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

[1]Anwar Mallongi, Darwin Safiu, [2]Hasnawati Amqam, [3]Aminuddin Syam, Muhammad Hatta
[5]Tatik Sutarti, [6]Muhith Abdul, [7]Sandu Siyoto and Apollo
[1]Department of Environmental Health,
[2]Department of Environmental Health, Faculty of Public Health,
[3]Public Health Nutrition,
[4]Department of Marine Science, Faculty of Fisheries and Marine,
University of Hasanuddin, Makassar, Indonesia
[5]STIKIP PGRI Pacitan, Pacitan, Indonesia
[6]Department of Nursing, STIKES Majapahit Mojokerto, Mojokerto, Indonesia
[7]Surya Mitra Husada Medical College of Kediri, East Java, Indonesia
[8]Politeknik Negeri, Ujung Pandang, Makassar, Indonesia

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 modelling 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 is SO2 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/m^3 a distance of 1,500 m of $S0_2$, SO2 1.247 and CO 1.039 μg/m^3 2,500 m distance of Pampang 0.878 μg/m^3 and CO 0.7317 μg/m^3 and a distance of 4,000 m of Rappokalling 0.6363 μg/m^3 and CO 0.5303 μg/m^3 from the pollutant source of the chimney PLTD Tello. The estimated concentration of Sulfur Dioxide ($S0_2$) 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/m^3 and CO 0.21530 ug/m^3, 1500 m distance of Panaikang SO_2 0.04447 μg/m^3 and CO 0.03134 μg/m^3, distance 2500 m of Pampang SO_2 0.01760 μg/m^3 and CO 0.00938 μg/m^3 and a distance of 4,000 m of Rappokalling SO_2 0.00740 μg/m^3 and CO_2 0.00611 μg/m^3 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 04061times 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. 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 1m above ground level, i.e., Aspol Tello 0-1.39 ug/m^3, Panaikang 0-1.247 μg/m^3, Pampang 0-0.878 μg/m^3 and Rappokalling 0-0.6363 μg/m^3. 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, SO_2, and CO pollution, TTL Aspol, quality

Corresponding Author: Anwar Mallongi, Department of Environmental Health, Faculty of Public Health, University of Hasanuddin, Makassar, Indonesia

INTRODUCTION

SO_2 is a clear, colourless 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 (SO_2) 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 (SOz) 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 polluter 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 SO_2, 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 (SO_2 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 modelling, also known as air pollution dispersion modelling, a mathematical simulation that illustrates how pollutants are dispersed in ambient air. This simulation or mathematical modelling concocted mathematical equations in a unified concept that describes phenomena or natural behaviour. Mathematical modelling allows testing of various variable combustion parameters using relatively short time and low cost (Gehrsitz, 2017).

After modelling the spread of SO_2 and CO gas pollutants, the ambient air quality (SO_2 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 modelling 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 modelling 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 PL TD 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 PL TD 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 (2x12,500 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 (2x2.8 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 1unit Gas as Power Plant (PLTG) Weast can with installed power of 14.466 MW. In March of 2007, PLTD Kendari Unit and Bau-Bau Vehicle Unit separated from PLN Sector Tello and became its own sector, namely Kendari Sector. The change was re-made in November 2010, Selayar PLTD Unit which was originally a Unit of PLN Sector Bakaru joined Unit from PLN Sector Tello. In May 2012 PLTU Barru Unit which was originally PLN Unit Sector Bakaru joined PLN Unit Tello Sector. Year 2013, based on Directors Decree No.570.KIDIR/2012 dated 30 November 2012, Tello Sector turned into Tello Generating Sector.

Design and variable research: This research is prognostic research (prognostic research), that is research which try to predict an air pollution event influenced by several factors that exist. This research method includes quantitative descriptive approach by designing a modelling form of CO_2 pollutant distribution SO_2 and CO using Gauss smoke assumption and dynamic system model approach ie., data collection to design a model that aims to describe and predict future air pollution events around Tello diesel in Makassar City. The first stage in designing the model that is making wind flowers during the city of Makassar. The second stage in designing the model is to make the model flow diagram as follows (Fig.1 and 2).

Population and sample: Population to be studied is the data of emission parameters generated by Tellos steam power plant influenced by atmospheric stability, wind direction and speed so as to obtain concentration of pollutant by using Gaussian calculation. SO_2 concentration of exhaust concentrate and CO PLTD Tello contained in monitoring report on RKL&RPL implementation 2012-2017.

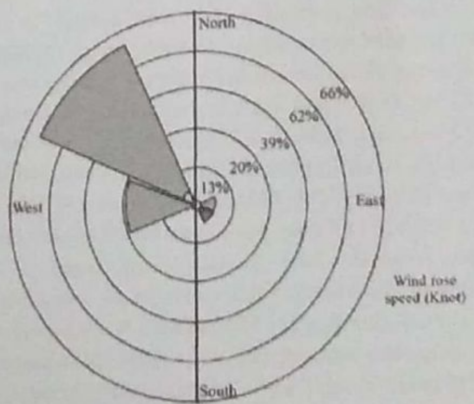

Fig. 1. Win rose in Makassar City year 2012-2016; Wind direction and speed

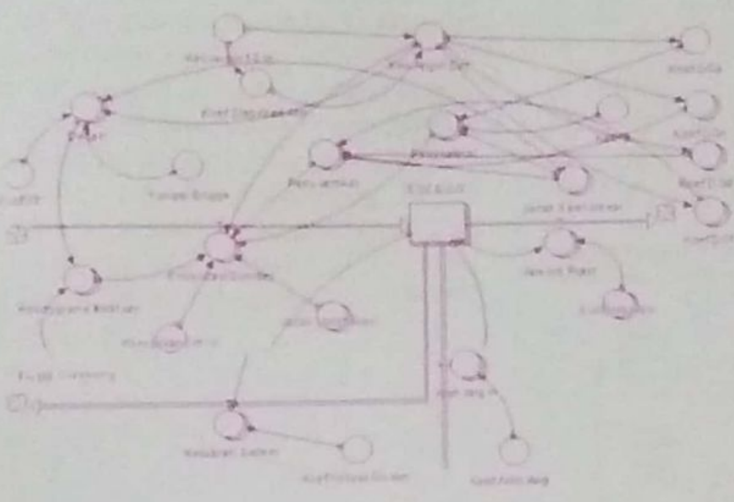

Fig. 2: Flow chart of SO2 and CO2 emission estimation model

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 TTY powerhouses are Aspol Tello, Panaikang, Pampang and Rappokalling. Total SO_2 and CO emission concentrations derived from Tello PL TD 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/m, CO 1.162 ug/m", a distance of 1,500 m of SO2 SO_2 1.247 µg/m^3 and CO 1.039 ug/m^3, 2.500 m distance of Pampang SO_2 0.878 µg/m^3 and CO 0.7317 µg/m3 and a distance of 4,000 m, ie., Rappokalling SO_2 0.6363 µg/m and CO 0.5303 µg/m3 from source contaminant of Tello PLTD chimney (Fig. 3 and 4).

The estimated concentration of Sulfur Dioxide (SO_2) 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 SO_2 0.26065 µg/m^3 and CO 0.21530 µg/m^3, 1.500 m distance of Panaikang SO_2 0.04447 µg/m^3 and CO 0.03134 µg/m^3, distance 2500 m of Pampang SO2 0.01760 µg/m^3 and CO 0.00938 µg/m3 and a distance of 4,000 m of Rappokalling SO_2 0.00740 µg/m^3 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 SO_2 0.0053 and CO 0.0044 times, Panaikang SO2 0.00061 times and CO 0.0004 times, Pampang SO_2 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 Northwest (NW) of pollutant. Here is a picture of the impact area and the estimated depth of SO_2 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).

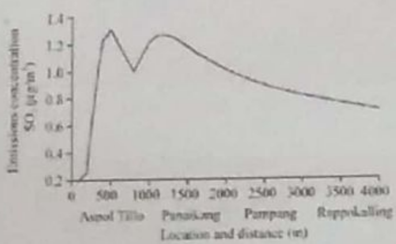

Fig.3. Total SO2 T2 Emission power concentration based on distance from 2012-2016

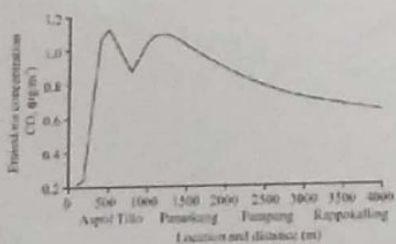

Fig.4. Total Emission concentration of CO PLTD Tello by distance year 2012-2016

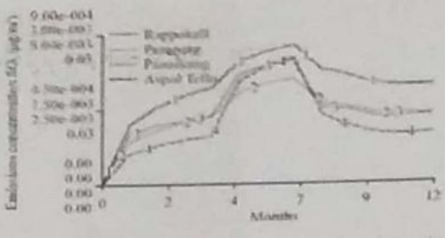

Fig.5. Estimated SO_2 emission concentration 12 months coming (2018) in four locations

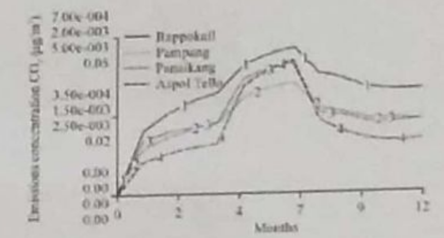

Fig.6. Estimated CO_2 12 months emission concentration coming (2018) in four locations

Fig. 7: Dominant areas affected by pollution SO_2 and CO

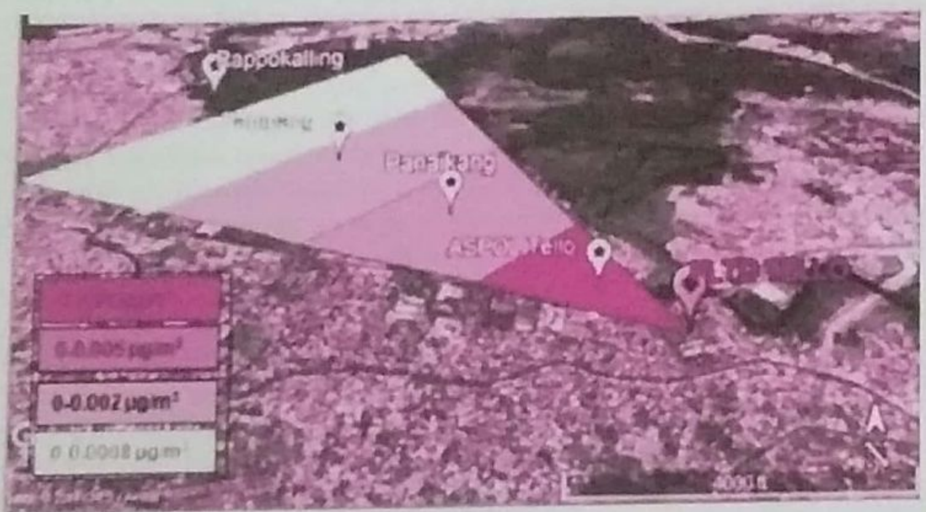

Fig. 8: Estimated distribution and concentration of SO_2 and CO emissions in 4 sites

The SO_2 and CO emission concentration obtained from the calculations are influenced by the average emission load, wind speed and dominant wind direction and atmospheric stability over 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 SO_2 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 SO_2 1.395 μg/m and CO 1.162 μg/m3, SO_2 1.247 μg/m³ and CO 1.039 μg/m³. Pampang SO_2 0.878 μg/m³ and CO 0.7317 μg/m³ and Rappokalling S0 0.6363 μg/m3 and CO 0.5303 μg/m³.

The estimated concentration of Sulfur Dioxide (SO_2) 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 SO_2 0.26065 μg/m^3 and CO 0.21530 μg/m^3 1.500 m distance of Panaikang SO_2 0.04447 μg/m^3 and CO 0.03134 ug/m', distance 2500 m of Pampang SO2 0.01760 μg/m and CO 0.00938 μg/m and a distance of 4.000m ofRappokalling SO2 0.00740 μg/m and CO 0.00611 μg/m^3 from the source of the bursts of the Tello steam power plant with the rate of increase in the emission concentration of Asp2 SO_2 0.0053 and CO 0.0044 times, SO_2 04061 times and CO 0.0004 times, Pampang SO_2 0.00021 times and CO 0.000073 times and Rappokalling SO_2 0.000078 times and CO 0.0000064 times every month.

Therefore, the higher the wind speed will make the condition of atmospheric stability in the air to be stable which causes SO_2 emissions and CO will be carried further away from the pollutant source of the Tello PLTD and the concentration of SO_2 emissions and CO will be spread to the air, thus, causing the SO_2 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 SO_2 and CO emissions will accumulate in the area around pollutant source that is Tello PLTD, causing SO_2 and CO emission concentration will be higher the area around Tello PLTD with distance 500-4,000 mat a height of 1 m above ground level.

Wind velocity affects the SO_2 and CO emission concentrations generated by the Tello PL TD. The greater the wind speed in the pollutant source area then the SO_2 and CO emission concentration in the Tello diesel field will be slightly reduced, if wind speed is smaller, then SO_2 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 pollutant SO_2 and CO.

Unstable atmospheric conditions will disperse more pollutants in a vertical direction, so that, SO_2 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 SO_2 and CO emission concentration generated by Tello PLTD chimney as further SO_2 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 SO_2 and CO emission speeds incurred by the Tello PLTD chimney.

SO_2 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 SO_2 and spasm will be more severe when SO_2 concentration is higher while air temperature is low. If the exposure time with S0 gas is long enough there will be great inflammation of the mucous membrane followed by cilia paralysis (cilia becomes stiff/paralyzed), resulting m 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 PL TD 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 Makassar is a dense area of traffic which can increase the concentration of SO_2 emissions that are inhaled by the communities surrounding the area (Russeng et al., 2018; Pulubuhu et al., 2018).

To reduce the concentration of SO_2 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 (SO_2 and CO) in the same system (Khairumizan, 2008).

CONCLUSION

From the data processing, it can be seen that the SO_2 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/m^3, Panaikang 0-1.247 μg/m^3 Pampang 0-0.878 μg/m^3 and Rappokalling 0-0.6363 μg/m^3. 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 (SO_2) 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 SO_2 0.26065 μg/m^3 and CO 0.21530 μg/m^3, 1,500 m distance of Panaikang SO2 0.04447 μg/m^3 and CO 0.03134 μg/m3 distance 2500 m of Pampang SO_2 0.01760 μg/m^3 and CO 0.00938 μg/m^3 and a distance of 4,000 m of Rappokalling SO_2 0. 00740 μg/m^3 and CO 0. 00611 μg/m^3 from the source of the bursts of the Tello steam power plant with the rate of increase in the emission concentration of Asp2 SO_2 0.0053 and CO 0.0044 times, SO_2 04061 times and CO 0.0004 times, Pampang SO2 0.00021 times and CO 0.000073 times and Rappokalling SO_2 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 PTLD Tello each time can degrade the health of the people living around the Tello power plant from time to time.

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