Analysis the Air Quality in the Area of Terminal Regional Daya in the City of Makassar

Jepi Paerunan, Sumarni Hamid Aly, A.Arwin Amiruddin

Abstract: ***The terminal is a transportation road for the purposes of ride-relegated passengers, the displacement intra or inters wheels transportation as well as maintains of arrivals and departures a public transport. Terminal as a public infrastructure must be free from the air pollution. Terminal Regional Daya Makassar, located at PerintisKemerdekaan KM.15 of road, city of Makassar is considered in this study for measure the quality of the air by taken 10 locations in the area of Terminal Daya. The measured parameters are Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO_2). The measurement is conducted for ten days for one day one location. The obtained results indicate the air quality of some location still far below the standard quality ambient air in government regulation No.40 years of 1999, Indonesia. The pollution mapping result from ArcGIS application shows that SO_2 and NO_2 parameters in the dominant green colour (Good) and CO is blue, yellow and red colour (unhealthy).***

Keywords: Air quality, Pollution mapping, Public transport, Terminal, Transportation

I. INTRODUCTION

Along with the high level of mobilization and the need for transportation facilities that are easy, cheap and safe, the demand for public land transportation usage is increasing. This increase the number of vehicles activities dynamic around the terminal area [1, 2]. The transportation is the major contribution to air pollution [3]. Since, a lot of pollutant air is released from the motor vehicle exhaust such as carbon monoxide (CO) and Nitrogen Dioxide (NO_2) gas that is harmful to humans and ecosystem [4, 5].

The bus terminal serve as a stopover for newly arrived and departing buses has the potential of high concentration pollution compared to residential areas. Aside from being a place for various vehicles and buses, others service also available in the terminal such as traders, food and beverage stalls, kiosks, and services such as tire repairman and so on. They are in the terminal for 8 to 24 hours, and are most likely exposed to the pollutants. Besides that, the local residents have high tendency exposure to the pollutant. [6].

Regional Daya Terminal is one of the terminals located in Makassar City, JalanPerintisKemerdekaan KM.15 with an area of ± 12 Ha serving 34 routes (routes), with details of 19 City-In-Provincial Transport Routes (AKDP), 12 Inter-City Inter-route Province (AKAP) and 3 ANGKOT (City Transport) routes. With a large area of land and increasing users of land transportation services that result in the use of motorized vehicles and other activities that contribute to air pollution, the area of the Terminal Regional Daya is chosen as the research location. Based on the above background, this study will discuss the relationship of air pollution that occurs in the terminal area in Makassar. This study analyse the air pollutant concentration, the ambient air quality and the pattern of distribution of ambient air pollutants in the Terminal Regional Daya area, Makassar city at specific location and time.

II. RESEARCH METHODOLOGY

The initial observations and field survey is conducted in the area around the Terminal Regional Daya Makassar city as a reference for selecting research locations. After the preliminary observations, the approach on research locations, experiment material and equipment as well as the research time are identified and prepared. The selection of research locations and tools placement is according to the outcome of the field survey. The considered location is at Terminal Regional Daya that the terminal route head to the north of the city which consists of several provincial capital, district and 2 municipalities which is never deserted from the hustle and bustle of vehicle activity connecting to the Makassar city. The Determination of Test Sampling Locations (Samples) Monitoring Ambient Air Quality is referring to SNI No. 19-7119.6-2005 [7].The measurement research locations are the entrance place, field, AKAP and AKDP parking lot, car workshop and washing, bus departures, front waiting room, front door retribution, public parking, city transport lines and private vehicles, and exits place. Table 1 shows the measurement information.

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Jepi Paerunan, Environment Engineering of Hasanuddin University, Jl. PorosMalino, Borongloe, Bontomarannu, Campus FT-UH, Gowa 92119,Sulawesi Selatan, Indonesia,

Sumarni Hamid Aly, Environment Engineering of Hasanuddin University, Jl. PorosMalino, Borongloe, Bontomarannu, Campus FT-UH, Gowa 92119,Sulawesi Selatan, Indonesia

A.Arwin Amiruddin, Environment Engineering of Hasanuddin University, Jl. PorosMalino, Borongloe, Bontomarannu, Campus FT-UH, Gowa 92119,Sulawesi Selatan, Indonesia

Table. 1 The measurement is conducted for 10 days with the following details

Measurement point	Location	Date	Time
Point 1	Terminal entrance	October 22, 2016	08:00 – 20:00
Point 2	Field	October 23, 2016	08:00 – 20:00
Point 3	AKAP and AKDP parking lot	October 29, 2016	08:00 – 20:00
Point 4	Workshop and car wash	October 30, 2016	08:00 – 20:00
Point 5	Bus departures	November 1, 2016	08:00 – 20:00
Point 6	Front waiting room	November 2, 2016	08:00 – 20:00
Point 7	Front door retribution	November 3, 2016	08:00 – 20:00
Point 8	Public parking	November 4, 2016	08:00 – 20:00
Point 9	Private vehicle and city transportation	November 5, 2016	08:00 – 20:00
Point 10	Terminal exits	November 6, 2016	08:00 – 20:00

Research Materials and Tools

The tools and materials used in air quality research are data recording device to record data from sensor readings, laptops equipped with DEMS programs, Wikimapia application, Cell phone (Stopwatch) to find out the measurement time, camera for documentation during the time of the study and the Mobile Laboratory of Air Quality which consists of 7 component sensors namely Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2) and Carbon Monoxide (CO)

Data Collection and Analysis Methods

The measurement of air quality levels is carried out for 12 hours at each measurement point. The measurement process is conducted by placing the air pollution mobile devices at the point of measurement by considering the wind direction factor, and then the device is set to collect data every minute for 15 minutes. The measurement process is every hour for 12hours in between 29 September - 6 November 2016. The digital monitoring system obtains the data from the air pollution mobile device in order to produce the graphic of air quality distribution. The obtained data is analysed based on the Standard of Air Quality Index (ISPU), Indonesia and thus mapping the results of ISPU pollutants with ArcGIS.

The pollutant concentration can be directly compared to the air quality standard in the attachment of Government Regulation No.41 of 1999 concerning the Control Air pollution. The next step is to estimate the concentration of pollutants into the standard exposure time with the equation, $C_2 = C_1 (t_1/t_2)^{0.18}$, where C_1, C_2, t_1 and t_2 represent instantaneous concentration (ug/m^3), standard concentration (ug/m^3), instantaneous exposure time (h) and standard exposure time (h). This is intended to calculate the value of the Standard Air Pollution Index (ISPU) because measurements in the field do not correspond to the standard exposure time. The result of ISPU calculation is used to determine the air quality distribution in Teminal Daya, Makassar City.

III. RESULTS AND DISCUSSION

Analysis of Pollutant Concentrations in Standard Time Estimation

1. Sulphur Dioxide Pollutants (SO_2) in the standard time estimates

Table 2 shows the exposure of standard time to SO_2 pollutants shows a decrease in concentration after estimation from 1 hour to 24 hours. SO_2 pollutants in the morning at 08.00-10.00 WITA showed a decrease in SO_2 concentration at each measurement point after estimating to the actual exposure time, which is from 15 minutes to 24 hours with the highest concentration at point 5, 39.31 µg/m³ and the lowest at point 4 that is 23.57 µg/m³. During the day at 11.00-13.00 WITA also experienced a decrease in concentration after estimating from 15 minutes to 24 hours with the highest concentration at point 1, 37.37 µg/m³ and the lowest at point 10, which was 22.97 µg/m³. In the afternoon at 14.00-16.00 WITA also showed a decrease in concentration at each measurement point after estimating from 15 minutes to 24 hours with the highest concentration at point 3, 39.46 µg/m³ and the lowest at point 9, which was 22.51 µg/m³. SO_2 pollutants at night at 5:00 a.m. to 3:00 p.m. also showed a decrease in concentration at each measurement point after estimating from 15 minutes to 24 hours with the highest concentration at point 8 which is 38.47 µg/m³ and the lowest at point 9 which is 18.98 µg/m³.

Table. 2 The calculation of standard exposure time estimates for Concentration SO_2

	Time (1 h)	Concentration SO_2 (ug/m3)									
		Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10
Morning	**15 min**	87.8	70.83	74.31	54.84	91.46	61.4	66.71	81.7	75.21	68.51
	24 hrs	37.74	30.44	31.94	23.57	39.31	26.39	28.67	35.12	32.32	29.45
Afternoon	**15 min**	86.95	75.85	82.46	53.87	86.00	58.74	65.16	76.37	80.26	53.45

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	24 hrs	37.37	32.6	35.44	23.15	36.96	25.25	28.01	32.82	34.50	22.97
Evening	**15 min**	79.87	73.02	91.81	73.44	65.09	65.22	62.14	89.78	52.37	63.99
	24 hrs	34.33	31.38	39.46	31.57	27.98	28.03	26.71	38.59	22.51	27.5
Night	**15 min**	79.29	80.21	88.08	70.47	83.93	52.68	63.12	89.51	44.16	74.97
	24 hrs	34.08	34.47	37.86	30.29	36.07	22.64	27.13	38.47	18.98	32.22

2. Pollutant Nitrogen Dioxide (NO_2) in standard time estimates

Based on equation, to determine the exposure time the standard parameter NO_2 uses an estimated time of 1 hour. From the calculation results in Table 3, it is shown that the exposure of standard time in NO_2 parameters undergoes changes at each point after estimate into the standard exposure time. NO_2 pollutant in the morning at 08.00-10.00 WITA showed a decrease in NO_2 concentration at each measurement point after estimating to the actual exposure time which is from 15 minutes to 1 hour with the highest concentration at point 5, 60.38 µg/m³ and the lowest at point 4 that is 31.64 µg/m³. NO_2 pollutants during the day at 11.00-13.00 WITA after estimating from 15 minutes to 1 hour also decreased the concentration with the highest concentration at point 1, 58.50 µg/m³ and the lowest at point 10, 33.29 µg/m³. NO_2 pollutant in the afternoon at 14.00-16.00 WITA after estimating from 15 minutes to 1 hour also showed a decrease in concentration at each measurement point with the highest concentration at point 3,60.20 µg/m³ and the lowest at point 9, 31.42 µg/m³. NO_2 pollutant at night at 17.00-19.00 WITA after estimated from 15 minutes to 1 hour also showed a decrease in concentration at each measurement point with the highest concentration at point 5, 54.72 µg/m³ and the lowest at point 9, which is 26.22 µg/m³.

Table. 3 The calculation of standard exposure time estimates for Concentration NO_2

	Time (1 h)	**Concentration NO2 (ug/m3)**									
		Point 1	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**	**Point 8**	**Point 9**	**Point 10**
Morning	**15 min**	72.75	56.68	61.76	40.89	78.04	51.25	54.82	62.98	58.68	63.51
	1 h	56.29	43.86	47.79	31.64	60.38	39.66	42.42	48.73	45.41	49.14
Afternoon	**15 min**	75.61	56.97	68.48	47.63	73.16	46.9	49.85	56.25	65.45	43.03
	1 h	58.5	44.08	52.99	36.86	56.61	36.29	38.57	43.53	50.64	33.29
Evening	**15 min**	68.98	58.97	77.8	58.81	58.93	51.7	52.37	69.06	40.6	54.19
	1 h	53.37	45.63	60.2	45.51	45.6	40.01	40.52	53.44	31.42	41.93
Night	**15 min**	65.51	66.62	70.27	57.05	70.72	38.91	52.47	69.42	33.89	64.82
	1 h	50.69	51.55	54.38	44.15	54.72	30.11	40.6	53.71	26.22	50.16

3. Carbon Monoxide (CO) Pollutants in standard time estimates

Based on equation, for the exposure of the standard time parameters CO uses an estimated time of 8 hours. From the results of the calculation in Table 4, the exposure of the standard time in CO pollutant showed a decrease in concentration after estimation from 1 hour to 8 hours. CO pollutants in the morning at 08.00-10.00 WITA showed a decrease in CO concentration at each measurement point after it is estimated to the actual exposure time which is from 15 minutes to 8 hours with the highest concentration at point 5,17.61 µg/m³ and the lowest at point 3, 11.08 µg/m³. CO pollutants during the day at 11.00-13.00 WITA after estimating from 15 minutes to 8 hours also experienced a decrease in concentration with the highest concentration at point 10,19.16µg/m³ and the lowest at point 2, 10.74 µg/m³. CO pollutants in the afternoon at 14.00-16.00 WITA after estimated from 15 minutes to 8 hours also showed a decrease in concentration at each measurement point with the highest concentration at point 10, 19.22 µg/m³ and the lowest at point 2, 11.29 µg/m³. CO pollutants at night at 17.00-19.00 WITA after estimated from 15 minutes to 8 hours also showed a decrease in concentration at each measurement point with the highest concentration at point 3, 18.32 µg/m³ and the lowest at point 2, 5.06 µg/m³.

Table 4. The calculation of standard exposure time estimates for Concentration CO

	Time (1 h)	Concentration CO (ug/m3)									
		Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10
Morning	**15 min**	17.32	17.7	16.28	20.8	25.87	24	24.09	17.89	22.25	24.76
	8 hrs	11.79	12.04	11.08	14.16	17.61	16.34	16.4	12.17	15.15	16.85
Afternoon	**15 min**	18.07	15.78	24.12	19.98	27.26	22.18	23.52	17.68	22.55	28.15
	8 hrs	12.3	10.74	16.41	13.6	18.55	15.1	16.01	12.03	15.35	19.16
Evening	**15 min**	17.14	16.59	25.77	21.06	26.25	23.12	24.09	20.65	19.5	28.24
	8 hrs	11.66	11.29	17.54	14.33	17.87	15.74	16.4	14.06	13.27	19.22
Night	**15 min**	18.63	7.44	26.92	21	26.54	18.75	20.85	18.69	16.99	26.45
	8 hrs	12.68	5.06	18.32	14.29	18.06	12.76	14.19	12.72	11.56	18

Air Pollution Standards Index (ISPU)

Air Pollution Standards Index (ISPU) is a number that does not have a unit that describes the condition of ambient air quality at a particular location and time based on the impact on humans, aesthetic values and other living things [8]. This ISPU value can be used as information material for the public about the quality of ambient air at the location in a certain time. In addition, it also serves as a consideration for the Regional Government in carrying out the management and control of air pollution. For the results of ISPU calculations on the location of the study can be seen in Table 5.

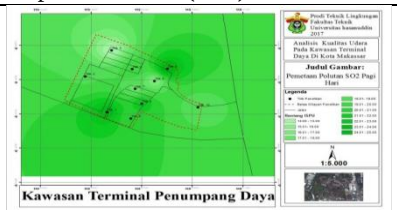
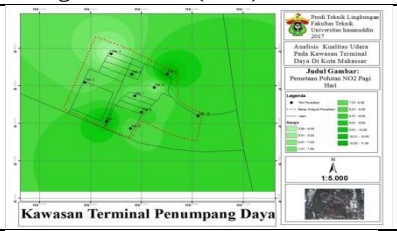
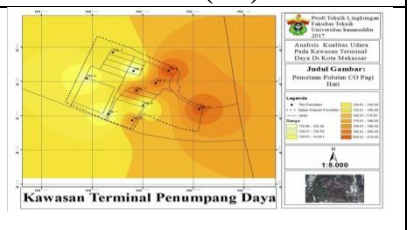
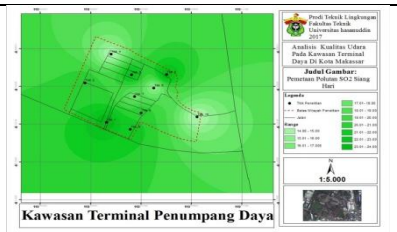
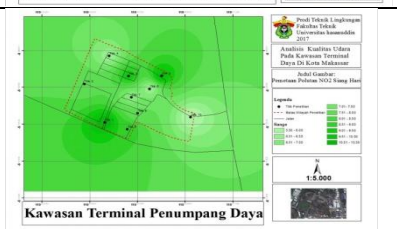
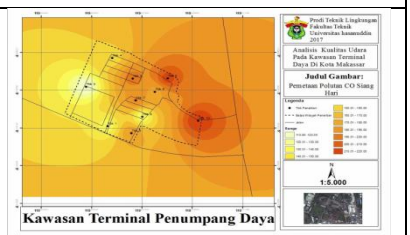
Table. 5 Results of ISPU on the research location Source: 2016 Research Results

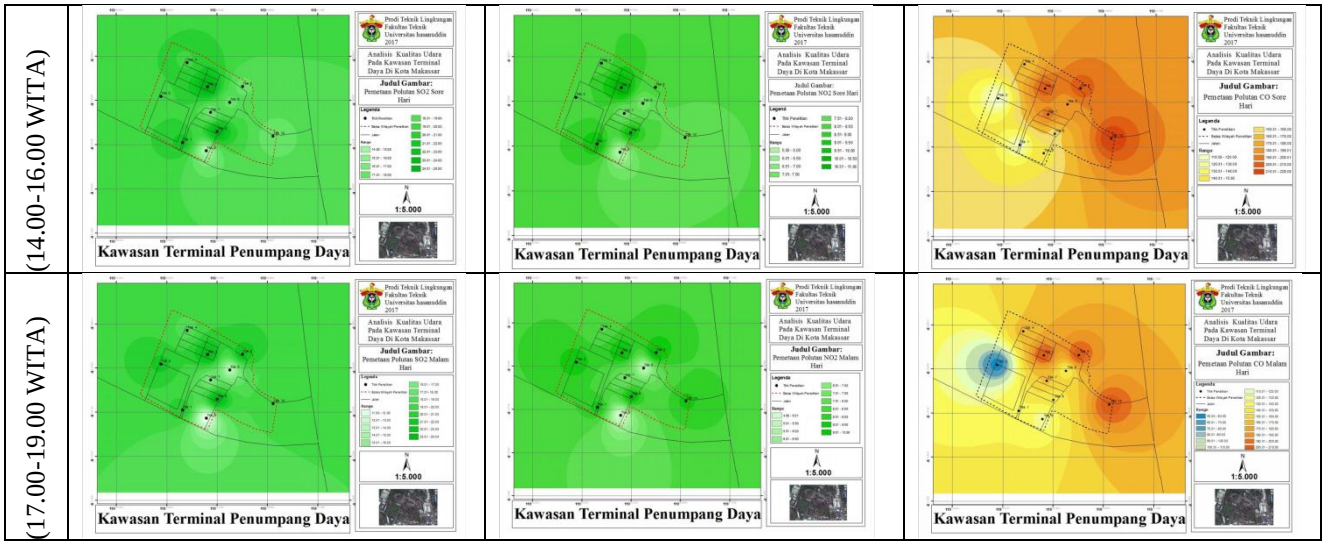
No	Parameter	Results ISPU	Range	Category
1	SO_2	19.44	0-50	Good
2	CO	163.11	100-199	Unhealthy
3	NO_2	8.10	0-50	Good

Mapping Air Ambient Quality in the Terminal DayaArea

Based on the Air Pollution Standard Index values for Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO), it can be used to map air quality at the Terminal Daya based on four time periods per measurement point, as shown in the Picture attachment with five colour levels namely green, blue, yellow, red and black according to the colours in the Air Pollution Standard Index (ISPU).Table 6 illustrates the mapping air ambient quality for Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO) during 4time periods

Table. 6 The Mapping Air Ambient Quality for Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO) during 4time periods

	Sulphur Dioxide (SO_2)	Nitrogen Dioxide (NO_2)	Carbon Monoxide (CO)
(08.00-10.00 WITA)			
(11.00-13.00 WITA)			



Based on the maps in Table 6,sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) pollutant distribution in four different time periods shows different concentrations at each measurement point, but is still in a good category based on the Air Pollution Standards Index, which ranges from 0-50 in green.The maps of Carbon Monoxide (CO) pollutant distribution in Table 6 show the distribution of CO pollutants has varying levels of concentration at each measurement point. Based on the colour gradation, several points that fall into the medium category with the ISPU range from 51-100 that is point 1 at night. In the unhealthy category, the ISPU range between 101-200 occurred at points 1,2,3,4,6,7,8,9, and 10 in the morning; points 1,2,3,4,6,7,8, and 9 during the day; 1,2,4,6,7,8, and 9 in the afternoon and evening. While for the very unhealthy category with ISPU range from 201-299 that is at point 5 in the morning, points 5 and 10 during the day, point 3, 5 and 10 in the afternoon and evening.

IV. CONCLUSIONS

The Air Pollution Standard Index Value (ISPU) for the Makassar Terminal Daya area for Sulphur Dioxide (SO_2), and Nitrogen Dioxide (NO_2) pollutants is good while for Carbon Monoxide (CO) pollutants classified as unhealthy. The map of pollutant distribution in the Terminal Daya indicated that Sulphur dioxide (SO2) and Nitrogen dioxide (NO_2) in four time periods is still in the good category based on the Air Pollution Standards Index, which ranges from 0-50 with colour indominance of green. While, Carbon Monoxide (CO) is in Medium category is coloured by blue with ISPU range from 51-100 during night.

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