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THE SOCIAL COST OF TRAFFIC CONGESTION AIR POLLUTION (A CASE STUDY ON AHMAD YANI STREET, SURABAYA)

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ABSTRACT: At present, Indonesia is facing several problems related with transportation system, especially highway transportation system. The increase of population, followed by the increase of income per capita has caused a significant increase in the growth of motor vehicles in Indonesia, especially that of motorcycles which is very high. Ahmad Yani street is one of Surabaya City's main entry access roads, of which the traffic burden is the highest. This traffic congestion surely causes high air pollution along the street. Therefore, a study on estimating social cost of air pollution caused by the densely motor vehicle traffic in Ahmad Yani street is considered necessary. The objectives of this study are not only (a) to analyse the peak-hour traffic performance, but also (b) to estimate the cost of air pollution caused by the emmision of motor vehicles in Ahmad Yani street. In this reserach, the methodology of Indonesian Highway Capacity Manual is used to analyse the traffic performance. Due to the inavailabity of Indonesian method, a US method is adopted to estimate the quantity of emission and the cost of air pollution. The cost of air pollution is measured based on the journey length and the average vehicle speed. The result of study shows that traffic congestion is very high in the morning peak hours (07.00-09.00) and is almost evenly happens along the Ahmad Yani street; at some points it even reaches the F level of service. Further result shows that the highest air pollution based on the journey length happens in segment III (GIANT Mall) on Thursday (May, 24th 2007; 07.00-09.00) reaching a cost of Rp. 246,575,690.-. The average vehicle speed is the highest in segment II (DOLOG Office) on Monday (May, 21th 2007; 07.00-09.00) reaching a cost of Rp. 254.431.756,-. In the case of segment II, if it is estimated that the ideal condition is the average speed of 40 kph (max speed allowed inside the city based on traffic law) then the cost of air pollution is Rp. 116.875.678,-, therefore the difference is Rp. 137.556.078,-. This implies that about Rp. 500 billion is needed annually for a one-way traffic. It is recommended that utilizing several measures in traffic management, such as road pricing, traffic divertion and frontage road development is necessary for the reduction of the cost of air pollution.

Keywords: Surabaya (Indonesia), traffic congestion air pollution, social cost of air pollution

INTRODUCTION

Surabaya, the second biggest metropolitan city in Indonesia, has an annual economic growth of almost 6% and significantly influences the increase in population growth. As a result, the number of population has reached almost 6 million, while the growth of urban area has also become larger and larger. Such a situation has made Surabaya become the center of urbanization and attraction/generation of transport for the surrounding areas, which in turn has raised many problems to solve. One of the significant problems in Surabaya is that of transportation due to the high demand of highway traffic, including its high air pollution, especially in the city center and several main entry streets.

At present, the highway infrastructure of the main entry street to Surabaya from the South, Ahmad Yani Street, cannot satisfy the users. This street geographically also functions as the main street connecting South Surabaya with other parts of the city. Therefore, it has a high demand of highway which further causes traffic jam and high air pollution (Bappeda Surabaya,2006).

Surabaya is one of the five big cities in Indonesia (Jakarta, Surabaya, Bandung, Semarang and Medan) with high air pollution caused by transportation. Therefore, it is important to study the social cost of air pollution caused by the highway traffic on Ahmad Yani Street, Surabaya. This study is done by measuring the existing traffic performance (LOS) and by predicting the air pollution and social cost of air pollution on Ahmad Yani Street. The objective of this study is to observe the LOS of Ahmad Yani Street, to predict the air pollutant caused by the highway traffic and to estimate the social

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Note: Discussion on this paper is open until June 2010

resource, the study is limited as below:

a. Based on the previous study, the predicted maximum traffic is on Monday and Thursday, therefore, the observation is held on Monday and Thursday, the observation time of which is divided into 3, namely 07:00-09:00; 13:00-15:00, and 16:00-18:00.
b. LOS is calculated using the Indonesian Highway Capacity Methods (1997).
c. Air pollution prediction and air pollution social cost estimation are measured by the US adopted methods considering that the relevant standard is not available in Indonesia.
d. The observed vehicles are categorized into three, namely, motorcycles (MC), light vehicles (LV), and heavy vehicles (HV), which are further respectively classified into motorcycle, automobile, and diesel for the air pollution prediction and social cost estimation.

LITERATURE REVIEW

Generally, the transportation planning objective is to make an efficient mobility and minimize the negative impact of transportation activity. Therefore, several approaches have been applied to calculate the traffic performance, however, the most common method used to calculate the level of service is the calculation of the degree of saturation. The calculation starts by quantifying the traffic volume with Eq.(1) as:

$$Q = \frac{n}{T} \quad (1)$$

where
Q = traffic volume (pcu/hour)
n = number of vehicles (passenger car unit-pcu)
T = observation time interval (hour)

The next step is the calculation of the street capacity through Eq.(2) as :

$$C = Co \; x \; FC_w \; x \; FC_{sp} \; x \; FC_{sf} x \; FC_{cs} \quad (2)$$

where:
C = Capacity (pcu/hour)
Co = Base capacity (pcu/hour)
FC_w = Adjustment factor for wide of the street
FC_{sp} = Adjustment factor for directional split (only for undivided street)
FC_{sf} = Adjustment factor for side friction
FC_{cs} = Adjusment factor for city size

Based on volume and capacity, the degree of saturation as a measure for Level of Service can be calculated using Eq.(3) as

$$DS = Q/C \quad (3)$$

where
DS = degree of saturation
Q = traffic volume (pcu/hour)
C = capacity (pcu/hour)

The prediction of air pollution and estimation of social cost of air pollutant has been done using methods based on the travel distance and on vehicle speed, as follows.

Based on the Travel Distance

As mentioned previously the value of emission is according to the US Standard (Litman, 1995), as can be seen in Table 1. While the volume of traffic is collected from the street under investigation and is further classified into three types, namely motorcycle, automobile, and diesel. Therefore, the emission can be calculated using Eq.(4).

$$\text{Emission} = \text{Traffic volume} \times \text{Constants emission volume} \quad (4)$$

The social cost of air pollution could be measured by multiplying each emission with the cost of each type of emission, using Eq.(5).

$$\text{Social cost of air pollutant} = \text{Emission} \times \text{Cost of air pollutant (Litman, 1995)} \quad (5)$$

Based on Vehicle Speed

The method of calculating air pollution based on vehicle speed is adopted from Faiz (1992) using graph as in Fig 1.

According to this method, firstly, the average spot speed should be calculated using Eq. (6) below:

$$\bar{X} = \frac{\sum f.x}{\sum f} \quad (6)$$

where
X = average spot speed (km/hour)
f = frequency for each classified speed class
x = spot speed mean in each classified speed class(km/hour)

METHODS

The steps of this study can be seen in Fig. 2. As earlier mentioned, the study has been undertaken on Ahmad Yani Street, the main Southern gate of Surabaya. The length of Ahmad Yani Street is about 4.3 km, which is split into 4 segments (see Fig.3), namely, a) segment I (ALFA Supermarket); (b) segment II

Table 1 Travel-distance based vehicle emission standard (gr/pax-mile)

Mode	Passengers	HC	CO	NOx	SOx	PM
Average						
Automobile	1.0	3.15	23.57	1.91	0.07	0.10
Car Pool	2.4	1.31	9.82	0.80	0.03	0.04
Van Pool	5.0	0.72	4.42	0.44	0.02	0.02
Diesel Bus	20	0.11	1.50	0.67	0.09	0.17
Articulated Diesel	23	0.2	1.67	0.74	0.10	0.19
Methanol Bus	20	0.01	0.02	0.49	0.00	0.00
Trolley Coach*	20	0.00	0.001	0.006	0.00	0.00
Articulated Trolley *	32	0.00	0.001	0.007	0.10	0.00
Rail Transit *	25	0.00	0.001	0.006	0.00	0.00
Rush hour						
Automobile	1.3	2.42	18.13	1.47	0.05	0.08
Car Pool	3.6	0.88	6.55	0.53	0.02	0.03
Van Po ol	7.2	0.50	3.77	0.31	0.01	0.02
Diesel Pool	37	0.06	0.81	0.36	0.05	0.09
Articulated Diesel	44	0.06	0.87	0.39	0.05	0.10
Methanol Bus	37	0.01	0.10	0.27	0.00	0.00
Trolley Coach*	37	0.00	0.001	0.003	0.00	0.00
Articulated Trolley *	44	0.00	0.001	0.004	0.00	0.00
Rail Transit *	53	0.00	0.001	0.003	0.00	0.00

Source : Litman, 1995

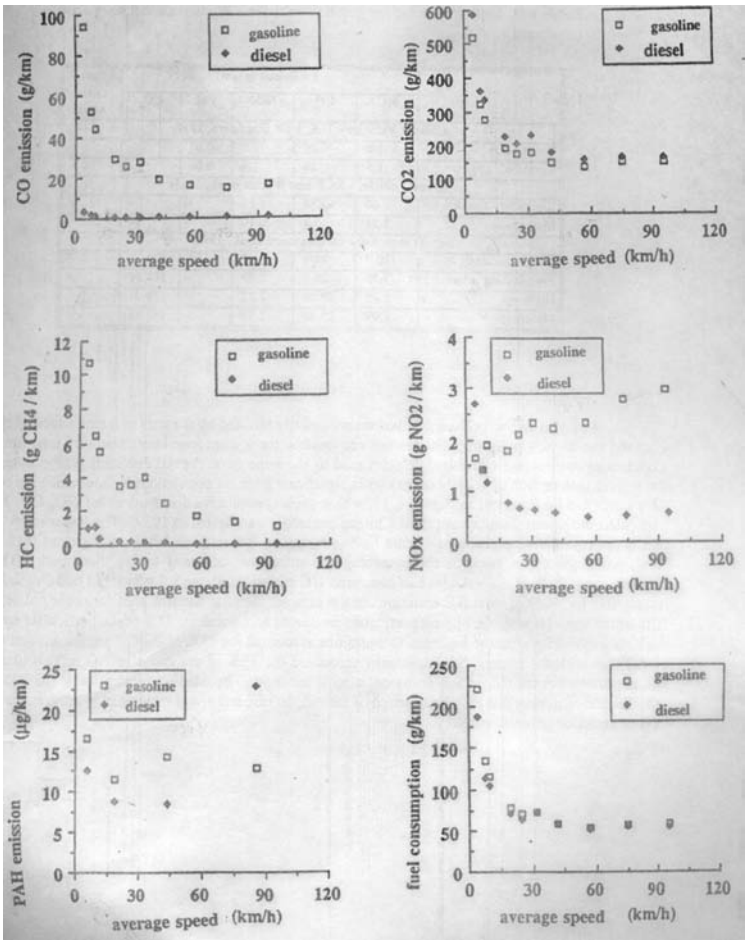

Fig. 1 Vehicle-speed based vehicle emission standard (gr/km), Source: Faiz, 1992

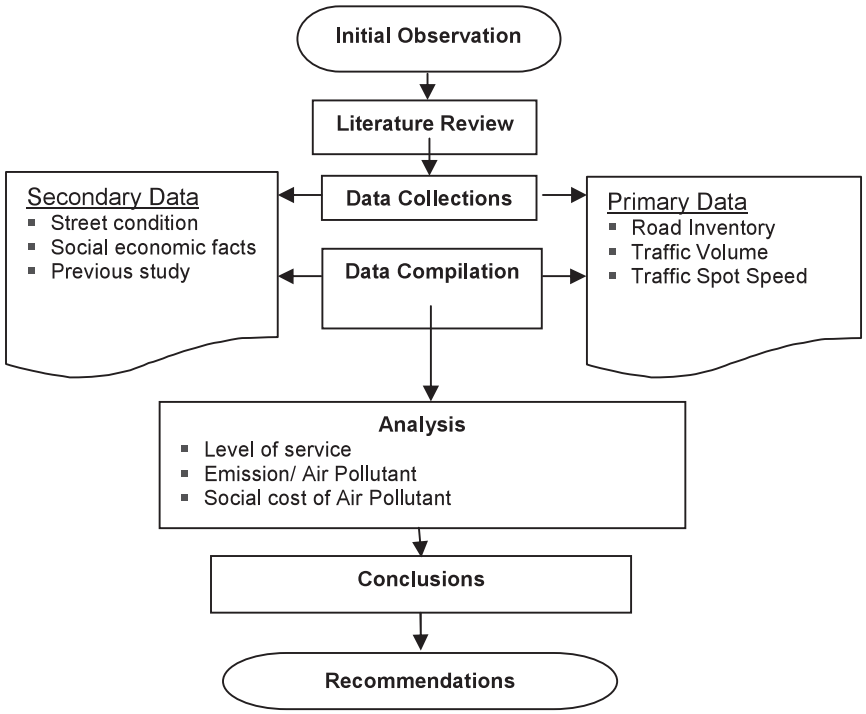

Fig.2 Steps of Study

Fig.3 Locations of Study

(DOLOG office); (c) segment III (GIANT Mall), and (d) segment IV (ROYAL Mall).

The data collected in this study are categorized into two the primary and secondary data.

Primary Data

The primary data are collected through observation on Ahmad Yani street, they consist of

a. Peak hour traffic identification
b. Road inventory
c. Traffic counting
d. Spot speed measurement
e. Traffic composition

Secondary Data

The secondary data collected are

a. Population of Surabaya City
b. Land use of study area for side friction analysis
c. Maps

RESULT OF ANALYSIS

The level of service in this study is analyzed using the Indonesian Highway Capacity Manual (IHCM, 1997), the result of which is shown in Table 2 in terms of the volume, speed, capacity and level of services on site. The data show that almost all the LsOS on site are in critical condition (F) during morning peak hours (07:00-09:00). The lowest LOS is evident on Monday morning, May 24th, 2007 in segment IV (Royal Mall while a moderate condition is shown on the same day in segment III (Giant Mall) during 13:00-15:00.

Based on the observed condition, it can be concluded that during the morning peak hours on Monday the worst traffic delay is evident; therefore, some measure on traffic management, such as road pricing, traffic diversion and the application of frontage road is needed. This result confirms the previous study conducted by GTZ (2006).

The present research is one of the initial researches on the social cost of air pollution in Indonesia, and it would therefore be not surprising that no reference is yet available on the standard of the air pollution quantification in Indonesia. As a consequence, this study has employed the US standard. However, the maintenance standard of vehicle in US is higher than that in Indonesia; in other words, this estimation is the minimum value of air pollution. The result of the estimation of air pollution is presented in Table 3.

The observation of the amount of air pollution as the result of highway traffic reveals that the highest air pollutants, namely HC, CO, NOx, Sox, and PM were evident in segment III (DOLOG Office) on Monday, May 24th, 2007.

Table 4 shows the result of air pollutant calculation based on existing spot speed observed, which is further classified into motorcycle, automobile, and diesel. Based on Table 3 and Table 4, the calculation of social cost of air pollutant can be done, of which the travel-distance based result is shown in Table 5 and the travel-speed based calculation is presented in Table 6.

Table 5 shows that the highest travel-distance based cost of air pollution of Rp. 281,279,626.- is located in segment II (DOLOG Office) during 07:00-09:00 on Monday, May 24th, 2007. Table 6 shows that at the same location and time, a spot-speed based calculation reaches Rp. 254,431,756.-

The maximum speed limit for vehicles inside the city in Indonesia is 40 km/hour. Therefore, calculation has to be made for when the volume of traffic is reduced in such a way to when the vehicle speed is reduced to 40 km/hour. In this way, the difference between the cost of air pollution at the existing speed and that at a speed of 40 Km/hr can be illustrated as shown in Fig. 4.In such a situation, the difference of air pollution cost in DOLOG office reaches Rp. 137,556,000. Therefore, the damage cost of air pollution almost stands at 140 million Rupiah in the 2 morning peak hours. Considering that the 2 morning peak hours (07.00-09.00) almost equal 8% of the annual daily traffic, it can be expected that there will be approximately a daily cost of 1.5 billion Rupiah or an annual cost of 500 billion Rupiah. As with such an amount of cost, it is necessary to improve the traffic LOS through demand management measures.

CONCLUSIONS

Based on the study results, it can be concluded that

a. The level of services on Ahmad Yani Street reaches the critical situation (F class), during the 2 morning peak hours (07.00-09.00).
b. The amount of air pollutants (HC, CO, NO, SO and PM) on Jalan Ahmad Yani indicates that the maximum happens during the Monday morning peak hours, especially in segment II of DOLOG office.
c. The social cost of air pollutants based on the travel distance calculation reaches its maximum of Rp. 281,279,626 during the Monday morning peak hours., while based on the spot speed, the cost reaches Rp. 254,431,756 (existing speed). In comparison with the situation in which the volume of traffic at the speed of 40 km/hr can be calculated, the different amount of air pollution cost will reach almost 500 billions rupiah a year.

It is thus recommended that the cost of air pollution be reduced to utilize several measures, such as road pricing, traffic divertion and frontage road development in traffic management.

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Table 2 The result of analysis on speed, volume, capacity, degree of saturation and level of service on Ahmad Yani Street, Surabaya

Segment	Hour	Speed (V)	Traffic volume (Q)	Capacity (C)	Degree of saturation (DS)	Level of service
			Monday, May 24th, 2007			
I (ALFA)	07.00-09.00	15	6150.4	5250.96	1.164	F
	13.00-15.00	19	3786.45	5250.96	0.721	C
	16.00-18.00	15	4309.6	5250.96	0.821	E
			Thursday, May 26th, 2007			
	07.00-09.00	27	7072.55	5250.96	1.347	F
	13.00-15.00	29	3176.65	5250.96	0.604	C
	16.00-18.00	29	4595.65	5250.96	0.875	E
			Monday, May 24th, 2007			
II (DOLOG)	07.00-09.00	15	6651.3	5250.96	1.267	F
	13.00-15.00	21	4010.2	5250.96	0.761	D
	16.00-18.00	17	4707.05	5250.96	0.896	E
			Thursday, May 26th, 2007			
	07.00-09.00	25	5121.65	5250.96	0.975	E
	13.00-15.00	24	3568.00	5250.96	0.679	C
	16.00-18.00	23	4444.15	5250.96	0.846	E
			Monday, May 24th, 2007			
III (GIANT)	07.00-09.00	9	3494,05	5250,96	0,665	C
	13.00-15.00	8	2626,85	5250,96	0,500	C
	16.00-18.00	10	3037,35	5250,96	0,578	C
			Thursday, May 26th, 2007			
	07.00-09.00	25	5749,05	5250,96	1,095	F
	13.00-15.00	25	2889,95	5250,96	0,550	C
	16.00-18.00	26	3348,15	5250,96	0,638	C
			Monday, May 24th, 2007			
IV (ROYAL)	07.00-09.00	21	7257.70	5250.96	1.382	F
	13.00-15.00	17	4262.50	5250.96	0.812	D
	16.00-18.00	16	7851.90	5250.96	1.495	F
			Thursday, May 26th, 2007			
	07.00-09.00	24	4216.60	5250.96	0.803	D
	13.00-15.00	20	46840	5250.96	0.892	E
	16.00-18.00	25	6141.650	5250.96	1.170	F

Table 3 The amount of air pollutant based on travel distance in each segment (gr)

Segment	Hour	HC	CO	NOx	SOx	PM
			Monday, May 24th, 2007			
		170,560.00	409,344.00	-	-	-
	07.00-09.00	28,208.07	210,848.20	17,095.80	854.79	1,139.72
		298,12	3,956.50	1,661.73	237.39	474.78
		26,230	69,952	-	-	-
I	13.00-15.00	22,475	167,995	13,621	681	908
(ALFA)		218	2,883	1,211	173	346
		30,350	72,840			
	16.00-18.00	24,471.81	182,920.60	14,831.40	741.57	988.76
		203,36	2,635.00	1,106.70	158.10	316.20
			Thursday, May 26th, 2007			
		153,450.00	362,388.00	-	-	-
	07.00-09.00	31,568.13	235,963.80	19,132.20	903.48	1,275.48
		303.80	3,668.00	1,594.95	227.85	455.70
		35,510.00	85,224.00	-	-	-
	13.00-15.00	20,500.92	153,239.20	12,424.80	557.16	828.32
		220.12	2,717.50	1,155.63	165.09	330.18
		70,670.00	169,608.00	-	-	-
	16.00-18.00	24,941.07	19,428.20	15,115.80	708.96	1,007.72
		197.24	2,331.50	1,035.51	147.93	295.86
			Monday, May 24th, 2007			
		440,430.00	1,029,060.00	-	-	-
	07.00-09.00	148,008.50	1,134,728.00	88,804.80	3,254.72	4,440.24
		701.20	9,569.00	4,207.20	560.96	1,121.92
		179,835.00	431,604.00	-	-	-
	13.00-15.00	78,108.00	598,828.00	46,864.80	1,676.50	2,343.24
		508.30	6,587.00	3,049.80	406.64	813.28
		234,750.00	563,400.00	-	-	-
II	16.00-18.00	82,698.00	634,018.00	49,618.80	1,732.78	2,480.94
(DOLOG)		611.50	8,054.20	3,699.00	489.20	978.40
			Thursday, May 26th, 2007			
		286,230.00	660,672.00	-	-	-
	07.00-09.00	101,511.00	778,251.00	60,906.60	2,368.59	5,413.92
		863.50	11,515.00	4,986.00	690.80	1,381.60
		283,032.00	123,375	-	-	-
	13.00-15.00	73.923,00	566,743.00	44,353.80	1,724.87	3,942.56
		624.90	8,748.60	3,570.00	499.92	999.84
		175,875.00	404,712.00	-	-	-
	16.00-18.00	87,927.00	674,107.00	52,756.20	2,051.63	4,689.44
		676.40	9,469.60	3,811.80	541.12	1,082.24

Table 3 (Continued) The amount of air pollutant based on travel distance in each segment (gr)

SEGMENT	HOUR	HC	CO	NO	SO	PM
			Monday, May 24th, 2007			
III (GIANT)	07.00-09.00	122,343.0	414,084.00			
		64,217.40	469,281.00	39,518,40	1,481.94	1,975.92
		549.99	7,333.20	3,055.50	427.77	855.54
	13.00-15.00	39,539.50	133,826.00			
		15,815.80	349,771.00	29,454.40	1,104.54	1,472.72
		414.09	5,521.20	2,300.50	322.07	644.14
	16.00-18.00	60,307.00	204,116.00			
		24,112.80	35,.860.00	30,304.00	1,136.40	1,515.20
		398.97	5,319.60	2,216.50	310.31	620.62
			Thursday, May 26th, 2007			
	07.00-09.00	163,091.50	552,002.00	-	-	-
		65,236.60	533,007.00	44,884.80	1,683.18	2,244.24
		546.21	7,282.80	3,034.50	424.83	849.66
	13.00-15.00	36,770.50	124,454.00	-	-	-
		14,708.20	405,878.00	34,179.20	1,281.72	1,708.96
		27,588.57	613,079.28	95,793.64	34.27	277.16
	16.00-18.00	61,847.50	209,330.00			
		2,.739.00	444,676.00	37,446.40	1,404.24	1,872.32
		452.52	6,033.0	2,514.00	351.96	703.92
			Monday, May 24th, 2007			
IV (ROYAL)	07.00-09.00	159,124.00	386,444.00	-	-	-
		34,643.00	257,348.00	22,270.50	742.35	989.80
		631.45	8,840.30	3,788.70	505.16	884.03
	13.00-15.00	35,854.00	87.074,00	-	-	-
		38,129.00	283,244.00	24,511.50	817.05	1,089.40
		410.20	5,742.80	2,461.20	328.16	574.28
	16.00-18.00	94,682.00	229,642.00	-	-	-
		41,711.60	309,857.60	26,814.60	893.82	1,191.76
		398.45	5,578.30	2,390.70	318.76	557.83
			Thursday, May 26th, 2007			
	07.00-09.00	61,659.50	149,744.50			
		50,561.00	375,596.00	32,503.50	1,083.45	1,444.60
		338.90	4,744.60	2,033.40	271.12	474.46
	13.00-15.00	55,034.00	133,654.00			
		38,235.40	284.034,40	24,579.90	819.33	1,092.44
		227.90	3,190.60	1,367.40	182.32	319.06
	16.00-18.00	77,399	187,969			
		40,400	300,113	25,971	866	1,154
		332	4,645	1,991	265	464

Table 4 The amount of air pollutant based on spot speed in each segment (gr)

Segment	Hour	HC	CO	NO	SO
		Monday, May 24th, 2007			
I (ALFA)	07.00-09.00	136,448.00	1,228,032.00	63,448.32	6,754,176.00
		18,829.20	161,738.00	9,221.48	941,460.00
		124.08	526.40	142.88	62,040.00
	13.00-15.00	37,246.60	262,300.00	20,879.08	1,857,084.00
		15,306.40	120,840.00	7,814.32	765,320.00
		192.29	891.10	281.40	8,110.00
	16.00-18.00	48,560.00	437,040.00	22,580.40	2,403,720.00
		17,056.10	151,130.00	8,204.20	850,646.00
		86.01	384.30	118.95	35,868.00
		Thursday, May 26th, 2007			
	07.00-09.00	99,742.50	613,800.00	67,824.90	4,971,780.00
		17,984.00	109,590.00	12,588.80	887,960.00
		84.00	360.00	136.80	43,920.00
	13.00-15.00	21,309.00	127,854.00	1,336.90	1,065,450.00
		11,130.00	66,780.00	8,533.00	556,500.00
		124.20	538.20	227.70	74,106.00
	16.00-18.00	41,274.20	247,362.50	32,793.20	2,091,980.00
		13,095.00	81,288.00	10,386.80	677,400.00
		51.90	224.90	95.15	14,150,308.00
		Monday, May 24th, 2007			
II (DOLOG)	07.00-09.00	118,823.90	1,052,870.00	57,155.80	5,926,154.00
		34,552.00	310,968.00	16,066.68	1,710,324.00
		112.86	478.80	129.96	56,430.00
	13.00-15.00	41,961.50	263,758.00	23,978.00	2,098,075.00
		16,635.20	125,888.00	8,767.20	809,280.00
		245.85	1,072.80	312.90	96,105.00
	16.00-18.00	54,821.68	470,735.00	30,204.50	3,004,800.00
		18,755.10	161,101.50	9,185.19	1.140,685.65
		245.85	1,072.80	312.90	96,105.00
		Thursday, May 26th, 2007			
	07.00-09.00	65,260.44	410,263.00	40,072.20	3,263,022.00
		18,733.40	117,684.00	12,160.68	935,868.00
		81.51	345.80	135.85	44,707.00
	13.00-15.00	27,557.10	172,746.00	17,850.42	1,373,742.00
		14,497.38	91,138.50	8,901.90	724,869.00
		196.08	889.20	282.72	80,256.00
	16.00-18.00	39,282.10	246,246.00	25,445.42	1,958,242.00
		17,374.00	109,208.00	9,928.00	868,700.00
		85.58	401.70	127.72	39,552.00

Table 4 (Continued) The amount of air pollutant based on spot speed in each segment (gr)

Segment	Hour	HC	CO	NO	SO
		Monday, May 24th, 2007			
III (GIANT)	07.00-09.00	84,699.00	715,236.00	33,879.60	3,952,620.00
		21,854.40	160,140.00	6,028.80	1,055,040.00
		142.00	582.20	156.20	53,960.00
	13.00-15.00	35,281.40	258,527.50	7,732.80	1,703,240.00
		17,643.60	129,285.00	4,867.20	851,760.00
		294.80	1,206.00	348.40	112,560.00
	16.00-18.00	46,395.00	371,160.00	15,774.30	2,319,750.00
		15,795.00	126,360.00	5,370.30	789,750.00
		108.80	480.00	128.00	39,680.00
		Thursday, May 26th, 2007			
	07.00-09.00	81,545.75	501,820.00	55,451.11	4,064,742.00
		14,685.00	91,225.00	9,745.50	734,250.00
		0.00	300.30	92.95	28,028.00
	13.00-15.00	18,385.25	113,140.00	12,501.97	916,434.00
		11,696.75	71,980.00	7,953.79	583,038.00
		143.62	651.30	207.08	64,128.00
	16.00-18.00	28,545.00	171,270.00	2,884.50	1,427,250.00
		12,746.50	78,440.00	8,667.62	635,364.00
		1,608.02	7,451.80	2,353.20	745,180.00
		Monday, May 24th, 2007			
IV (ROYAL)	07.00-09.00	165,943.60	1,182,064.00	89,564.08	8,092,592.00
		16,198.70	115,388.00	8,742.86	789,964.00
		160.50	706.20	215.07	64,200.00
	13.00-15.00	39,132.08	317,564.00	19,770.92	1,966,848.00
		19,032.00	163,480.00	9,320.80	951,600.00
		156.42	663.60	180.12	78,210.00
	16.00-18.00	103,342.49	836,664.00	52,212.28	5,194,178.00
		20,854.25	176,814.50	10,080.97	1,029,212.00
		141.90	602.00	163.40	70,950.00
		Thursday, May 26th, 2007			
	07.00-09.00	58,136.10	361,148.50	38,851.23	2,906,805.00
		20,968.50	131,802.00	11,982.00	1,048,425.00
		73.53	33.45	106.02	32,832.00
	13.00-15.00	57,396.25	408,850.00	30,978.25	2,779,050.00
		17,977.80	14,930.00	9,178.14	898,890.00
		124.64	577.60	182.40	57,760.00
	16.00-18.00	71,873.75	442,300.00	48,874.15	3,582,630.00
		16,003.00	98,480.00	10,882.04	797,688.00
		92.12	411.60	127.40	38,416.00

Table 5 The social cost of air pollutant based on travel distance (Rp.)

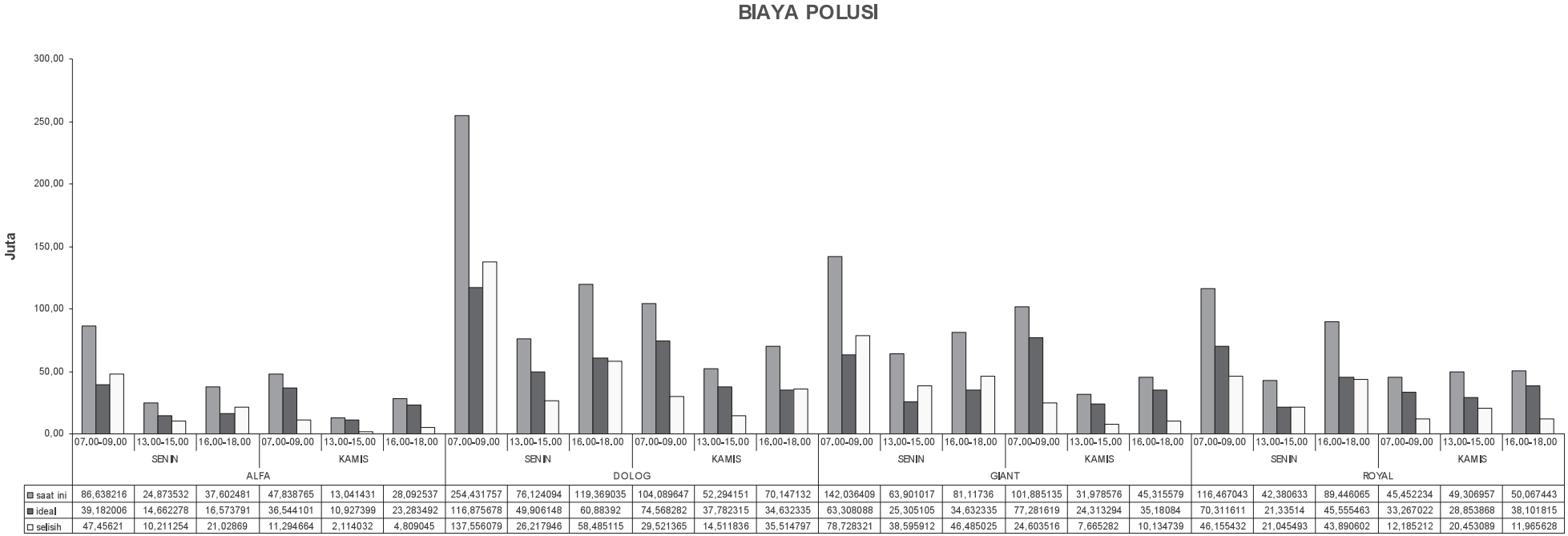
Segment	Hour	HC	CO	NO	SO	PM	Air Pollution Cost
			Monday, May 24th, 2007				
I (ALFA)	07.0-09.0	13114480.6	68531527.26	772341.30	114.92	686.93	82419151.01
	13.0-15.0	3223027.48	25674512.04	610710.07	89.87	533.56	29508873.02
	16.0-18.0	3625058.20	28371836.88	656251.27	94.67	555.23	32653796.24
			Thursday, May 26th, 2007				
	07.0-09.0	12209008.75	66101774.04	853440.40	119.04	736.57	79165078.81
	13.0-15.0	3704500.92	26481640.86	559174.21	76.00	492.91	30745884.89
	16.0-18.0	6311851.46	39348773.46	665030.19	90.17	554.64	46326299.92
			Monday, May 24th, 2007				
II (DOLOG)	07.0-09.0	38812490.52	238634598.60	3829769.10	401.50	2366.56	281279626.26
	13.0-15.0	17026771.64	113864686.20	2055233.66	219.20	1343.02	132948253.72
	16.0-18.0	20953759.86	132360847.56	2194125.17	233.81	1471.86	155510438.26
			Thursday, May 26th, 2007				
	07.0-09.0	25601264.46	159258092.40	2,713,127.81	321.92	2891.32	187575697.91
	13.0-15.0	81835125.84	1973262.47	234.10	2102.87	4911215.65	88721940.93
	16.0-18.0	10719137.24	2329187.40	272.82	2455.71	5837191.99	109888245.16
			Monday, May 24th, 2007				
III (GIANT)	07.0-09.0	12326832.49	97798662.36	1752980.33	200.95	1204.72	111879880.85
	13.0-15.0	3674087.41	53705178.36	1307508.01	150.12	900.67	58687824.57
	16.0-18.0	5588519.37	62508656.88	1339031.59	152.23	908.74	69437268.80
			Thursday, May 26th, 2007				
	07.0-09.0	15078239.54	119933639.64	1973077.18	221.82	1316.38	136986495.55
	13.0-15.0	3419005.32	5843532.88	1503122.20	169.14	1004.28	63766833.83
	16.0-18.0	5734130.64	72472348.08	1645369.47	184.80	1096.13	79853129.11
			Monday, May 24th, 2007				
IV (ROYAL)	07.0-09.0	12806969.89	71659026.89	1072987.56	131.27	797.27	85539912.52
	13.0-15.0	4901024.02	41291475.84	1110600.92	120.50	707.85	47303929.14
	16.0-18.0	9011860.25	59882493.42	1202528.23	127.59	744.41	70097753.90
			Thursday, May 26th, 2007				
	07.0-09.0	7415413.27	58203343.98	1422056.86	142.53	816.51	67041773.16
	13.0-15.0	6159602.12	46212514.20	1068380.08	105.40	600.56	53441202.36
	16.0-18.0	7482440.63	54101347.74	1151327.12	119.02	688.73	63035923.24

Table 6 The social cost of air pollutant based on travel speed calculation (Rp.)

Segment	Hour	HC	CO	NO	CO2	Air Pollution Cost
			Monday, May 24th, 2007			
I (ALFA)	Motorcycle = 14 km/jam		Automobile =16 km/jam		Diesel=16 km/jam	
	07.00-09.00	5,118,918	76,327,272	1,820,346	3,371,680	86,638,216
	Motorcycle = 22 km/jam		Automobile =19 km/jam		Diesel=14 km/jam	
	13.00-15.00	1,737,430	21,083,307	874,303	1,178,492	24,873,532
	Motorcycle = 14 km/jam		Automobile =15 km/jam		Diesel=15 km/jam	
	16.00-18.00	2,164,228	32,311,631	1,696,605	1,430,018	37,602,481
			Thursday, May 26th, 2007			
	Motorcycle =27 km/jam		Automobile = 28 km/jam		Diesel= 25 km/jam	
	07.00-09.00	3,880,678	39,733,875	1,658,333	2,565,878	47,838,765
	Motorcycle = 30 km/jam		Automobile =30 km/jam		Diesel=27 km/jam	
	13.00-15.00	1,072,632	10,714,954	516,697	737,148	13,041,431
	Motorcycle = 31 km/jam		Automobile =30 km/jam		Diesel=27 km/jam	
	16.00-18.00	1,792,631	18,055,259	890,927	7,353,719	28,092,537
			Monday, May 24th, 2007			
II (DOLOG)	Motorcycle = 15 km/jam		Automobile =14 km/jam		Diesel=15 km/jam	
	07.00-09.00	15,167,759	224,702,977	4,530,430	10,030,590	254,431,756
	Motorcycle = 23 km/jam		Automobile =20 km/jam		Diesel=19 km/jam	
	13.00-15.00	5,814,820	64,351,386	2,041,750	3,916,136	76,124,094
	Motorcycle = 18 km/jam		Automobile =16 km/jam		Diesel=16 km/jam	
	16.00-18.00	7,283,640	104,153,858	2,442,005	5,489,529	119,369,035
			Thursday, May 26th, 2007			
	Motorcycle = 24 km/jam		Automobile =25 km/jam		Diesel=26 km/jam	
	07.00-09.00	8,312,279	87,009,824	3,234,424	5,333,120	104,089,647
	Motorcycle = 25 km/jam		Automobile =24 km/jam		Diesel=22 km/jam	
	13.00-15.00	4,175,200	43,608,228	1,669,752	2,840,970	52,294,151
	Motorcycle =25 km/jam		Automobile =23 km/jam		Diesel=22 km/jam	
	16.00-18.00	5,607,509	58,609,434	2,192,639	3,737,550	70,147,132

Table 6 (Continued) The social cost of air pollutant based on travel speed calculation (Rp.)

Segment	Hour	HC	CO	NO	CO2	Air Pollution Cost
			Monday, May 24th, 2007			
III (GIANT)	Motorcycle = 12 km/jam		Automobile =8 km/jam		Diesel=8 km/jam	
	07.00-09.00	9,137,821	125,034,273	2,144,558	5,719,757	142,036,409
	Motorcycle = 8 km/jam		Automobile =8 km/jam		Diesel=7 km/jam	
	13.00-15.00	4,557,957	55,528,501	800,150	3,014,409	63,901,017
	Motorcycle = 11 km/jam		Automobile =10 km/jam		Diesel=9 km/jam	
	16.00-18.00	5,335,518	71,084,520	1,138,669	3,558,652	81,117,360
			Thursday, May 26th, 2007			
	Motorcycle =27 km/jam		Automobile =26 km/jam		Diesel=21 km/jam	
	07.00-09.00	8,241,568	84,694,108	3,494,787	5,454,653	101,885,135
	Motorcycle = 27 km/jam		Automobile =27 km/jam		Diesel=22 km/jam	
	13.00-15.00	2,588,643	26,516,995	1,106,030	1,766,907	31,978,576
	Motorcycle = 30 km/jam		Automobile =27 km/jam		Diesel=23 km/jam	
	16.00-18.00	3,674,086	36,707,275	1,761,340	3,172,877	45,315,576
			Monday, May 24th, 2007			
IV (ROYAL)	Motorcycle = 21 km/jam		Automobile =21 km/jam		Diesel=20 km/jam	
	07.00-09.00	8,407,076	99,776,439	2,839,651	5,443,887	116,467,043
	Motorcycle = 18 km/jam		Automobile =16 km/jam		Diesel=16 km/jam	
	13.00-15.00	2,689,508	37,024,046	843,688	1,823,391	42,380,633
	Motorcycle = 17 km/jam		Automobile =15 km/jam		Diesel=16 km/jam	
	16.00-18.00	5,721,549	78,094,410	1,800,157	3,829,949.	89,446,065
			Thursday, May 26th, 2007			
	Motorcycle = 26 km/jam		Automobile =23 km/jam		Diesel=22 km/jam	
	07.00-09.00	3,651,379	37,913,379	1,460,414.	2,426,636	45,452,234
	Motorcycle =21 km/jam		Automobile =19 km/jam		Diesel=19 km/jam	
	13.00-15.00	3,481,698	42,377,345	1,162,665	2,285,250	49,306,957
	Motorcycle = 27 km/jam		Automobile =26 km/jam		Diesel=21 km/jam	
	16.00-18.00	4,056,722	41,595,986	1,725,995	2,668,689	50,067,443



	ALFA						DOLOG						GIANT						ROYAL					
	SENIN			KAMIS			SENIN			KAMIS			SENIN			KAMIS			SENIN			KAMIS		
	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00	07.00-09.00	13.00-15.00	16.00-18.00
saat ini	86,638216	24,873532	37,602481	47,838765	13,041431	28,092537	254,431757	76,124094	119,369035	104,089647	52,294151	70,147132	142,036409	63,901017	81,11736	101,885135	31,978576	45,315579	116,467043	42,380633	89,446065	45,452234	49,306957	50,067443
ideal	39,182006	14,662278	16,573791	36,544101	10,927399	23,283492	116,875678	49,906148	60,88392	74,568282	37,782315	34,632335	63,308088	25,305105	34,632335	77,281619	24,313294	35,18084	70,311611	21,33514	45,555463	33,267022	28,853868	38,101815
selisih	47,45621	10,211254	21,02869	11,294664	2,114032	4,809045	137,556079	26,217946	58,485115	29,521365	14,511836	35,514797	78,728321	38,595912	46,485025	24,603516	7,665282	10,134739	46,155432	21,045493	43,890602	12,185212	20,453089	11,965628

Fig. 4 The social cost of air pollutant in existing speed, 40 km/hr speed and its difference

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