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by Suryanto_ Andi

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Analysis of Air Pollution Level In Settlement Area Using Passive Sampler Method

Normalia Djamal*
Department of Chemical Engineering, Universitas Muslim Indonesia, INDONESIA

Andi Suryanto
Department of Chemical Engineering, Universitas Muslim Indonesia, INDONESIA

Andi Artiningsih
Department of Chemical Engineering, Universitas Muslim Indonesia, INDONESIA

Nizar Nasrullah
Department of Landscape Architecture, IPB University, INDONESIA

Rosyi Damayanti T Manningtyas
[1]Department of Environmental Science and Landscape Architecture, Chiba University, JAPAN
[2]Department of Landscape Architecture, IPB University, INDONESIA

Yessy Velina
Graduate School of Human and Environmental Studies, Kyoto University, JAPAN

***Correspondence: E-mail:** syamiq77@gmail.com

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Abstract

Air pollution, especially in big cities in Indonesia, has reached a very worrying level. The main sources of air pollution come from various human activities, including industry, transportation, offices, and housing. These various activities are the biggest contribution of air pollutants that are released into the free air. In this study, observations and measurements of air pollution levels were carried out in the Final Disposal Site (FDS). The absence of good waste management in Sinjai Regency has triggered the community to manage waste by means of Open Dumping, where waste is simply dumped in a landfill without any treatment. Pollutant gas originating from the landfill will produce harmful gases, including Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2) and others. This study aims to determine the concentrations of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) in Final Disposal Site (FDS) Tondong and in residential areas around Tondong FDS, Sinjai Regency by using the passive sampler method. The test results obtained are the NO_2 value at point 1 which is 3.69 g/m^3, point 2 is 5.25 g/m^3, point 3 is 3.1 g/m^3 and point 4 is 7.1 g/m^3 with an average value The average NO_2 parameter test is 4.785 g/m^3. While the SO_2 value at point 1 is 4.46 g/m3, point 2 is 7.34 g/m^3, point 3 is 8.47 g/m^3 and point 4 is 5.93 g/m^3. The average value of the SO_2 parameter test is 6.55 g/m^3. Calculating the Air Quality Index based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 27 of 2021 concerning the Environmental Quality Index, air pollution at the Tondong Landfill is worth 93.14 indicating the very good category.

Keywords: passive sampler; nitrogen dioxide (NO_2); sulfur dioxide (SO_2); air quality index (AQI); environmental quality index

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INTRODUCTION

Currently, air pollution occurs in various countries in the world **(Figure 1)** (Barber et al., 2005), one of which is Indonesia (Artiningsih, N. K. A. 2008). High levels of air pollution generally occur in big cities in Indonesia and have reached a very worrying level (Allan et al., 2021). The main sources of air pollution come from various human activities, including industry, transportation, offices, and housing (McLeod et al., 2022). These various activities are the biggest contribution of air pollutants

that are released into the free air. Sources of air pollution can also be caused by community activities in Final Disposal Site (FDS) (Kementrian Pekerjaan Umum dan Perumahan Rakyat Direktorat Jenderal Cipta Karya Direktorat Sanitasi., 2018). The absence of good waste management in Sinjai Regency, Indonesia has triggered the community to manage waste by means of Open Dumping, where waste is simply dumped in a landfill without any treatment.

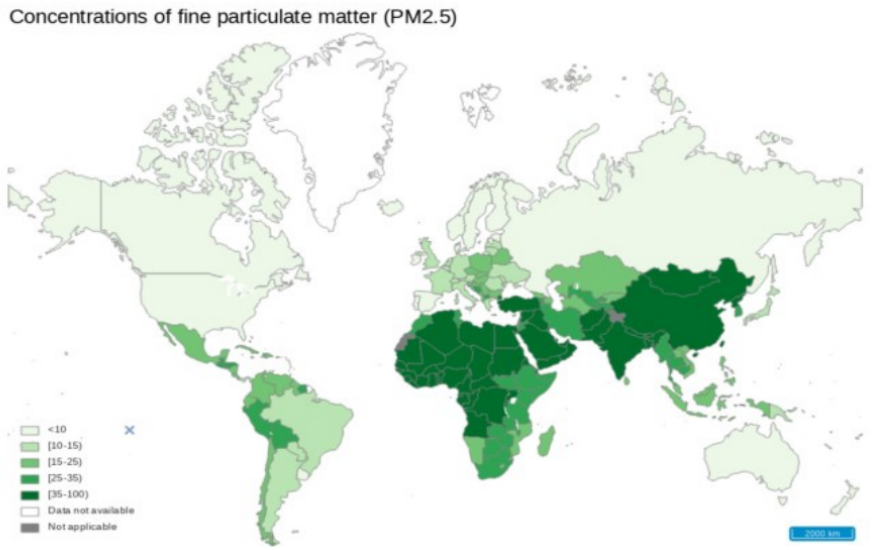

Figure 1. Air pollutants show the highest levels in different countries

Generally, the final waste processing carried out at the Final Disposal Site (FDS) is mostly carried out by open dumping, which results in environmental problems such as air pollution due to gas, odor and dust (Stern, A. C., 1977). The absence of ground cover will cause air pollution to be undamaged. Gas production resulting from the degradation of waste material which will cause unpleasant odors and flying dust. Pollutant gas originating from the landfill will produce harmful gases, including Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2) and others (Kholisyah, Z., 2019). These gases can interfere with the respiratory tract, cause hormonal disturbances, and even cause cancer (Adly et al., 2017).

Air quality monitoring data in Indonesia carried out by the Directorate of Air Pollution Control with the passive sampler method. The passive sampler method has been used since 2008 and has been integrated since 2015 (Pertiwi, J., 2015). In Indonesia, the number of monitoring points continues to increase every year using the passive sampler method. In 2020, monitoring has been carried out at 2,000 monitoring locations spread over 500 districts/cities. Some of the advantages of monitoring with the passive sampler method which is quite effective with exposure for 14 days, namely it does not require electrical energy, is cheap and easy to place because it is small in size (Allan et al., 2021).

Another study conducted the Clean Production Technology and Air Pollution Prevention group, at the Directorate of Environmental Technology with the title Application of Passive Sampler Method for Ambient Air NO_2 Analysis (Yanagisawa, Y. & Nishimura, H., 1982) in Several Locations in Jakarta and Surrounding Areas, concluded that the method Passive sampler is quite simple and easy to implement so that it is possible to monitor air quality from cities to all corners. To support this method, only simple laboratory equipment is needed, such as a spectrophotometer (Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia., 2021). While the use of Impenger for hemorrhoidal air sampling, because it is only installed for 1 hour, the exposure is very short so that

the accuracy of the data is very less and requires relatively more expensive testing costs when compared to the Passive Sampler method (McLeod et al., 2022).

This study aims to determine the ambient air quality in residential areas around the Final Disposal Site (FDS) and to determine the level of ambient air pollution and to determine the distribution of pollutant gases, especially the concentrations of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) by using the passive sampler method around the Tondong FDS, Sinjai Regency, South Sulawesi, Indonesia.

METHOD

The research method used is a descriptive research method with a qualitative approach of ambient air conditions in Tondong FDS and residential areas around Tondong FDS and analysis of ambient air pollution levels of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2). The tools used in this study are as follows: a. Sample Holders; b. shelter; c. 2.5 m Sampler Pole; d. Passive Sampler Container; e. Gloves; f. Face mask; g. Helmet. The location of the research was carried out in the Tondong FDS and residential areas around the Tondong FDS, Sinjai Regency, South Sulawesi, Indonesia (Badan Pusat Statistik Kabupaten Sinjai., 2020; Badan Pusat Statistik Kabupaten Sinjai., 2021) **(Figure 2)**.

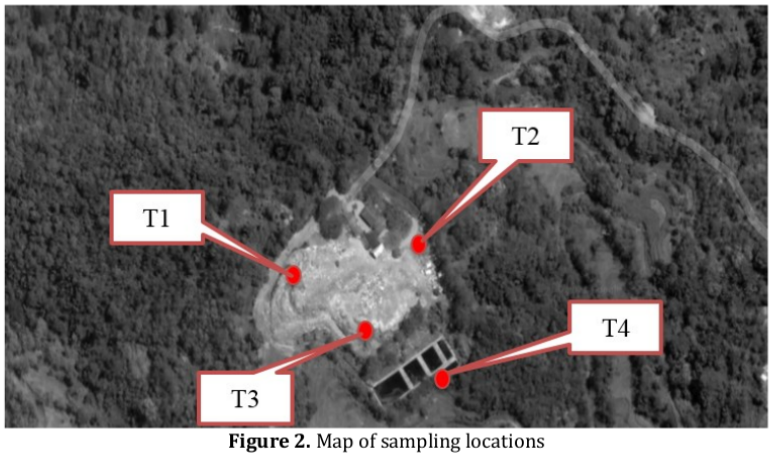

Figure 2. Map of sampling locations

Research Time

The research time begins with the submission of the research title which is set in July 2021, the initial survey, bibliography search, proposal preparation, consultation with supervisors, research implementation, data collection and data management (Al-Fedaghi, S. & Al-Azmi, A., 2012) until the preparation of the final report is planned for January 2022, so that This research plan lasted for 6 months.

Research variable and sources of data

There are two variables in this study, the first is a fixed variable, namely the examination of levels of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) using the passive sampler method. While the second, the independent variables are the factors that affect the air quality of the Tondong FDS area and residential areas around the Tondong FDS and residential areas around the Tondong FDS, Sinjai Regency, South Sulawesi, Indonesia. Sources of data needed in the study can be seen in **Table 1**.

Table 1. Sources of research data

No	Data Type	Method	Data Source
1	Quantitative data which is the result of examination of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) using the passive sampler method	Determination of sampling locations for ambient air quality monitoring tests with SNI 19-7119.6-2005	Primary data
2	Qualitative data	Observation	Primary data
3	Qualitative data	Literature studies such as maps, regional profiles, population, Tondong landfill location, journals, books etc	Secondary Data

(**Source**: Primary data and secondary data in this study)

Research Analysis

The results of testing the NO_2 and SO_2 parameters using the passive sampler method and based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 27 of 2021 concerning the Environmental Quality Index in calculating the EU (I_{EU}) model air index are converted to the Air Quality Index (AQI) through the equation as follows:

$$IKU = 100 - [50/0{,}9 \times (I_{eu} - 0{,}1)] \quad (1)$$

Information:
- AQI is the Air Quality Index
- Ieu is the average of the monitored SO_2 concentration divided by the EU Ref $_{EU}$ SO_2 ambient air quality standard and the monitored NO_2 divided by the EU Ref NO_2 ambient air quality standard.
- The EU Ref ambient air quality standard for SO_2 is 20 g/m^3 and for NO_2 is 40 g/m^3.

Research Stages

The research was carried out in 3 stages including preparation, implementation of research and analysis and discussion **(Figure 3)**. The preparation stage to conduct this research is to conduct a literature study as will be used as consideration and as the basic literature to carry out the next stage of research, which includes books, articles and journals related to this research. The implementation of research stage, the implementation of research which includes data collection and data processing. The analysis and discussion stage is compiling a report which includes data analysis and discussion as well as compiling conclusions and suggestions for further research.

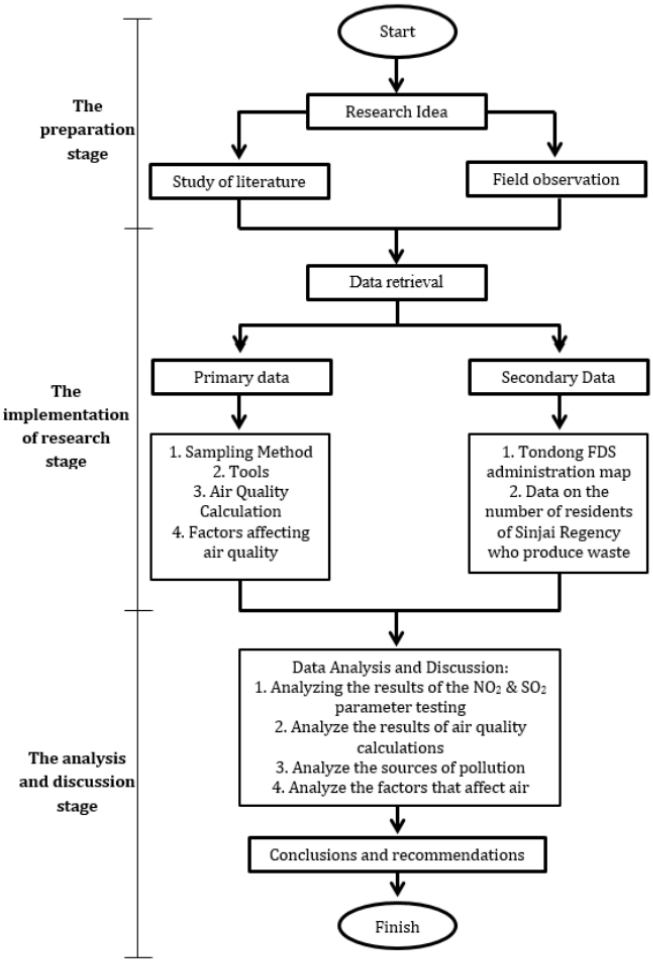

Figure 3. Research flow chart

RESULTS AND DISCUSSION

In the areas around the Tondong FDS, Sinjai Regency, South Sulawesi, Indonesia, waste comes from the rest of human activities (Wahid. & Nurul, C. 2009). In the regional policy and strategy, management of household waste and similar household waste (Fardiaz, S. 2010). Waste generated per individual is 0.4 kg/day, so that until 2020 with a population of 259,480 people. The total waste generation in Sinjai Regency in 2020 (0.4 kg/day x 259,480 people) is 103,792 kg/day.

The implementation of sampling in this study was carried out using the passive sampler method. This method is based on the principle of molecular diffusion. The gas molecules will diffuse into the sampler and collect in the filter. The filter has previously been given a specific absorbent solution for each gas. In addition, the determination of the sampling location also used the SNI 19-7119.6-2005 method. The results of the NO_2 and SO_2 parameter testing can be seen in **Table 2**.

Table 2. Test Results of parameters for NO_2 and SO_2

No	Side Location	Test Parameters	Result	Unit	Measurement Method	Information
1	Point 1	NO_2	3,69	µg/m³	18-SPEKTRO-33/MU/SSM-AAS(Spectrophotometer - *Passive sampler*)	Sampling time 22/08/2021 at 03.05 WITA to 05/09/2021 at 04.36 WITA, 2 days sunny weather, 12 rainy days
		SO_2	4,46	µg/m³	18-HPLC-12/MU/SMM-AAS(HPLC-IC-*Passive sampler*)	
2	Point 2	NO_2	5,25	µg/m³	18-SPEKTRO-33/MU/SSM-AAS(Spectrophotometer - *Passive sampler*)	Sampling Time 22/08/2021 at 03.43 WITA to 05/09/2021 at 05.04 WITA, Sunny Weather 2 Days, Rain 12 Days
		SO_2	7,34	µg/m³	18-HPLC-12/MU/SMM-AAS(HPLC-IC-*Passive sampler*)	
3	Point 3	NO_2	3,10	µg/m³	18-SPEKTRO-33/MU/SSM-AAS(Spectrophotometer - *Passive sampler*)	Sampling Time 22/08/2021 at 03.58 WITA to 05/09/2021 at 04.56 WITA, Sunny Weather 2 Days, Rain 12 Days
		SO_2	8,47	µg/m³	18-HPLC-12/MU/SMM-AAS(HPLC-IC-*Passive sampler*)	
4	Point 4	NO_2	7,10	µg/m³	18-SPEKTRO-33/MU/SSM-AAS(Spectrophotometer - *Passive sampler*)	Sampling time 22/08/2021 at 04.05 WITA to 05/09/2021 at 04.48 WITA, 2 days sunny weather, 12 rainy days
		SO_2	5,93	µg/m³	18-HPLC-12/MU/SMM-AAS(HPLC-IC-*Passive sampler*)	
5	Sample Blank	NO_2	< 0,41	µg/m³	18-SPEKTRO-33/MU/SSM-AAS(Spectrophotometer - *Passive sampler*)	-
		SO_2	< 2,57	µg/m³	18-HPLC-12/MU/SMM-AAS(HPLC-IC-*Passive sampler*)	

(**Source :** Data of this study)

In this study, the level of measurement of NO_2 and SO_2 parameters can be seen in the diagram **(Figure 4)**. In Diagram, it can be seen that the test results at point 3 of the SO_2 parameter reached the highest value of 8.47 g/m³. Meanwhile, the test results at point 3 of the NO_2 parameter reached the lowest value of 3.1 g/m³. The value of the NO_2 blank is < 0.41 g/m³ and the value of the SO_2 blank is < 2.57 g/m³.

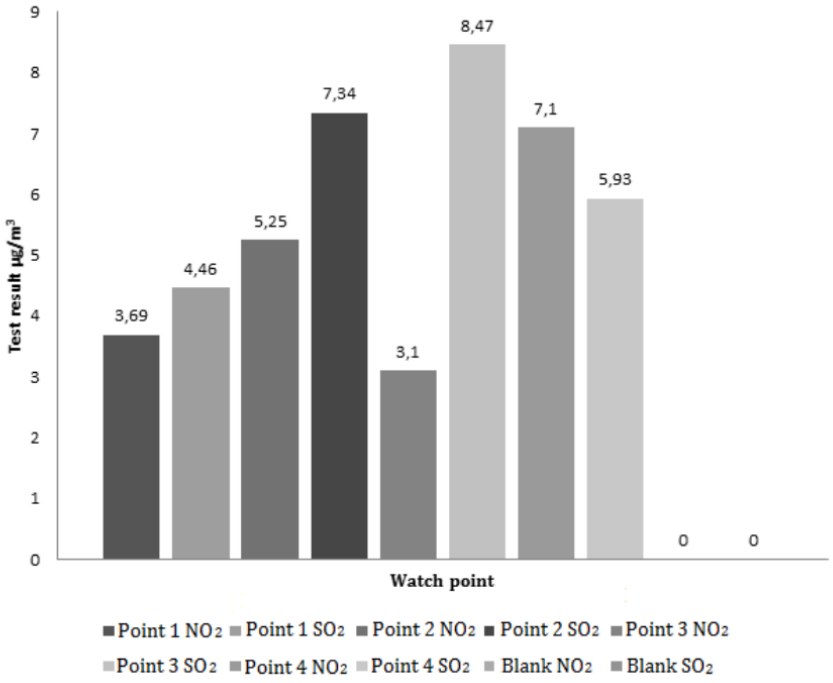

Figure 4. Parameter Test Results NO_2 and SO_2

In addition, the value of NO_2 at point 1 is 3.69 g/m³, point 2 is 5.25 g/m³, point 3 is 3.1 g/m³ and point 4 is 7.1 g/m³. From the results of the NO_2 test, the average value of the test was 4.785 g/m³. While the SO_2 value at point 1 is 4.46 g/m³, point 2 is 7.34 g/m³, point 3 is 8.47 g/m³ and point 4 is 5.93 g/m³. From the results of the SO_2 test, the average value of the test is 6.55 g/m³.

The results of measurements of NO_2 and SO_2 levels in 4 locations located in the Tondong FDS, Sinjai Regency, South Sulawesi, Indonesia can be seen in **Table 1**. The measurement results show that the average level of NO_2 is 4.785 g/m³ and the average level of SO_2 is 6.55 g/m³. The SO_2 level was higher than the NO_2 level in Tondong FDS, but the results of the Tondong FDS the Air Quality Index (AQI) calculation were still in the "very good" category (Gilbert et al., 1996; Guth et al., 2019) with a value of 93.14. The study was conducted in the rainy season for 14 days with sunny weather conditions for 2 days and rain for 12 days. Sampling was carried out on August 22, 2021 until sampling on September 5, 2021. During the exposure of the sample, measurements of air humidity and air temperature were carried out for more details in **Table 3**.

Table 3. Measurement of humidity and air temperature in Tondong FDS

No	Date and time	Indonesia WITA time	Humidity %	Temperature °C
1	Sunday / August, 22 2021	15.00	51	29
		18.00	67	27
2	Monday/ August, 23 2021	06.00	79	29
		12.00	46	31
		18.00	61	28

3	Tuesday / August, 24 2021	06.00	79	24
		12.00	53	31
		18.00	67	23
4	Wednesday / August, 25 2021	06.00	78	27
		12.00	79	28
		18.00	65	29
5	Thursday / August, 26 2021	06.00	75	25
		12.00	78	25
		18.00	73	25
6	Friday / August, 27 2021	06.00	73	24
		12.00	75	25
		18.00	79	24
7	Saturday / August, 28 2021	06.00	74	24
		12.00	79	26
		18.00	76	24
8	Sunday / August, 29 2021	06.00	78	25
		12.00	47	31
		18.00	79	26
9	Monday/ August, 30 2021	06.00	75	25
		12.00	48	31
		18.00	57	30
10	Tuesday / August, 31 2021	06.00	79	25
		12.00	51	31
		18.00	68	26
11	Wednesday / September, 1 2021	06.00	78	24
		12.00	51	31
		18.00	68	26
12	Thursday / September, 2 2021	06.00	79	24
		12.00	41	33
		18.00	68	31
13	Friday / September, 3 2021	06.00	75	23
		12.00	42	30
		18.00	65	27
14	Saturday / September, 4 2021	06.00	79	24
		12.00	50	30
		18.00	61	26

15	Sunday / September, 5 2021	06.00	79	20
		12.00	66	22
		18.00	62	23
Average			**68**	**27**

(**Source :** Data of this study)

Based on Table 3 above, the average air humidity at the time of sample exposure is 68% with an average temperature of 27 ^{o}C. This is because the study was conducted in the rainy season so that the distribution of concentrations of NO_2 and SO_2 levels was less. In the dry season, hot weather and sunlight can cause concentrations of pollutant levels of NO_2 and SO_2 to react photochemically which releases O_3 gas and the speed of spread of NO_2 and SO_2 is higher than the rainy season.

Based on another study conducted by Jasmina Pertiwi entitled "Comparative Study of Ambient Air Quality Based on Parameter Measurements of SO_2, NO_2 and Pb in Total Suspended Particulates (TSP) in a number of DKI Jakarta areas during the rainy and dry seasons". The results show that the concentration of SO_2 levels during the rainy season is lower than in the dry season, as well as the concentration of NO_2 levels during the rainy season is lower than in the dry season (Standart Nasional Indonesia., 2005; Standart Nasional Indonesia., 2002).

Another study was also conducted by Jaward et al., (2004) with the title "Study of Sulfur Dioxide (SO_2) Ambient Air Quality at Tamangapa FDS, Makassar City, Indonesia". The method used by the researcher is a purposive sampling method with an examination of sulfur dioxide levels at the Tamangapa landfill using the OdaLog 7000 series tool and divided into 6 measurement points with a distance of ± 100 m. The results obtained when examining Sulfur dioxide (SO_2) gas the value obtained at point I is 0 ppm, point II is 0.1 ppm, point III is 0.1 ppm, point IV is 0.1 ppm, point V is 0.1 ppm, and point V is 0.1 ppm. VI of 0.2 ppm. By measuring the average concentration of Sulfur dioxide (SO_2) in Tamangapa FDS is 0.1 ppm (260 g / Nm^3), temperature is 34ºC, humidity is 28%, and wind speed is 5.8 m/s. The conclusion is that the ambient air quality of Sulfur dioxide (SO_2) at the Tamangapa FDS is categorized as meeting the requirements according to the Government Regulation of the Republic of Indonesia Number 41 of 1999 concerning Air Pollution Control.

Tondong FDS with facilities using the sanitary landfill method, but its implementation is still using the controlled landfill method. Although the sanitary landfill is the best choice, the local government of Sinjai Regency has not been able to implement the system. Garbage in the FDS has not been properly and properly managed (Sujarwo, T. & Widyaningsih., 2014) so that it will have the potential to cause a decrease in air quality which in turn increases the risk of respiratory disease (Kuat, P. & Muslim, B. 2018; Mathur, A., 2012; Mukono, H. J., 2008). FDS is a place where waste reaches its final stage. FDS waste can be a source of environmental pollutants and can be a source of disease if it is not managed properly and correctly. The results showed that the air quality was still very good, this was because the area around the Tondong FDS was still in a beautiful condition surrounded by trees **(Figure 5)**.

Figure 5. The condition of the Tondong FDS

CONCLUSION

In this study, it was concluded that the concentration of Nitrogen Dioxide (NO_2) in the residential area around the Tondong FDS, Sinjai Regency by using the passive sampler method at 4 sampling locations, namely at point 1 which is 3.69 g/m^3, point 2 is 5, 25 g/m^3, point 3 is 3.1 g/m^3 and point 4 is 7.1 g/m^3 with an average test value of 4.785 g/m^3. While the concentration of Sulfur Dioxide (SO_2) in the residential area around the Tondong FDS, Sinjai Regency using the passive sampler method at 4 sampling locations, namely at point 1 which is 4.46 g/m^3, point 2 is 7.34 g/m^3, point 3 is 8.47 g/m^3 and point 4 is 5.93 g/m^3 with an average test value of 6.55 g/m^3. For the category of ambient air pollution levels in the area around the Tondong FDS, Sinjai Regency with an Air Quality Index (AQI) value of 93.04 indicating the "very good" category. To support the reduction of air pollution at the Tondong FDS, it is recommended that waste management in the FDS be carried out using the Sanitary Landfill method and preserving the trees around the FDS area. In addition, it is recommended to conduct research by adding parameters, especially for testing methane gas and other gases that have the potential for air pollution in Tondong FDS.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

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