The Relationship between the Decline of Oxygen and the Increase of Methane Gas (CH4) Emissions on the Environment Health of the Plant

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Abstract

Background: The intensive utilization of low-grade coal (<5,100 kcal / kg) as a fuel in a steam power plant can lead to intense emission of methane (CH_4), whose amount is increasing in the atmosphere. The intensive emissions of CH_4 gas will affect the global warming, especially climate change. The chemical reaction between CH_4 gas and oxygen (O_2) in the combustion of coal will reduce the concentration of oxygen and increase CO_2 (carbon dioxide) and H_2O (water vapor). A decrease in the oxygen concentration of 2% will increase the concentration of CH_4 in the air by 10%. An intensive decrease of oxygen will adversely affect the health of the plants, it can even cause death.

Aim and Objectives: The aim of this study is to show the effects of a decrease in oxygen on the increased CH_4 emissions from the burning of coal of different types of calories. The characteristics of the coal burning is analogized with the actual conditions occurring in nature which are associated with the environmental health, especially the disruption to the health of plant.

Methods: This study was conducted in the laboratory using a range of coal samples from coal of low-calorie to coal of high-calorie. The combustion systems used in this study was a modified fixed-bed coal combustion. The oxygen concentration and CH_4 emission were read from multigas detector, and a thermocouple was used to measure the temperature of the combustion of coal. The variables observed in this study were the oxygen concentration (%) and CH_4 emission (ppm) of various grades of coals, from a low-calorie coal to a high-calorie coal with codes of BA-59, BA-63, BA-67, BA-76. The data obtained from this study were processed using statistical methods. The data generated were compared to the minimum permissible oxygen in plants, namely by 20%. In addition, a decrease in oxygen concentration can also be proved by chemical reactions occurring between gases of CH_4 and oxygen which produces CO_2 (carbon dioxide) and H_2O (water vapor).

Results: Based on the statistical tests comprising of a data normality test, hypothetical test and non-linear regression analysis, a significant correlation between the decrease in oxygen concentration and increased CH_4 emissions was obtained. The calculations carried out produced oxygen concentrations and emissions of CH_4 from each category of coal from low to high-grade coal respectively as follows: BA-59: 11.8% and 4.8 ppm; BA-63: 15.3% and 1.3 ppm; BA-63: 16.4% and 0.3 ppm; BA-

76: 17.2% and 0.1 ppm. While the percentage of oxygen allowed for plant respiration is a minimum of 20%.
Conclusion: The combustion of low grade coal for the power plant activity will decrease the concentration of oxygen and increase the CH_4 gas emissions in the atmosphere that can damage the health of the plants and it can even cause death. The mitigation of CH_4 emission generated by the combustion of low grade coal for power plant can be done by upgrading low-calorie coal so that its characteristics change.

Keywords: Low-calorie Coal, CH4 Gas Emissions, Global Warming, Steam Power Plant

Introduction

Mining activities can cause air pollution by generating the greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) from the coal seams below the soil surface, spontaneous coal combustion, and coal combustion at steam power plant. Intensive coal utilization at the plant is a complicated and complex issue. The steam power plant uses low-grade coal (<5,100 kcal / kg) as a boiler fuel. The consideration for the use of low-calorie coal is because the boiler setting requires low-grade coal, the coal is cheaper, and the reserves are more abundant. The combustion of low-grade coal may cause higher emissions of CH_4 gas than that of the high calorie coal. The continuous utilization of low grade coal will cause adverse environmental impact, especially global warming.[1-8]

CH_4 gas is a gas that can indirectly cause a decline in the quality of health of the environment. The nature of CH_4 gas is nontoxic, odorless, and its density is very light compared to other gases, especially oxygen which causes the gas easily get out into the atmosphere and the cycle can reach 10 years or more. CH4 gas is a gas that can bind oxygen in the air so that the oxygen concentration decreases. A decrease in the oxygen concentration will result in the disruption of the plant. Plants need oxygen at least 20% for respiration. The continuous concentration of oxygen below 20% will cause the plants to have difficult respiration that may disrupt the growth and development of the plants and even cause them to perish.[9-27]

The diseases that occur in plants due to lack of oxygen have been studied by the experts in the world. The factors that cause disease in plants can be divided into two categories, namely: [14-15, 19, 22, 25, 27]

1. Living pathogenic organisms (fungi, bacteria, viruses, and nematodes) and pests (insects, mites, mollusks, mammals, and birds) or they can be grouped into biotic factors.

2. Non-living as mechanical factors (breakage or abrasions), environmental conditions (extremes of temperature, light, moisture, or oxygen), and chemicals (herbicides or nutritional disorders) or they can be grouped into physical factors.

The emission of CH_4 factor is classified as the environmental conditions or physical factors that cause the oxygen concentration to decrease. Plants will grow and develop on the basis of specific abiotic and biotic factors. The disruption of these two factors will have an impact on the growth and development of the plants. Therefore, the control of oxygen depletion in the atmosphere needs to be done to keep the oxygen demand of the plant so they can perform respiration perfectly. [14-15, 19, 22, 25, 27]

Based on the aforementioned description, it can be concluded that the need for oxygen by plants is very necessary especially for respiration process. The reduced concentration of oxygen and increasing amount of CH_4 gas in the air can disrupt the growth and the development of plants.

Materials and Methods

The data on oxygen concentration and CH_4 gas emission in this study were gathered by using a range of samples of coals from low to high grade coal with the codes of BA-59, BA-63, BA-67 and BA-76. The sample code shows the calorific value of the coal, such as BA-59 which means the calorie of the coal is 5900 kcal / kg and so on. Coal burning was done with fixed-bed combustion coal in the form of a modified furnace and the equipments used in this study were multigas detectors, thermocouples and stopwatch. The data obtained from this study were processed using statistical methods. The data which had been processed were analyzed by comparing the data of the study with the oxygen concentration which is allowed and the chemical reactions that occur as a result of emissions of CH_4 gas with oxygen to produce carbon dioxide and water vapor.

Results

The study which has been conducted shows a significant correlation between the decrease in oxygen concentration and increased CH_4 emissions. Figure 1 shows that the condition of oxygen (O_2) which is low will cause higher emissions of CH_4 gas. The burning of low-grade coal showed highly reduced concentration of oxygen and increasing emissions of CH_4 (Figure 2). The reaction between the emission of CH_4 gas and oxygen (O_2) will form carbon dioxide (CO_2) and water content (H_2O). Reaction (1) shows that a decrease in oxygen will increase the emissions of CH_4 and form CO_2 and H_2O.

In nature, the reaction between methane (CH_4) and oxygen (O_2) will easily occur and can be written as follows:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \quad \text{.......... (1)}$$

Reaction (1) produced three kinds of condition as follows: (1) the concentration of oxygen decreases, (2) the concentration of CO_2 increases, and (3) the concentration of H_2O increases.

Discussion

Air consists of 21% oxygen, 78% nitrogen and 1% of other gases. The life of living creature is very much influenced by the availability of oxygen that exists in nature. A decrease in the oxygen concentration will lead to the increase of other gases. The studies which have been conducted show that a decrease in the oxygen concentration in the combustion of mainly low grade coal will lead to an increase in emissions of CH_4. The increased emission of CH_4 gas produces CO_2 and H_2O. CH_4 and CO_2 are greenhouse gases that can cause global warming. The real impact of global warming is climate change which will cause increase in temperature, high rainfall, long droughts, rise of sea level, flooding, and other natural disasters. Global warming due to greenhouse gases will reduce the concentration of oxygen. CH_4 gas has a global warming potential of 21-25 times greater than that CO_2. The greater the concentration of CH_4 gas, the greater the impact on the environment.

A decrease in the oxygen concentration of 15% would lead to human physical and intellectual capacity to decline. A decrease in the oxygen concentration will lead to increased concentrations of other gases such as nitrogen, argon, helium, CO_2, CH_4, and H_2O. A decrease in oxygen concentrations below 15% will boost greater influence on living beings and can even lead to death. A decrease in the oxygen concentration will occur in greater amount in toxic gases and flammable gases.

Low grade coal as an energy resource that is intensively used for fuel of power plants and other activities will lead to a decrease in oxygen concentration, the increase in greenhouse gases (CO_2 and CH_4), and water vapor (H_2O). The data of CH_4 gas emissions for various activities such as agriculture (20%), livestock (15%), mining and petroleum (14%), biomass burning (10%), and wetlands (24%) showed a tendency to increase every year. The global average of CH_4 gas emission of 1.75 to 1.80 ppm with a rate increase of 0.30 to 1.20 ppm / year and is able to increase the global temperature of approximately 1- 2°C. [26-30]. Mining and petroleum activities accounted for emissions of CH_4 gas by 14%, including the burning of coal as an energy source for power plant. Increased emissions of CH_4 gas may indicate reduced oxygen concentration in the atmosphere. A decrease in the oxygen concentration will increase the concentration of other gases in the atmosphere. The consequences of these conditions will result in the disruption of living things, especially plants that require oxygen for respiration process.

Conclusion

Based on the results of the study and the aforementioned discussion on the burning of coal, the following conclusions can be drawn:

1. The burning of low-grade coal will lead to decreased oxygen concentration shown by the analysis of the relationship between the decrease in oxygen and the emission of CH_4;
2. The increase in CH_4 emission caused by a decrease in oxygen concentration is indicated by the tendency of CH_4 emissions data which increase annually by 0.30 to 1.20 ppm / year;

3. The continuous burning of low-grade coal for the fuel of the power plant and other activities will lead to decreased oxygen concentrations in nature;
4. The decrease in oxygen concentration will disrupt the health of living things, especially the plants as shown by previous researchers.

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Figure 1. The relationship between oxygen concentration and CH_4 gas emissions

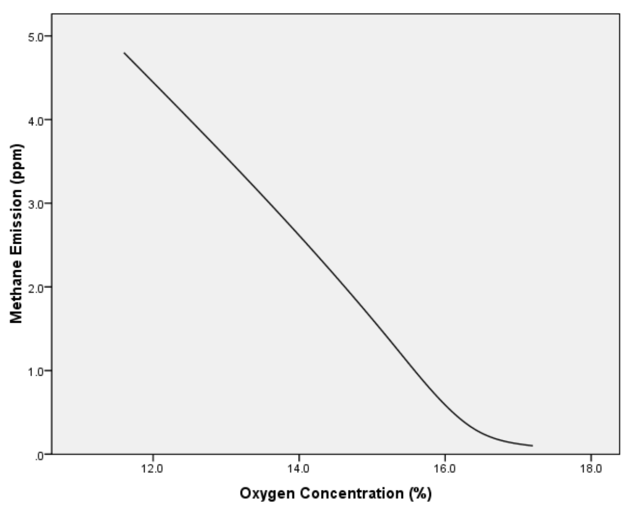

Figure 2. The relationship between oxygen and CH_4 gas for various types of coal calorie