

Modelling of SO₂ and CO Pollution Due to Industry PLTD Emission Tello in Makassar Indonesia

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Abstract: This study aims to determine the pattern of dissemination, distribution model and estimation of SO₂ and CO gas emission concentration derived from the Tello diesel engine with a dynamic model approach. The design of this research is descriptive quantitative with Gaussian Model approach and dynamic system model. The study was conducted at PLTD Tello Kota Makassar by collecting secondary data. For model distribution and estimation of SO₂ and CO pollution using Gaussian Model and dynamic modeling with Stella. Population in this research is data of emission parameters generated by Tello's steam power plant influenced by atmospheric stability, wind direction and velocity so as to obtain concentration of pollutant by using Gaussian calculation sample sample is SO₂ concentration concentration and CO PLTD Tello contained in monitoring report on RKL&RPL implementation for 2012-2017. The results of the dominant area of research are the impact of pollution from the Tello diesel power plant based on the dominant wind direction during 2012-2016 is the Northwest part of the Tello steam power plant at a height of 1 m above the ground with a distance of 500, 1, 500, 2, 500 and 4,000 m of the Tello diesel powered TTL Aspol, Panaikang, Pampang and Rappokalling. Total SO₂ and CO emission concentrations derived from Tello PLTD during 2012-2016 in each location at 1 m above ground level with a distance of 500 m, i.e., Aspir Tello SO₂ 1.395 and CO 1.162 µg/m³, a distance of 1,500 m of SO₂, SO₂ 1.247 and CO 1.039 µg/m³, 2,500 m distance of Pampang 0.878 µg/m³ and CO 0.7317 µg/m³ and a distance of 4,000 m of Rappokalling 0.6363 µg/m³ and CO 0.5303 µg/m³ from the pollutant source of the chimney PLTD Tello. The estimated concentration of Sulfur Dioxide (SO₂) and Carbon monoxide (CO) gas emissions based on 12 month dynamic model simulation (2018) is increasing every time until July 2018 at each of four location points at 1 m above the surface soil with a distance of 500 m of Aspol Tello SO₂ 0.26065 µg/m³ and CO 0.21530 µg/m³, 1,500 m distance of Panaikang SO₂ 0.04447 µg/m³ and CO 0.03134 µg/m³, distance 2500 m of Pampang SO₂ 0.01760 µg/m³ and CO 0.00938 µg/m³ and a distance of 4,000 m of Rappokalling SO₂ 0.00740 µg/m³ and CO 0.00611 µg/m³ from the source of the bursts of the Tello steam power plant with the rate of increase in the emission concentration of Asp2 SO₂ 0.0053 and CO 0.0044 times, SO₂ 0.04061 times and CO 0.0004 times, Pampang SO₂ 0.00021 times and CO 0.000073 times and Rappokalling SO₂ 0.000078 times and CO 0.000064 times every month. The concentration of SO₂ and CO emissions generated by the Tello steam power plant during 2012-2016 is still far below the ambient air quality standard (South Sulawesi Governor Decree No. 69 Year 2010) in each location at a height of 1 m above ground level, i.e., Aspol Tello 0-1.39 µg/m³, Panaikang 0-1.247 µg/m³, Pampang 0-0.878 µg/m³ and Rappokalling 0-0.6363 µg/m³. So, it can be said that the four areas are still included in the air quality is quite healthy.

Key words: Gaussian Model, model estimation, dynamics, SO₂ and CO pollution, TTL Aspol, quality

INTRODUCTION

SO₂ is a clear, colorless gas and levels up to 18%. This gas smells sting and very harmful to humans, Sastrawijaya (1991). The concentration of air pollution in urban areas has a close relationship with meteorological factors. The concentration of SO₂ can be influenced by meteorological factors such as temperature, relative humidity, wind speed, solar radiation and pressure (Hosseiniebalam and Ghaffarpasand, 2015). In the Peace River District of Northeastern British Columbia Canada, high concentrations of ambient Sulfur dioxide (SO₂) are found. Emissions of industrial activity interacting with meteorology and topography, resulting in atmospheric dispersion variations that can increase air pollution concentrations (Islam *et al.*, 2016).

Monitoring results in Korea for the period 1997-2010, the relative SO₂ concentration levels showed an increase during the winter due to the combined effects of domestic heating and meteorological conditions. SO₂ emissions are affected by the incomplete combustion of fossil fuels. Similarly, research conducted in Germany, that one of the largest contributors to sulfur dioxide (SO₂) comes from power plants (AlRafea *et al.*, 2016). Aji (2006) explains that Carbon monoxide (CO) is a colorless, non-flavored, odorless, non-flavored, gas-based primary pollutant having a density smaller than air and is highly stable and has a residence time of 2-4 months.

In South Asia, Carbon monoxide (CO) concentrations show an increase of 16.5% during 2000-2010. Increased CO levels are found in the Indo-Gangetic Basin (IGB), the mining areas east of India, Bangladesh and other urban areas. Some of the major contributors to these emissions come from agricultural waste, land transportation industrial production and power generation (Ul-Haq *et al.*, 2016). In China, power plants generate nearly 40% of carbon emissions (Yan *et al.*, 2017).

The results of the research conducted by Siregar on the relationship between concentration of SO₂, TSP and the physical environment with the incidence of ARI in the population in East Jakarta shows that there is a significant relationship between the increase of SO₂ concentration and the incidence of ARI. Then, the results of research conducted by Sakti (2012) which mentions that there is a relationship between ambient air quality (SO₂ and TSP) with the incidence of ARI in the city of Bekasi in 2004-2011.

Carbon monoxide (CO) can cause adverse health effects by reducing oxygen delivery to the organs of the body (including heart and brain) and tissues. CO can be shut off in indoor or other enclosed spaces. In Britain in

1985 as many as 1365 people died of CO gas poisoning. In France in 1991 17.5/100,000 people have been poisoned by CO gas and 5% of them died. In the United States in 1988 it was recorded that 600 people died from accidents of CO gas poisoning (Mukono, 2011).

Air pollutant dispersions can be controlled by a method called air pollution modeling, also known as air pollution dispersion modeling, a mathematical simulation that illustrates how pollutants are dispersed in ambient air. This simulation or mathematical modeling concocted mathematical equations in a unified concept that describes phenomena or natural behavior. Mathematical modeling allows testing of various variable combustion parameters using relatively short time and low cost (Gehrsitz, 2017).

After modeling the spread of SO₂ and CO gas pollutants, the ambient air quality (SO₂ and CO) is estimated from the activity of PLTD Tello Makassar. This estimation is done with Stella 5.0 program, i.e., flow chart based modeling and computer simulation which can facilitate a researcher to perform problem identification system formulate problem, determine research procedure consisting of group of interacting elements, so as to produce cause and effect relationship.

Stella 5.0 program is used because it can use several variables simultaneously and can display simulation model approach in the form of mind mapping, so that, we can see the variables that affect directly. Therefore, the results of the modeling in this study are expected to produce appropriate control strategies in pressing or reducing the rate of increase in air pollution, especially, SO₂ and CO parameters in the area around the PLTD Tello Makassar.

MATERIALS AND METHODS

Research sites: The research will be conducted at PLTD Tello which become the source of exhaust gas emission from the chimney produced by Tello PLTD production process. In increasing the electricity demand in Makassar and surrounding areas, the government in this case PLN build Steam Power Station as much as 2 units (2×12,500 MW) located in Tello. In 1971 it was operated and inaugurated by the president of the Republic of Indonesia Soeharto. To support the smooth supply of electricity in 1973 built 2 units of diesel engine with installed power (2×2.8 MW) located in the area of PLTU Tello. In June 1976 formed a Tello sector unit under the name PLN Region 8 Sector Tello with Bontoala and GI/Transmission Power Plant Units. In 1976 PLN Region 8 received an additional 1 unit Gasas Power Plant (PLTG) Weast can with installed power of 14.466 MW. In March of 2007,

Method of collecting data: The type of data collected in this study is secondary data. Secondary data consist of exhaust concentration obtained from PLTD Tello contained in monitoring report of RKL and RPL implementation year 2012-2017, data of wind speed, wind direction and sunlight obtained from BMKG Makassar City.

Data analysis: This research is done through several stages of activity, both in the form of library research, data collection and processing as well as Gaussian Model analysis activities and estimation models using Stella 5.0.

RESULTS AND DISCUSSION

The dominant area affected by pollution from the Tello diesel power plant based on the dominant wind direction during 2012-2016 is the Northwest Territory (NW) of the Tello steam power plant at a height of 1 m above ground level with a distance of 500, 1,500, 2,500 and 4,000 m of Tello’s TTV powerhouses are Aspol Tello, Panaikang, Pampang and Rappokalling. Total SO₂ and CO emission concentrations derived from Tello PLTD during 2012-2016 in each location at 1 m above ground level with a distance of 500 m, i.e., Aspir Tello SO₂ 1,395 µg/m³ and CO 1.162 µg/m³, a distance of 1,500 m of SO₂ 1.247 µg/m³ and CO 1,039 µg/m³, 2,500 m distance of Pampang SO₂ 0.878 µg/m³ and CO 0.7317 µg/m³ and a distance of 4,000 m, ie., Rappokalling SO₂ 0.6363 µg/m³ and CO 0.5303 µg/m³ from source contaminant of Tello PLTD chimney (Fig. 3 and 4).

The estimated concentration of Sulfur Dioxide (SO₂) and Carbon Monoxide (CO) gas emissions based on 12-month dynamic model simulation (2018) is increasing every time until July 2018 at each of four location points at 1 m above the surface soil with a distance of 500 m of Aspol Tello SO₂ 0.26065 µg/m³ and CO 0.21530 µg/m³, 1,500 m distance of Panaikang SO₂ 0.04447 µg/m³ and CO 0.03134 µg/m³, distance 2500 m of Pampang SO₂ 0.01760 µg/m³ and CO 0.00938 µg/m³ and a distance of 4,000 m of Rappokalling SO₂ 0.00740 µg/m³ and CO 0.00611 µg/m³ from the source of the bursts of the Tello steam power plant with the rate of increase in the emission concentration of Asp2 SO₂ 0.0053 and CO 0.0044 times, Panaikang SO₂ 0.00061 times and CO 0.0004 times, Pampang SO₂ 0.00021 times and CO 0.000073 times and Rappokalling SO₂ 0.000078 times and CO 0.0000064 times every month (Fig. 5 and 6).

From the results of wind direction data processing, the wind direction is dominantly blowing is toward the

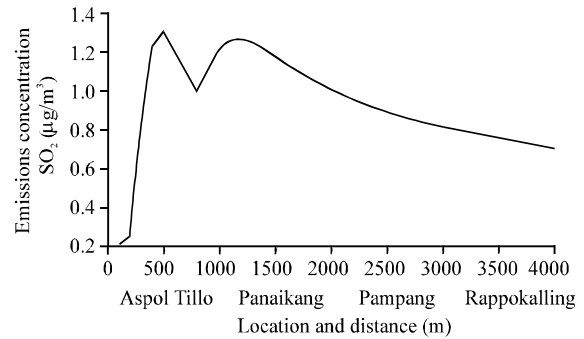


Fig. 3: Total SO₂ T₂ emission power concentration based on distance from 2012-2016

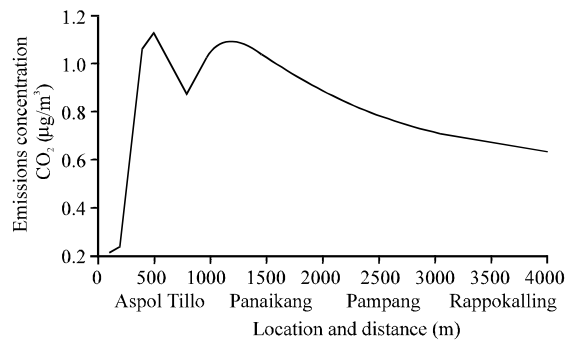


Fig. 4: Total emissions concentration of CO PLTD Tello by distance year 2012-2016

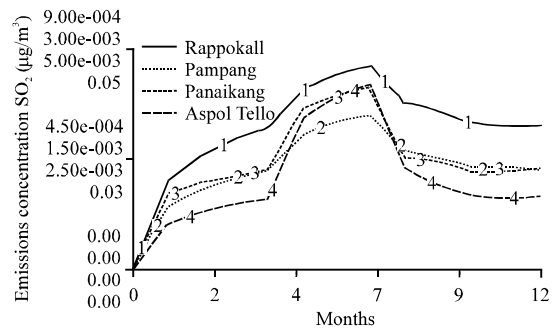


Fig. 5: Estimated SO₂ emission concentration 12 months coming (2018) in four locations

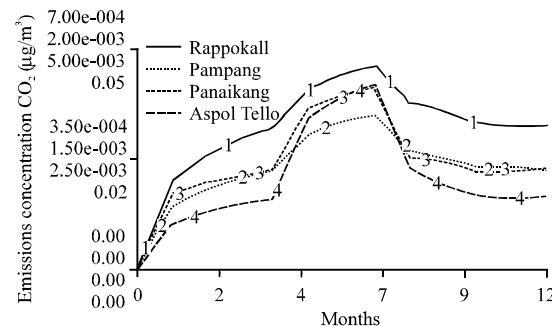


Fig. 6: Estimated CO 12 months emission concentration month coming (2018) in four locations



Fig. 7: Dominant areas affected by pollution SO₂ and CO



Fig. 8: Estimated distribution and concentration of SO₂ and CO emissions in 4 sites

Northwest (NW) of pollutant. Here is a picture of the impact area and the estimated depth of SO₂ and CO concentration of the Tello PLTD at each location.

From the data processing, it can be seen that the SO₂ and CO emission concentration generated by the Tello steam power plant during 2012-2016 is still far below the ambient air quality standard (South Sulawesi Governor Decree Number 69 year 2010) in each location at altitude 1 m above ground level, i.e., Aspero Tello 0-1.39 µg/m³, Panaikang 0-1.247 µg/m³, Pampang 0-0.878 µg/m³ and Rappokalling 0-0.6363 µg/m³. So, it can be said that the four areas are still included in the air quality is quite healthy (Fig. 7 and 8).

The SO₂ and CO emission concentrations obtained from the calculations are influenced by the average emission load, wind speed and dominant wind direction and atmospheric stability over the past 5 years. The average wind speed during the last 5 years is 4 knots with the dominant wind direction to the Northwest (NW) then atmospheric stability ranges between unstable and slightly stable (A-C) conditions. Wind speeds that blow at a height of 10 m above ground level will affect the condition of atmospheric stability in the air. When wind speeds above 2 m/sec then the condition of atmospheric stability in the air will experience instability. Conversely

when the wind speed below 2 m/sec then the condition of atmospheric stability in the air will experience stability.

The calculation result using Sreen View 3.5.0 Software obtained total SO₂ and CO emission concentration produced by Tello PLTD during 2012-2016 at height 1 m above ground level at each point location, i.e., Aspect Tello SO₂ 1.395 µg/m³ and CO 1.162 µg/m³, SO₂ 1.247 µg/m³ and CO 1.039 µg/m³, Pampang SO₂ 0.878 µg/m³ and CO 0.7317 µg/m³ and Rappokalling SO₂ 0.6363 µg/m³ and CO 0.5303 µg/m³.

The estimated concentration of Sulfur Dioxide (SO₂) and Carbon monoxide (CO) gas emissions based on 12 months dynamic model simulation (2018) is increasing every time until July 2018 at each of four location points at 1 m above the surface soil with a distance of 500 m of Aspol Tello SO₂ 0.26065 µg/m³ and CO 0.21530 µg/m³, 1.500 m distance of Panaikang SO₂ 0.04447 µg/m³ and CO 0.03134 µg/m³, distance 2500 m of Pampang SO₂ 0.01760 µg/m³ and CO 0.00938 µg/m³ and a distance of 4.000 m of Rappokalling SO₂ 0.00740 µg/m³ and CO 0.00611 µg/m³ from the source of the bursts of the Tello steam power plant with the rate of increase in the emission concentration of Asp2 SO₂ 0.0053 and CO 0.0044 times, SO₂ 04061 times and CO 0.0004 times, Pampang SO₂ 0.00021 times and CO 0.000073 times and Rappokalling SO₂ 0.000078 times and CO 0.000064 times every month.

Therefore, the higher the wind speed will make the condition of atmospheric stability in the air to be stable which causes SO₂ emissions and CO will be carried further away from the pollutant source of the Tello PLTD and the concentration of SO₂ emissions and CO will be spread to the air, thus, causing the SO₂ and CO emission concentration that is in the air will be lower. Conversely, when wind speed is lower it will make the condition of atmospheric stability in the air become unstable causing SO₂ and CO emissions will accumulate in the area around pollutant source that is Tello PLTD, causing SO₂ and CO emission concentration will be higher the area around Tello PLTD with distance 500-4,000 m at a height of 1 m above ground level.

Wind velocity affects the SO₂ and CO emission concentrations generated by the Tello PLTD. The greater the wind speed in the pollutant source area then the SO₂ and CO emission concentration in the Tello diesel field will be slightly reduced, if wind speed is smaller then SO₂ and CO concentration will remain in the region. Another influence of wind speed, namely turbulence. Stronger winds cause frequent turbulence, so with turbulence, polluted air is mixed more quickly with air around the Tello power station and can resolve pollutants SO₂ and CO.

Unstable atmospheric conditions will disperse more pollutants in a vertical direction, so that, SO₂ and CO pollutants at maximum concentration will fall closer to the source of the Tello diesel bursts. So, the more stable the atmosphere will cause the decrease of SO₂ and CO emission concentration generated by Tello PLTD chimney as further SO₂ and CO pollutants fall at a certain distance with maximum emission concentration will be dispersed due to wind impulse. The temperature difference around the chimney with the temperature inside the Tello diesel plant will cause a different air pressure difference and the difference in air pressure will affect the SO₂ and CO emission speeds incurred by the Tello PLTD chimney.

SO₂ gas is a harmful contaminant for children, the elderly and people suffering from chronic respiratory illness and cardiovascular disease. Respiratory muscle can experience spasm when irritated by SO₂ and spasm will be more severe when SO₂ concentration is higher while air temperature is low. If the exposure time with SO₂ gas is long enough, there will be great inflammation of the mucous membrane followed by cilia paralysis (cilia becomes stiff/paralyzed), resulting in respiratory inflammation, shortness of breath and narrowing of the airway, damage to the epithelium layer, facilitate air pollution in and out of the respiratory tract both biological and chemical.

According to Fardiaz (1992) the relatively slow decomposition of COHb causes the inhibition of the molecular work of pigment cells in its function of carrying oxygen throughout the body. Conditions like this can be fatal because it can cause poisoning. Carbon monoxide (CO) gas poisoning can be characterized by mild conditions such as dizziness, headache and nausea. This condition can happen, so that, it can have an impact on the decreasing of public health condition that live around TTT PLTD region especially in the dominant area affected by the eruption of Aspol Tello, Panaikang, Pampang and Rappokalling. Moreover, the location in the Southwest (NW) PLTD Tello is on Jalan Urip Sumiharjo 7 km Makassa is a dense area of traffic which can increase the concentration of SO₂ emissions that are inhaled by the communities surrounding the area (Russeng *et al.*, 2018; Pulubuhu *et al.*, 2018).

To reduce the concentration of SO₂ and CO emissions generated by the Tello PLTD can be done by installing a filter tool on the chimney that is scrubber. This tool serves to dissolve or absorb the gas pollutant into the liquid. The liquid granules still present in the post-washing gas stream should then be separated from the clean gas by another device called mist eliminator or entrainment separator. This tool can obtain high exhaust efficiency for particulate or gaseous pollutants, even in certain instances can obtain high exhaust efficiency for both pollutants (SO₂ and CO) in the same system (Khairumizan, 2008).

CONCLUSION

From the data processing, it can be seen that the SO₂ and CO emission concentration generated by Tello PLTD during 2012-2016 is still far below the ambient air quality standard (South Sulawesi Governor's Decree Number 69 Year 2010) in each location at 1 m altitude above ground level of Aspol Tello 0-1.39 µg/m³, Panaikang 0-1.247 µg/m³, Pampang 0-0.878 µg/m³ and Rappokalling 0-0.6363 µg/m³. So, it can be concluded that the four areas are still included in the air quality is quite healthy. The estimated concentration of Sulfur dioxide (SO₂) and Carbon monoxide (CO) gas emissions based on 12 months dynamic model simulation (2018) is increasing every time until July 2018 at each of four location points at 1 m above the surface soil with a distance of 500 m of Aspol Tello SO₂ 0.26065 µg/m³ and CO 0.21530 µg/m³, 1,500 m distance of Panaikang SO₂ 0.04447 µg/m³ and CO 0.03134 µg/m³, distance 2500 m of Pampang SO₂ 0.01760 µg/m³ and CO 0.00938 µg/m³ and a distance of 4,000 m of Rappokalling SO₂ 0.00740 µg/m³ and CO 0.00611 µg/m³ from the source of the bursts of the Tello steam power plant with the rate of increase in the emission concentration of Asp2 SO₂ 0.0053 and CO 0.0044 times, SO₂ 0.04061 times and CO 0.0004 times, Pampang SO₂ 0.00021 times and CO 0.000073 times and Rappokalling SO₂ 0.000078 times and CO 0.0000064 times every month.

RECOMMENDATIONS

For local government and management of PLTD Tello it is necessary to review the condition of the feasibility of the location of the Tello power station located in the middle of the settlement. This should be done because emissions bursts that are released by PTLTD Tello each time can degrade the health of the people living around the Tello power plant from time to time.

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