]. It also happened to peat fires 2013 in Riau where smog from forest fires and peatland disrupted the activities of people in Malaysia and Singapore. Forest fires and peat land also occurred in 2014 in August-October in Kalimantan and Sumatra. Numbers of flight activities in Sumatra impaired due to smog of land and forest fires, thus the detriment numbers of airlines.

Emissions from forest fires and peatland in 1997 pollute the air with a tremendous impact on humans health, visibility, the economy and affected global climate as well [9,1,7,10]; Peat fires produces smoke that worsening air quality, due to thick fog may cause health problems [10], influence a serious problems of social activities and peatland ecosystem [4].

Peat fires even with low intensity can generate a large particulates emission, CO and other gaseous compounds [10]. Results of research conducted by Hayakasa *et al*. [7] noted that the characteristics of the smog pollution from peat fires in the West Palangkaraya 2014 through photochemical is PM_{10} (more than $1000x10^{-6}$ gm^{-3}). Additionally peat fires resulted in a very low visibility conditions. Later research conducted by Fuji *et al*.[11] states that there is $PM_{2.5}$ aerosol in the smoke from peat fires in Southeast Asia.

This study will analyze the physical and chemical properties of peat fire smoke. The physical properties analyzed are dust fall and TSP while chemical properties analyzed are CO, NO, NO_2, CO_2, SO_2, and H_2S. The results of this study will provide useful information for assessing air pollution caused by peat fires and can be a reference for drafting legislation related to air quality.

Study Area

Peat soil for this study was taken in the village of Kuala Sekampung, District Sragi Lampung Province in October, 2015. Measurement of parameters is done in the Rumah Kebun,Gardu Dalam RT 02/01 No. 48 Margajaya, Bogor and IPB laboratory in April, 2016. Meanwhile, the peat soil analysis carried out in the Laboratory of soil Biotrop, Bogor in November, 2015.

Grass planting on peat soil was conducted from November, 2015 to March, 2016. The grass is taken from Bogor and then planted on peat soil that has been taken in 1 x 1 meters. Grass growing on peat soil dug up and then dried to burned.

MATERIAL AND METHOD

Materials of this study are peat and grass. This study measured the physical and chemical properties from smoke emission peat fires. A combustion plot made at the location of measurements that makes smoke emission peat fires focus on one point. Burning grasses are used as fuel placed on the furnace which is positioned on a closed tunnel so there is no influence of the wind outside. Fire is made from below so that the grass burnt slowly. Combustion carried out for 1 hour for each repetition (Figure 1). Measurement of chemical property use Portable Flue Gas Analysis. Portable Flue Gas Analysis can only be use for 15 minutes. The data of chemical properties carried out for 10 minutes to record the results of measurements every 10 seconds. Physical property for dustfall and TSP measurements carried out for 1 hour (figure 2 and figure 3). The falling dust particles are taken using the glass slide placed parallel to *dustfall*. Then measuring the size of any existing dust falls along with the numbers using a digital microscope.

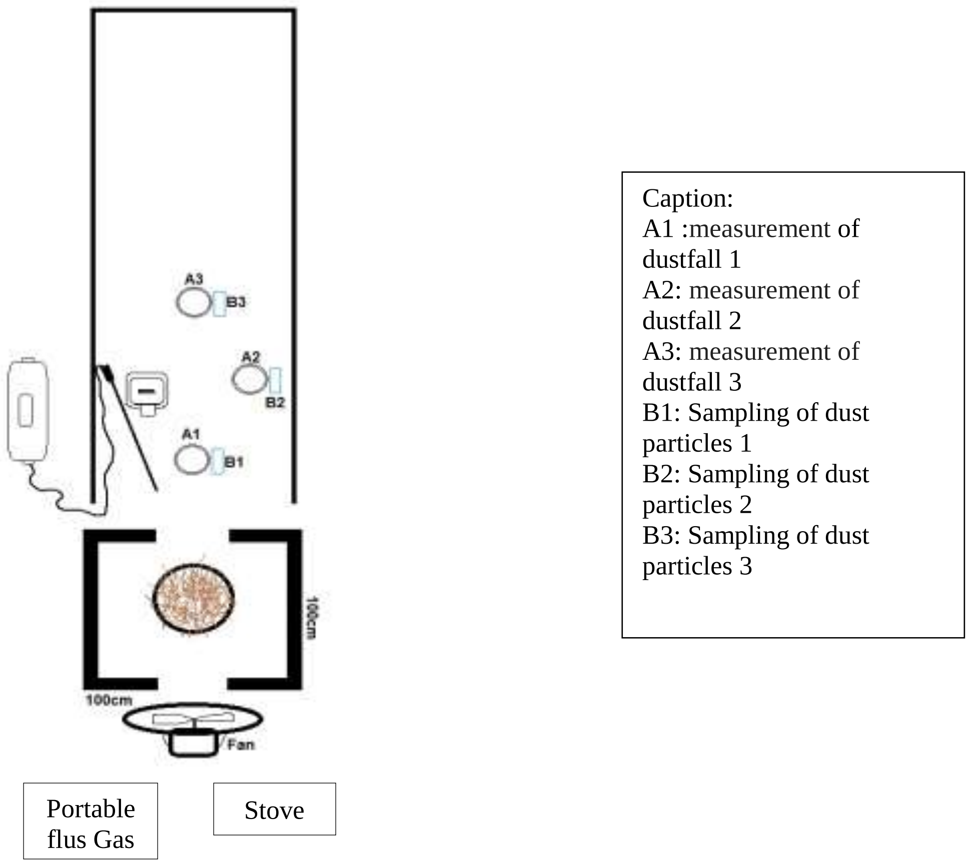

Fig-1: Measurement scheme of analyze the physical and chemical properties of peat fire smoke for laboratory scale

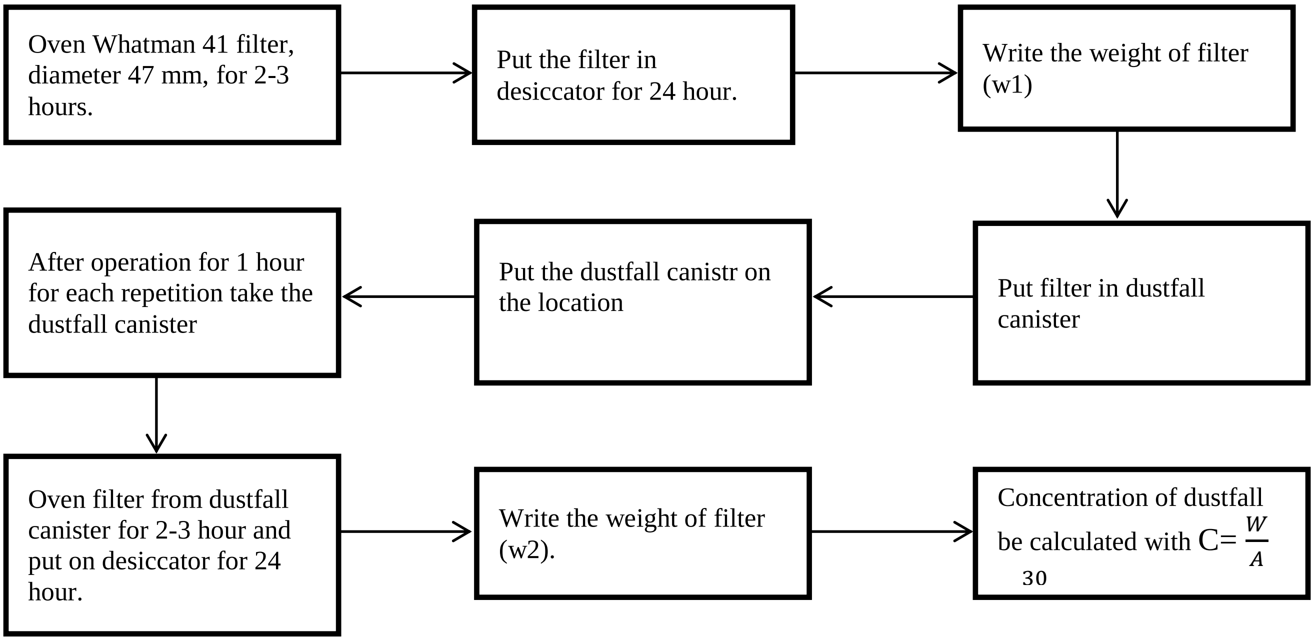

Fig-2: The Schema of dustfall measurement

Description of equation:
C : Concentration of dustfall (gram m^{-2} $bulan^{-1}$)
W : weight of dustfall (gram)
T : Time of measurement (day)
A : Surface area of dustfall canister funnel (m^2)

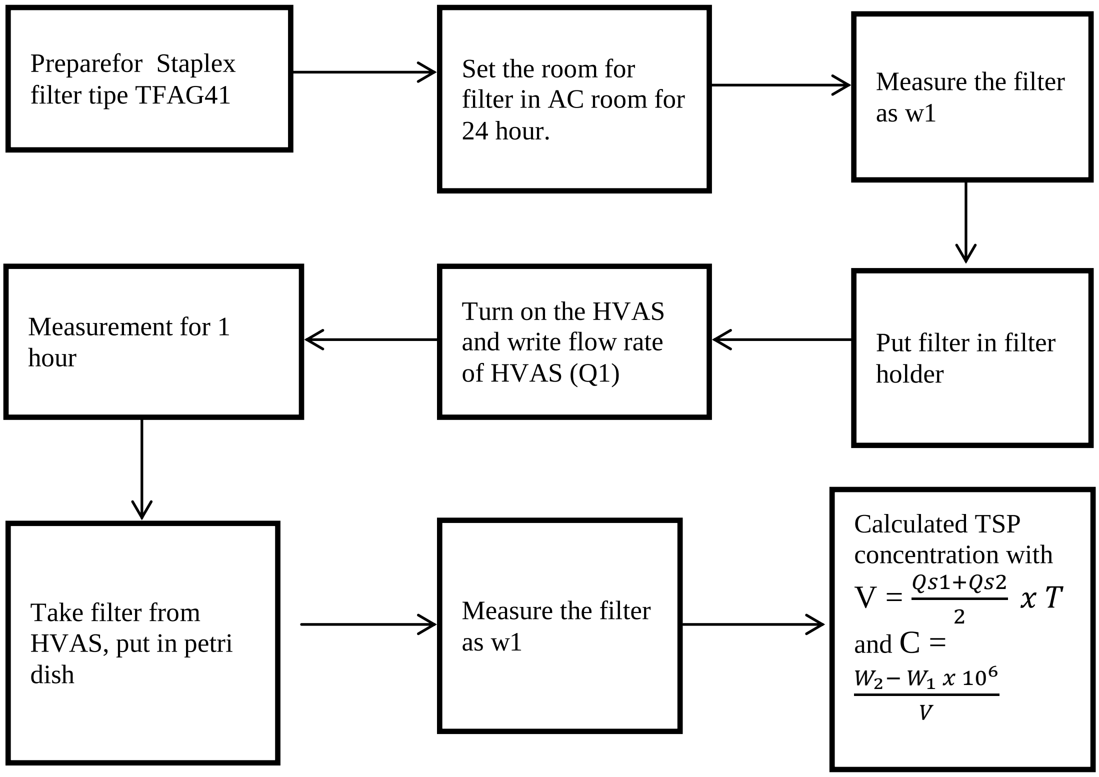

Fig-3: The Scheme of TSP measurement

Description of eqution
V : air volume (m^3)
Qs1 : flow rate for first measurement (m^3/minute)
Qs2 : flow rate for second measurement (m^3/minute)
T : duration of mesurement (minute)

C : concentration of period of suspended particles (µg/Nm^3)
W1 : weight of first filter (g)
W2 : weight of second filter (g)
V : air volume (Nm^3)

RESULTS AND DISCUSSION

Burning of grass peat soils are carried out four times repetition result in chemical properties as follows.

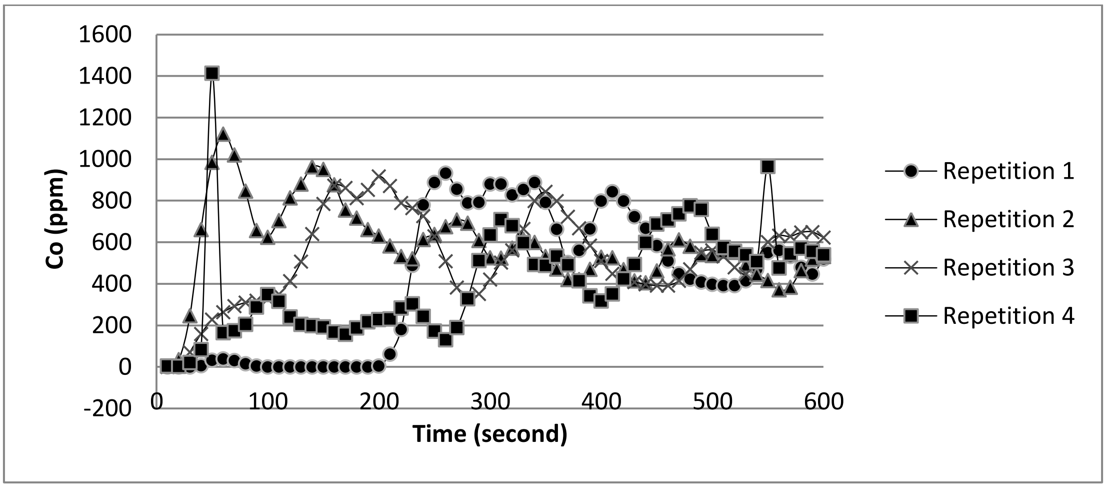

Fig-4: Concentration of CO

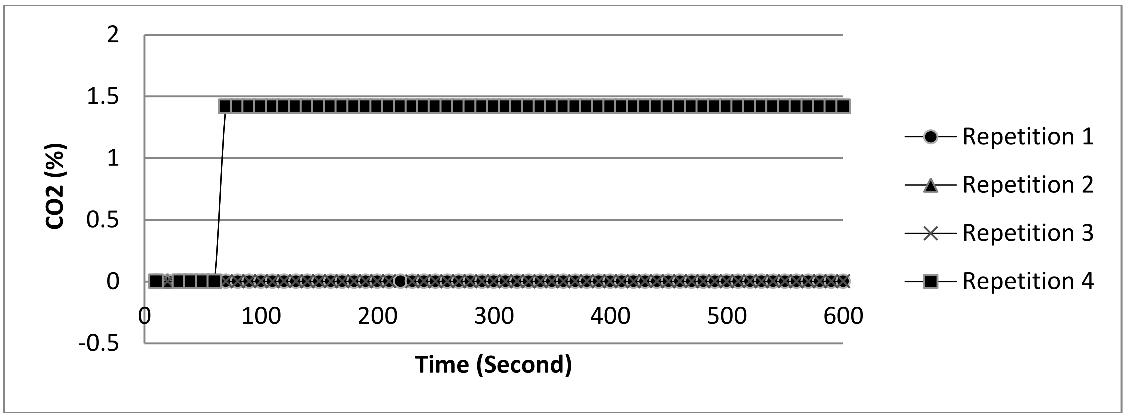

Fig-5: Concentration of CO2

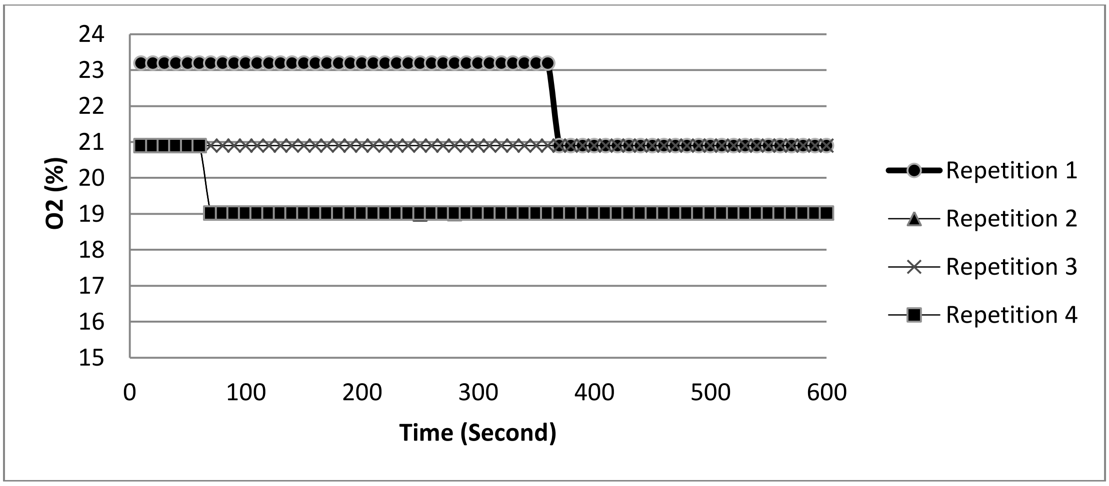

Fig-6: Concentration of O2

Of the existing graphic image can be seen that the value of CO achieve the highest score is 1413 ppm, while the highest CO_2 value is 1,42% or 14200 ppm. The process of formation of CO gas through several processes below:

$$2C + O_2 \rightarrow 2CO$$

$$CO_2 + C \rightarrow 2CO$$

And at high temperatures, CO_2 can be decomposed back to $CO_2 \rightarrow CO + O$.

Based on the chemical processes, the high value of CO in the chemical property measurement of the smoke grass in the peat soil can be caused by the decomposition of CO_2. The concentration of CO and CH_4 is directly proportional to the concentration of CO_2. While the relationship between N_2O and CO_2 show inflection. [12]. Results of some research, emission from fires in Southeast Asia in 1997-1998 has a big impact on concenration od atmosphere, produce compounds compounds CO_2, CO, CH_4 and PM_{10} [12, 2, 18].

The measurement conducted in a room tunnel with less oxygen. CO gas can come from burning fossil fuels, it is in accordance with the fuel used. In a study entitled The Content of Greenhouse Emission In Peat Swamp Forest Fire in Pelawan, Riau result in the measurement of CO_2 emissions value is higher than CO. But in this study the highest CO2 value is 0%, this difference may be due to combustion by Nurhayati *et al.* done in an open environment while burning in this study was done in a closed environment.

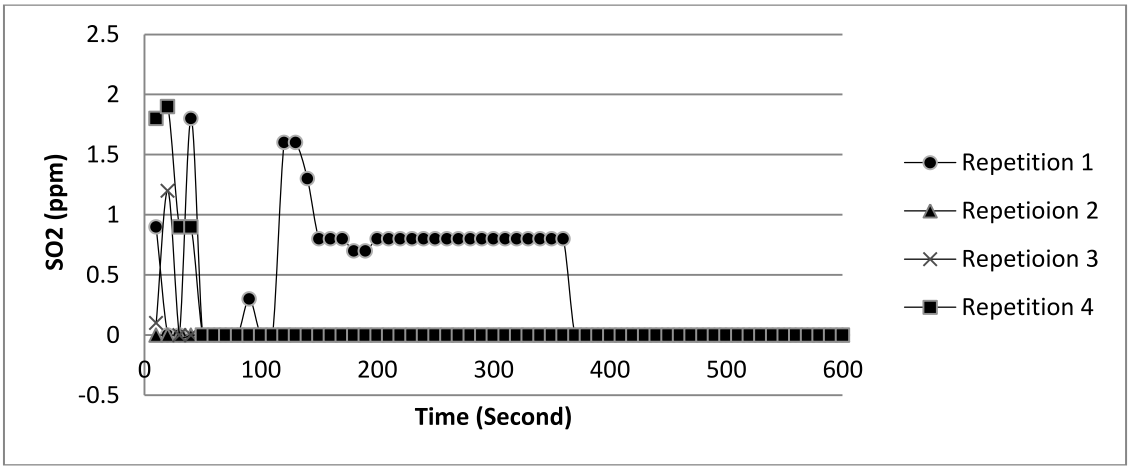

Fig-7: Concentration of SO2

SO_2 value of 1.9 ppm measured as the highest value, this value cannot be detected by sense of smell. Lower value of SO_2 can be derived from the furnace used, which caught fire when burning the grass. SO_2 and NOx are oxidized in the atmosphere and form $(NH_4)2SO_4$ or $NH_4HSO_4$and NH_4NO_3 in the presence of NH_3 under thermodynamically favorable conditions [17]. Moreover, the oxidation products, H_2SO_4 and HNO_3 vapors, can also bind themselves to preexisting primary aerosols forming internally mixed smoke plumes, leading to an increase in particle size and mass concentration [15]. The increase in the concentration of radiatively active secondary inorganic aerosols [$(NH_4)2SO_4$ or NH_4HSO_4 and NH_4NO_3] is indicative of the contribution of these particles to atmospheric visibility reduction during the smoke-haze period [14].

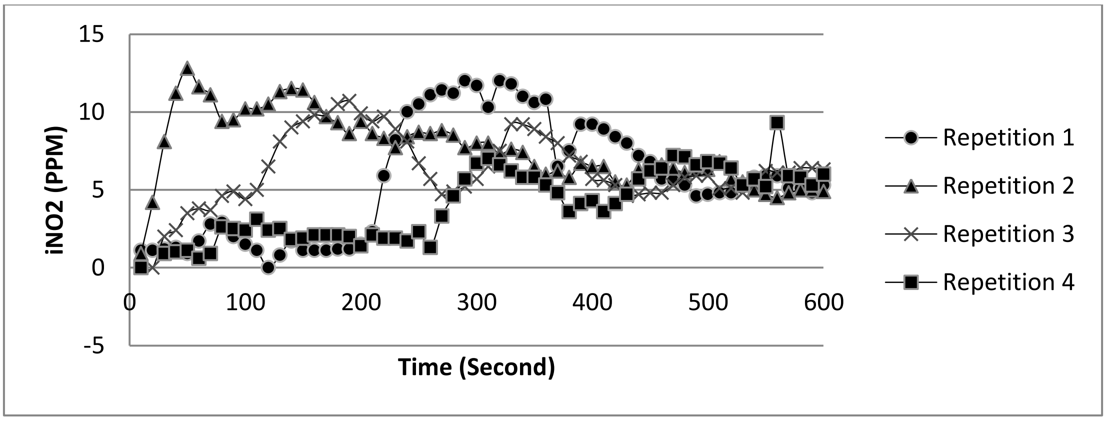

Fig-8: Concentration of NO2

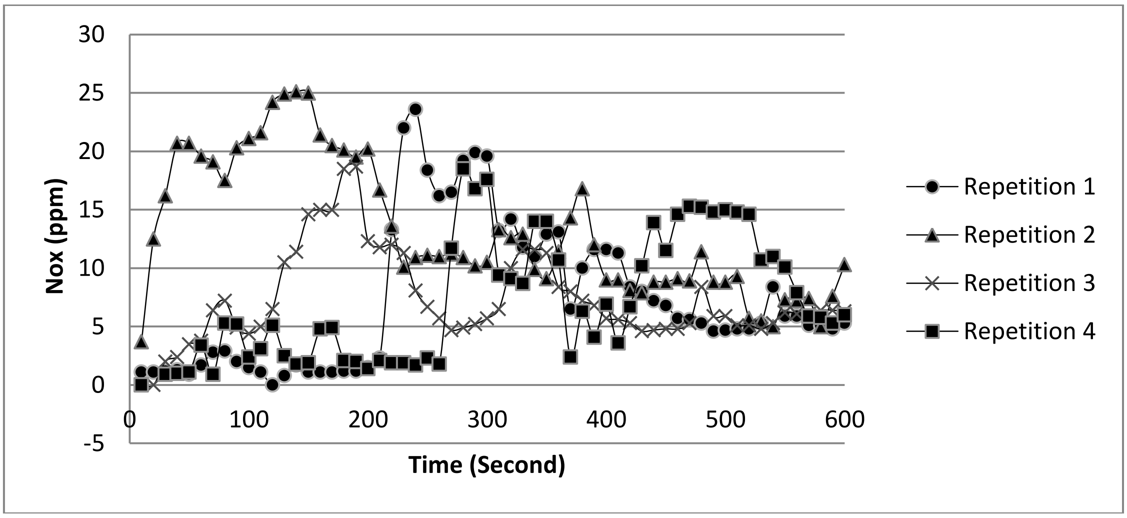

Fig-9: Concentration of NOx

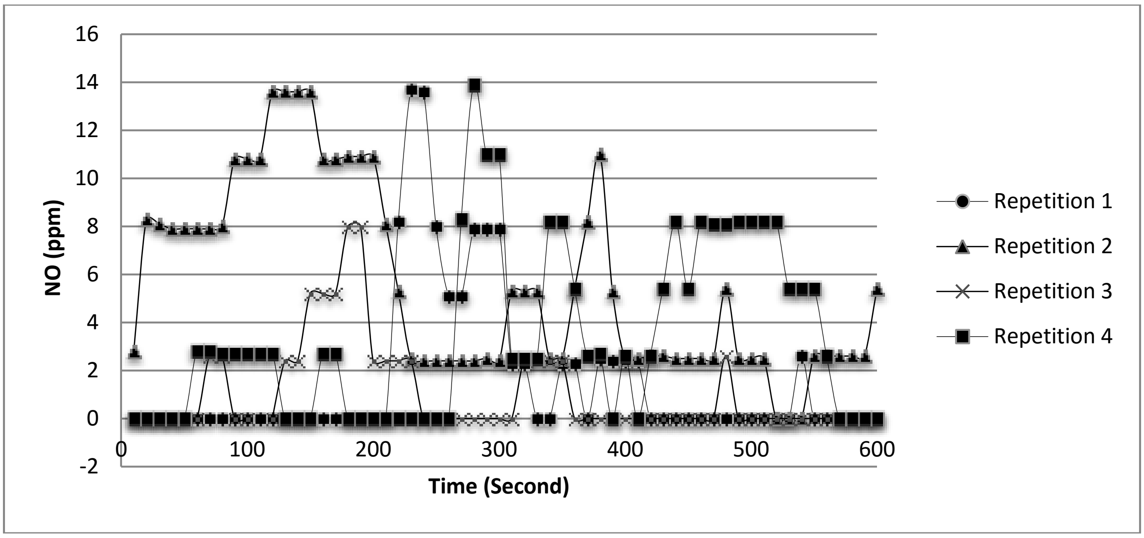

Fig-10: Concentration of NO

Trends values of NO_2 show not much different value. Starting with 1.1 ppm in the initial combustion and continues to move up to 11.5 ppm. NO_2 gas can be sourced from combustion, but the highest value NO_2 is derived from combustion machines such as generators. That is causing the value of NO_2 is not high on grass burning of peat. Besides combustion conducted in a closed environment and away from vehicle fumes can also be the cause.

The formation of NO and NO_2 is a reaction between nitrogen and oxygen in the air to form NO, which further reacts with more oxygen to form NO_2. Between the value of NO and NO_2 in combustion 1 and 2 dominated by NO_2 greater values, while in combustion 2 and 3 NO value is greater than NO_2. However, there are no significant differences in values.

Increasing NO_2 in proportion to the initial concentration of NO and SO_2 and O_2 and water vapor were found within one hour after collection of samples at a temperature of 25°C [13]. However, the measurement of chemical properties from smoke peat fires is not done for one hour. Measurements were performed for 10 minutes in accordance with the requirements of the tool used (no more than 15 minutes). Significant increase in NO_2 happened in the first repetition during combustion has not lasted for one hour. This is because the measurement done right at the source of emission.

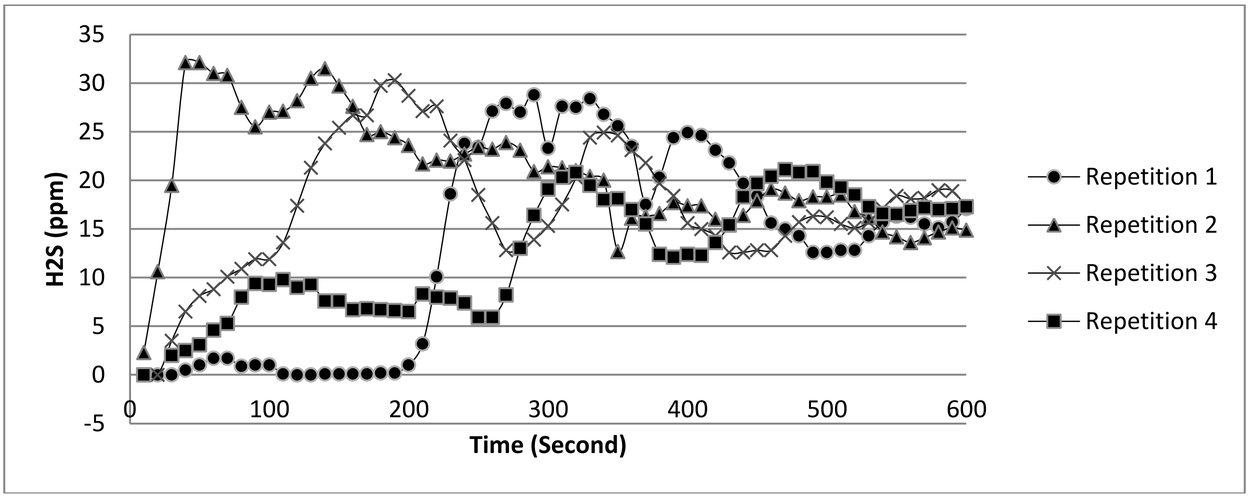

Fig-11: Concentration of H2S

At the beginning of combustion H_2S value still 0 ppm was later increased in the first minute which is the measurement in 40th seconds. Value of H_2S experienced ups and downs during combustion, with highes value is 32.1 ppm. When the increase in the value of H_2S can be caused by the addition of weed biomass is burned, because H_2S can be derived from the bacterial decomposition of organic material.

Numbers of Falling Dust Particles

Based on the size of the PM_{10} and PM_{25}, the amount of dust particles of PM_{10} is 360 particles while for PM_{25}in 169 particles. Of the total 58.8% of dust particles counted as PM_{10} dust, whereas for PM_{25} already included in it.

Measurement of the distribution of dust falling performed using glass slide for an hour combustion, and in the view with a digital microscope magnification of 10x. Result from the observation that was done using a digital microscope there are 43.6% of dust particles 0,1-5 µm. Particles size 0.1-5 µm based on new theories is set as emissions, but the size below and above the 0.1-5 µm is not well understood [19]. For more particle size that is 56.4% obtained a particle size greater than 5 µm is 6-90 µm. Research conducted by Chand *et al.* [20] conclude that combustion peat in Indonesia analyzed by electron microscopy show that 30% of the dust particles larger than 0.1 mm, shaped like a shell or hollow. Figure of particles on microscope glass slide at figure 12.

TSP measurement results conducted for one hour at a distance of 1 meter from the smoke source results as follows:

Table 1: TSP Concentration

Repetition	1	2	3	4
TSP (µg/Nm^3)	5509,18	5010,63	5085,51	5088,41

If seen from the distribution of dust falls then this outcome is balanced, because as observed with a digital microscope and calculating the amount of dust falling particles produce large quantities of 612 dust particles calculated by dividing preparationsinto 5 sections for one preparation.

The results measurements of dust by using three dustfall canister placed for one measurement at a distance dustfall canister 1 is 35 cm, dustall canister 2 is 70 cm and dustfall canister 3 is 100 cm results as follows:

Table 2: Dustfall Concentration

Repetition (1)	1	2	3
Dustfall (gram m -2 month -1)	0,049	0,057	0,141
Repetition (2)	1	2	3
Dustfall (gram m -2 month -1)	0,053	0,038	0,148
Repetition (3)	1	2	3
Dustfall (gram m -2 month -1)	0,018	0,070	0,151
Repetition (4)	1	2	3
Dustfall (gram m -2 month -1)	0,178	0,036	0,077

Dust fall obtained from this study did not come from the wind generated from the surrounding environment, but is due to the influence of wind from the fan tools that are used to direct the smoke toward the measurement tools. Measurements of dust fell was done for one hour, together with TSP measurements and distribution of dust fell.

The amount of dust results obtained linearly related to the chemical properties of existing content. In the produced dust can be contained chemical properties. Further research is needed to analyze the chemical properties of the dust produced from peat fires. As well as analyzing existing content in the dust that is larger than 5 mm.

Fig-12: Dust particles on glass slide

Besides health effects, impaired visibility affected the economy of Indonesia, Singapore and Malaysia. Land, air and sea traffic to be limited, tourism revenue, idustry and fishing activity decreased [16]. A plane crashed in September in northern Sumatra caused 234 people died and ship collision in the Malacca Strait, Malaysia killed many souls, all partly caused by impaired visibility [1].

In the study conducted by A. Heil and J.G Goldammer generate visibility affected by the TSP and PM_{10}. The higher the value of TSP and PM_{10}, the visibility get lower. The research measurement results show that high TSP values> 5000 (μg / Nm^3), it is indeed affected the visibility in the environments that are exposed smog from peat fires.

The main cause of the decrease in visibility, seen from this study and several journals of reference, it can be sourced from particles of dust generated from peat fires. Measurement parameters of TSP, PM_{10}, and the distribution of dust falling plus the wind speed and direction, it can deduce the state of visibility in an area that is exposed to the smoke smoke fires. Therefore, it is necessary to overcome the decline of TSP, PM_{10}, and other dust particles to avoid impaired visibility.

Impaired visibility widely used as an indicator of the quality of air ambient during the occurrence of smoke in Indonesia. However, visibility is not only dependent on the concentration of particles, but also on the subjective perception of the observations, relative humidity and light conditions [2]. This study measured the intensity of light to determine the decrease in light intensity from peat fires. From the measurement conducted in the centre of fires results 19640 before burnt and when burned the light intensity is 16890. It showed a decrease intensity of light after combustion. Measurements were made at one point that the central part of the area burnt due to smoke generated from combustion is concentrated in a short time in the middle, while the other part does not significantly affect the measurement result or only a slight decline because of wind velocity around environment.

CONCLUSIONS

Analysis of physical and chemical properties of smoke from peat fires conducted by a laboratory scale resulted in the conclusion:

1. Chemical properties are measured, namely CO, CO_2, NO, NO_2, NOx, SO_2 and H_2S concentrations produce values that are harmful to health and the environment. Chemical properties of CO and CO2 achieve the highest score is 1413 ppm, while the highest CO_2 value is 1,42%. O2 has a constant value. Score of SO2 is low and can not be detected by sense of semll. NO2, NO and NOx have a flutuatif trend score during combustion and that is not safe for health. H2S only detected a low score.

2. The physical properties of the dust particles in the form of either dustfall and TSP measured in high quantities, the highest value for dustfall is0,178 gram m -2 month -1 and TSP 5509,18μg/Nm^3. This of course happened because the measurement is done right at the source. But if fires occur on a large scale such as forests will produce dusts that endanger health and the environment, as evidenced every land fires there will be a decrease in light intensity.

3. The light intensity decreased the event of forest fires caused by the presence of dust particles caused fires.

4. Dust particles from forest fires produce dust particles with sizes ranging from 0,1 – 90 μm.

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