Estimated Ambient Air Pollution Development of the Takalar Industrial Area Using a Box Model

Nur Aulia[1], Agus Bintara[2], Eymal Demmalino[3]
[1,2,3]Universitas Hasanuddin, Indonesia
nuraulia.salihi@gmail.com

Abstract

Air pollution is the presence of chemicals or other pollutants into the atmosphere that can cause changes to the air composition, so that it deviates normal conditions. Based on data from the Takalar Regency Health Office, ARI (Upper respiratory infection) entered into the category that many people suffered. This study aims to determine air quality by predicting pollutant concentrations based on the types of activities that will be built in industrial estates and the influence of environmental conditions on polluting concentrations. The model box is used to assume the average concentration of pollutants in an area that is devised as a box where the emissions source is spread evenly on the bottom surface of the box. The estimation results showed that from each pollutant there was an increase in concentration from the absence of development projects and with predicted development using the calculation of the box model. The highest concentration increase occurs in TSP pollutants of 5.55%, then NO2 1.03%, SO2 0.19% and the smallest, namely CO of 0.01%. Environmental conditions are very influential on pollutant concentration. Concentration of pollutants is inversely inversely with temperature. When high wind speeds and stable temperatures, the spread of faster pollutants and pollutant concentration does not accumulate around the source of emissions somewhere. The greater the wind speed blows then the polluting concentration will get smaller because it is dispersed in all directions.

I. Introduction

Air pollution in Indonesia is the main determinant of environmental quality. Air is one of the environmental factors that has a serious impact on human health and quality of life (Silitonga & Wispriyono, 2020). Air pollution can occur naturally, such as forest fire smoke, due to volcanoes, meteorite dust and salt beam from the sea, but can also be caused by human or anthropogenic activities, such as the result of transportation, industry, waste disposal, both due to the process of decomposition or combustion and household activities. Chemical air pollutants in air that are often found in large cities can be particulated (PM), carbon monoxide (CO), sulfur oxide (SOX) and Nitrogen Oxide (NOx) (Prabowo, 2018).

The Ministry of Industry in 2019 accelerated the development of industrial estates in Takalar Regency, South Sulawesi. Plans for the Development of Takalar Industrial Areas, which are in the village of Laikang and Desa Punaga, Mangarabombang District. Takalar Regency is considered potential to become a metal industry area with a number of aspects that are fulfilled. For example strategic areas with mileage from Makassar port about 25

kilometers. In addition, Takalar has a geographical area with coastal and waterfront areas that can be used into special port development land. Takalar also has abundant water availability.

Every activity certainly has an impact that needs to be considered. Industrialization has changed many of the quality of the environment because of the rapid use of raw materials and the increasing number of waste disposed of returning to the environment and causing pollution both air, water and soil (Soemirat, 2011). Research Results of the Southeast Asia Greenpeace and the Center for Research on Energy and Clean Air (Crea) in 2020 shows, the impact of air pollution from burning fossil fuels such as coal, oil and gas is associated with early death throughout the world as many as 4.5 million people per year. The impact of this air pollution, causes early death, with various diseases such as lung cancer, heart attack, lung function decreases, premature birth and others. If the substance has entered the environment, control is needed by reducing the level of polluting concentration.

The model box is used to assect the average concentration of pollutants in an area, which is devised as a box where the emissions source is spread evenly on the bottom surface of the box. Furthermore, pollutants are brought and distributed from the source area by lateral motion according to the wind direction. This model considers a region and city as a box. In the box an activity that produces emissions gas (Hassan and Crowther, 1998).

Development is a systematic and continuous effort made to realize something that is aspired. Development is a change towards improvement. Changes towards improvement require the mobilization of all human resources and reason to realize what is aspired. In addition, development is also very dependent on the availability of natural resource wealth. The availability of natural resources is one of the keys to economic growth in an area. (Shah, M. et al. 2020)

Development of industrial estates if not followed by good environmental management can have a negative impact on health, especially in the air inhaled every day by humans. Therefore, to prevent the prevention of research by predicting the concentration of pollution substances with the development project using a box model based on the types of activities to be built and the influence of environmental conditions on polluting concentrations.

II. Review of Literature

Air pollutants in the form of particulate material have a floating properties in the air, but eventually settle so that it is measured in the total size of the sulpended particulate (TSP) resulting from various sources, namely coal burning, power plants, metal industries, biomass burning, and road transportation Raya and many are associated with various types of health effects (Kelly & Fussell, 2015). Air pollutants in the form of gas mainly come from motorized vehicles including carbon monoxide (CO) which is the result of non-perfect combustion of carbon-containing fuel (Dewanti, 2018).

Combustion at high temperatures in the vehicle engine will produce 98% gas no gas which is then in the air will be oxidized into NO2 and if the number of vehicles increasingly increases the concentration of no2 in the area close to the highway (Dwirahmawati et al., 2018). Apart from motorized vehicles. The main source of SO2 gas producers comes from burning coal, one of which is an incinerator which is a burning furnace to process solid waste, then convert solid material (garbage) into gas and ash material (bottom ash and fly ash) and produce so2 (Anugrah, 2017).

Astuti and Kusuma (2017) conducted research by analyzing air pollution with box models in the city of Tangerang and obtained the results of the calculation of emissions load shows that for all pollutant parameters, namely NO2, SO2, H2S, NH3, HC, CO, TSP, O3, PB , PM10 and PM2.5 mostly come from industrial and transportation activities. In the industrial

sector, CO2 emissions come from fuel use, while CH4 emissions come from processing industrial waste. Based on the results of monitoring ambient air quality and calculation of emissions expenses, it can be said that the industrial and transportation sector is the main source of air pollution in the city of Tangerang. Research is also carried out by Huboyo and Samadikun (2018), concerning simple model box applications for the estimated concentration of black carbon pollutants in the atmosphere and found the results of the study that the average calculation of the Estimation of the Black Carbon using the Box model is not much different or relatively equal to the average test results Black Carbon obtained from measuring samples in the field. Yowono (2012) conducted a research on the estimated production and dispersion of gas pollutants from aluminum waste recycling activities and the results of the analysis showed that at the production level of 700 ton/year waste of crust waste by 177 kg / day, SO2 gas emissions emissions of 2857 µg/s, NO2 gas emissions are 10,551 µg/s, and gas CO emissions are 2777 µg/s.

III. Research Method

This research is an observational study. The study was conducted in March - June 2021. The research was conducted in Punaga Village, Mangarabombang District, Takalar Regency, South Sulawesi. The location of air sampling conducted in Panaga Village was based on SNI 19-7119.6-2005 where pollutant measurements presented residential areas and time around the development project

Emission speed (Q) region is directly proportional to the production target per year. In this study the plan for managing non-metal waste was 750,000 tons / year for two types of activities. Based on Yowono's reference (2012) conducted research in an aluminum waste recycling industry at 700 tons / year processing levels. So that the emission speed can be calculated using the comparison formula:

$$Q \text{ region} = \frac{\text{Production every year by regional } \times Q \text{ reference}}{\text{Production every year by reference}} \quad (1)$$

Information:
Q region = regional pollutant emission speed
Regional production = 2 x 750000 tons / year
Q reference = reference pattern emission speed
Reference production = 700 tons / year

Prediction of concentration (c) regions with projects are calculated using a box model with formulas based on Rau & Wooten research (1980) where an area assumed as a box:
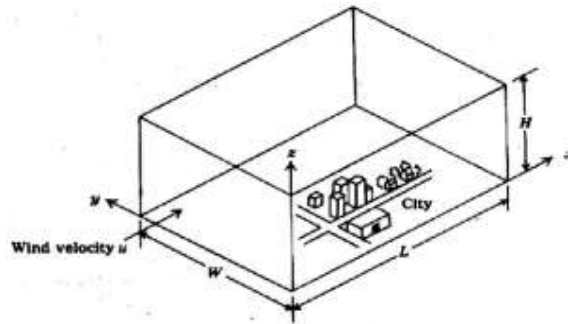
Figure 1. *Model Box (Vyankantesh, 2014)*

$$C = \frac{Q \text{ region}}{u\ w\ h} + C_{\text{initial}} \qquad (2)$$

Information:

C   = concentration pollutant with the project (mg/m^3)
Q_{Region} = Emission Speed (µg/s or mg/s)
u   = wind speed (m/s)
W   = area width (M)
H   = high region (M)
C_{Initial} = concentration pollutant without project (µg/nm^3 or mg/m^3)

IV. Result and Discussion

4.1. Result Result

The construction site is 350 ha with the type of activity, namely the recycling industry of copper processing and aluminum processing recycling industry with a capacity of 750,000 tons per year. Measurement of air samples is carried out in the laboratory using the method in accordance with Indonesian national standards. Pollututant sampling is carried out in the area around the Takalar Industrial Development Project that represents the direction of the wind which can be in the following table.

Table 1. Environmental conditions in ambient air

Parameters	Result
Temperature (ºC)	32.9
Moisture (%)	76.1
Air pressure (mmHg)	252.4
Wind speed (m/s)	1.2

The results of the calculation of each pollutant there is an increase in concentration from before the project and after development is predicted to use the calculation of the BOX model. Based on the formula in equation (1) and (2) and environmental conditions in Table 1, get the concentration of pollutants as follows:

Table 2. Concentration of pollutants

Parameters ($\mu g/Nm^3$)	Without Project	With Project
SO_2	45,27	45,356
CO	580	580,083
NO_2	30,86	31,177
TSP	40,0	42,219

Exposure to each concentration in the ambient air is divided into two calculations, namely without the current project or condition and with predictive activities. The results of calculations from each pollutant there is an increase in concentration from the absence of development projects and with predicted development using the calculation of the box model.
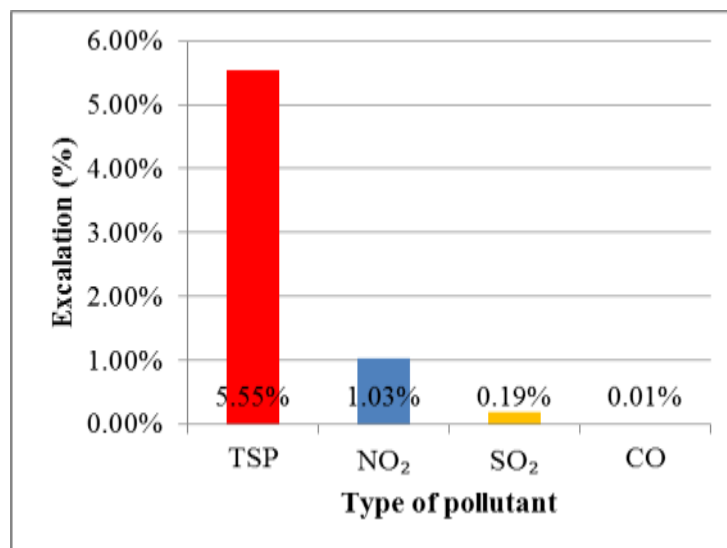

Figure 2. Graph of Increased Pollutants

Based on the graph of increasing pollutants in Figure 2, the highest concentration increase occurs in TSP pollutants of 5.55% and the smallest increase in co concentration of 0.01%. The high percentage of TSP increases is caused by environmental conditions in the form of wind speed and also sampling locations on the coast. In addition to TSP, a fairly high increase in NO_2 compounds.

4.2. Discussion

Measurement of concentration from TSP, CO, SO_2 and NO_2 in Ambien air aims to determine the spread of pollutants in the environment. The concentration of pollutants in the ambient air will enter into the community of people living in the area of research locations through the inhalation path and will have a health impact. Transportation activities and community exiles such as burning of garbage, the use of fuel in households will experience various physical and chemical reactions. The physical and chemical reactions are influenced by meteorological factors such as temperature, moisture, wind speed and air pressure. Wind speeds affect the dispersion direction of pollutants following the wind direction. Some pollutants on their way can be expedited to ground surface, water, buildings, and plants. Some others will be suspended in the air and will change the quality of ambient air. With the existence of a variety of physical and chemical reactions in ambient air, in addition to measuring the concentration of TSP, CO, SO_2, and NO_2 also measuring temperature, humidity, and wind speed. Sampling takes place with a cloudy sunny weather. Environmental

conditions at the research site, high temperatures because they are so close to the coast, so are the moisture. According to Agustin et al., (2019) air pressure is influenced by the temperature, the height of somewhere, and the distribution of the ocean and land.

The results showed that higher TSP emissions of construction activities have an environmental impact. The characterization of particulate material is influenced by meteorological conditions, including temperature, moisture, rainfall and wind speed (Ingrid et.al, 2014). The spread of dust levels in the air is also strongly influenced by moisture and wind gusts (wind speed). Low air moisture will make dust particles settle on the ground. So that the dust particle capture tool only catches a little dust that is there, it is caused by uncertain weather factors and the effect of the direction of the wind that blows because the wind will affect the speed of deployment and mixing air pollutants with the surrounding air in the atmosphere. If the wind speed blows hard will cause the dust to disappear and carry the wind to another place, on the contrary if the wind speed blows slowly will cause dust to settle the surface of the land and in the air will increase (Rafidah, 2018). Transportation is the main source of air pollution produced by almost 70% emissions on earth, 60-65% consists of carbon monoxide (CO) and nitrogen dioxide (NO_2). In addition to TSP, the increase in high concentrations of NO_2 can be caused by combustion at high temperatures in the vehicle engine will produce 98% gas no gas which is then in the air will be oxidized into no2 and if the number of vehicles increases more will increase the concentration of NO_2 in the area close to the area Highway (Dwirahmawati et al., 2018)

Based on Government Regulation of the Republic of Indonesia Number 41 of 1999 concerning the Quality Standard of the National Ambient Air Quality About Ambient Air Quality Standards for TSP Parameters 230 $\mu g/nm^3$ for 24-hour exposure time. Then based on the South Sulawesi Governor Regulation Number 69 of 2010 concerning the Quality Standards and the criteria for the environmental damage to the maximum limit allowed for CO parameters was 30,000 $\mu g/nm^3$ for one-hour exposure time, for SO_2 parameters was 900 $\mu g/nm^3$ one hour of exposure time, then parameters NO_2 is 400 $\mu g/nm^3$ for one hour exposure time. Based on both regulations, the concentration of TSP, CO, SO_2 and NO_2 around the Development Region of the Takalar Industrial area do not exceed the maximum allowed.

The concentration of pollutants in ambient air cannot be separated from the existence and type of pollutant source located at the research site. To predict the concentration of pollutants at the research location, the box model is used as a calculation of pollutant concentration by entering the comparison of the emission rate from the reference then adjusted to the activities to be built and current environmental conditions.

V. Conclusion

1. The results of calculations from each pollutant there is an increase in concentration from the absence of development projects and with predicted development using the calculation of the box model. The highest increase occurred at TSP concentration of 5.55% and the smallest increase in CO concentration of 0.01%.
2. Environmental conditions are very influential on pollutant concentration. The best concentration of pollutants is proportional to temperature. When high wind speeds and stable temperatures, the spread of faster pollutants and pollutant concentration does not accumulate around the source of emissions somewhere. Wind speed is inversely proportional to the pollutant concentration produced. The greater the wind speed blows then the polluting concentration will get smaller because it is dispersed in all directions.

References

Agustin, R., Farid, M., & Nirwana, N. (2019). Implementasi olah data tekanan udara ekstrim dari BMKG untuk meningkatkan hasil belajar siswa pada pokok bahasan tekanan Di SMP Negeri 4 kota Bengkulu. PENDIPA Journal of Science Education, 3(3), 160–166. https://doi.org/10.33369/pendipa.3.3.160-1

Anugrah, N. (2017). Analisa Dispersi Sulfur Dioksida (SO2) Dari Sumber Point Source Insinerator Rumah Sakit St. Antonius Menggunakan Model Meti-Lis. In Jurnal Teknologi Lingkungan Lahan Basah 5(1). https://doi.org/10.26418/jtllb.v5i1.18401

Astuti W., dan Kusumawardani Y,. (2017). Analisis Pencemaran Udara Dengan Box Model (Daya Tampung Beban Pencemar Udara) Studi Kasus Di Kota Tangerang. Jurnal Neo Teknika. 3(1), 21–28.

Dewanti, I. R. (2018). Identification of CO Exposure, Habits, COHb Blood and Worker's Health Complaints on Basement Waterplace Apartment, Surabaya. In Jurnal Kesehatan Lingkungan 10(1). https://doi.org/10.20473/jkl.v10i1.2018.59-69

Dwirahmawati, F., Nasrullah, N., & Sulistyantara, B. (2018). Analisis Perubahan Konsentrasi Nitrogen Dioksida (NO2) Pada Area Bervegetasi Dan Tidak Bervegetasi Di Jalan Simpang Susun. In Jurnal Lanskap Indonesia 10(1). https://doi.org/10.29244/jli.2018.10.1.13-18

Greenpeace Indonesia. (2015). Kita, Batubara & Polusi Udara. April, 1–16.

Hassan, A., & Crowther, J.M., (1998). A Simple Model Of Pollutant Concentrations In A Street Canyon. Annals of Operations Research, 97(1–4), 131–141. https://doi.org/10.1023/A

Huboyo, H. S., & Samadikun, B. P. (2018). Aplikasi Box Model Sederhana Untuk Estimasi Konsentrasi Polutan Black Carbon Di Atmosfer. Jurnal Presipitasi Media Komunikasi Dan Pengembangan Teknik Lingkungan, 15(2), 148. https://doi.org/10.14710/presipitasi.v15i2.148-151

Ingrid P. S. A., D. B. (2014). Identification and Characterization of Particulate Matter. Journal of Sustainability, ISSN: 7666-7688.

Kelly, F. J., & Fussell, J. C. (2015). Air pollution and public health: emerging hazards and improved understanding of risk. In Environmental Geochemistry and Health 37(4). Springer Netherlands. https://doi.org/10.1007/s10653-015-9720-1

Kementerian Perindustrian. (2019). Kemenperin Akselerasi Pembangunan Kawasan Industri Takalar. Diakses pada 20 September 2020, dari https://kemenperin.go.id/artikel/

Prabowo, K; Burhan, M;. (2018). Penyehatan Udara. Jakarta: Kementerian Kesehatan RI.

Rafidah dan Rahayu. (2016). Studi Kadar Debu di Terminal Malengkeri Kota Makassar. Jurnal Media Kesehatan, 9(2): 79-83.

Shah, M. et al. (2020). The Development Impact of PT. Medco E & P Malaka on Economic Aspects in East Aceh Regency. Budapest International Research and Critics Institute-Journal (BIRCI-Journal). P. 276-286.

Silitonga, A; Wispriyono, B;. (2020). Analisis Risiko Kesehatan Pajanan Inhalasi Debu Particulate Matter 2.5 pada Siswa Sekolah Menengah. Jurnal Nasional Kesehatan Lingkungan Global, 1(1): 10-16.

Soemirat, J. (2011). Kesehatan Lingkungan. Yogyakarta: Gadjah Mada University Press.

Yowono, A. S.(2012). Estimasi Produksi dan Dispersi Gas Polutan dari Kegiatan Daur Ulang Limbah Aluminium. Jurnal Waste Management. 223-228.