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AIR POLLUTION from ROAD TRAFFIC - MEASUREMENT USING REGRESSION ANALYSIS

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ABSTRACT : In transport sector, road transport or automobile is major source of Carbon Monoxide (CO) emission as the major global warming gas. It seems that CO emission from morotorized are gradually becoming a serious problem for the health of human life. The methods of measuring emission content can be divided into two main methods: surveyed by tools and using formula. The first method need some equipments and fairly expensive. The main objective of this research is the analysis emission content measurement from motorized with regression formula.

The period of survey divided into four days (Wednesday, Friday,Saturday and Sunday) during peak hour (06:30-09.30 AM), (12:30 AM. - 3.30 PM) and (4.30 PM.- 7.30 PM).The area of study located in RA Kartini Bandar Lampung, with five observed point to find the total numbers of vehicles passed by and the kind of vehicle. The primary data that collected are number and type of vehicles while secondary data are standard of gas emission output in Bandar Lampung .

Data were provided as graph and table of relation between volume, percentage and type of vehicles at certain period with emission content on the appointed research area. Data calculation will show emission content also type and volume of vehicles that surveyed. Then the result compared to the air-quality standard in Bandar Lampung. The results show that pollutant content produced by vehicles that passing by Jl. RA. Kartini Bandar Lampung achieved up to: CO = 55.345% (31.06905 ppm), more than air-quality standard (20 ppm): N02 = 69,2864% (156,59 mg/m3), more than air-quality standard (92,5 µg/m3); Smoke= 49,23% (0,388 µg/1113), more than air quality standard (0,26 µg/1113) and the last results is Pb = 4,467% (0,06268 µg/m3), more than air quality standard (0,06 µg/m3).

KEYWORDS : Emission , Pollution, Measurement, Air - Quality Standard, Regression Formula

I. INTRODUCTION

1.1 Research Background

Fast growth of economic development in Bandar Lampung viewed by large increases in urban population lead to a proportional increase in transport trips. Increase of household income creates greater propensity for travel and car ownership. Substantial expansion of road capacity may be unavoidable when the demand for urban transport grows rapidly. The most notable effects are widespread traffic congestion and greatly increased costs particularly in fuel consumption and travel time. Large increases in fuel consumption results in pollutant emission and a marked increase in air pollution.

In transport sector, road transport or automobile is major source of Carbon Monoxide (CO) emission on the major global warming gas. Some previous researches found the decrease of air ambient quality caused by emission. So, CO emission is one important element of air pollution. It seems that CO emissionn from motorized are gradually becoming a serious problem for the health of human life.

Faced with increasing congestion and air pollution problems, we have realized the importance of dealing with how to reduce emission content from motorized. The methods of measuring emission content can be devided into two main methods: surveyed by tools method and using formula method. The first method need some equipments and fairly expensive. Based on those reason, it's important to find the formula that can be describe emission content in study area .

1.2 Objectives

The main objective of this research is the analysis emission content measurement from motorized with regression formula. With this study, the result we hope is reach some data to find the way of solving problem reduce air pollution caused by emission.

1.3 Scope Of Study

To reach the objective of this research, scope of study are:

- Study area was located in RA Kartini Bandar Lampung
- Type of vehicle which is surveyed is vehicle with four wheels.
- Parameter of gas emission are Carbon Monoxide (CO), Smoke (S), Bauxite (Pb) and Dioxide itrogen (N02)

2. LITERATURES

2.1 Air Pollution

Acording to Stoker and Seager (1972), there are five primary pollutants in the air: Carbon Monoxide (CO); Nitrogen Oxide (NO); Hydrocarbon (HC): Sulfur Dioxide (S02) and Particle.

Several sources of pollutant from motorized, which can cause the air pollution are CO, N02. HC, dust, smoke and Pb. Transportation activity contribute CO (60% in air pollution) and HC (15% in air pollution). So, focus of this study is to analysis emission concentration of CO, N02. Pb and smoke. There are two kinds of fuel used by vehicle, motor gasoline and automotive diesel oil.

Table 1. The Relativity Toxic Air Pollution

Polutan	Level Tolerant		Relative Toxic Value
	ppm	µg/m3	
Carbon Monoxide (CO)	32	4000	1
Hydrocarbon (HC)	-	9300	2,07
Sulfur Oxide (SOx)	0,5	430	28
Nitrogen Oxide (NOx)	0,25	514	77,8
Particle	-	375	6,7

From : Stoker dan Seger (1972)

The most important factor feat determined CO affect to the human body is COHb contain in blood. The higher haemoglobine combined with CO as COHb will affect badly for the human body, such as heart function, colaps, breath problems even death. The N02 gas caused by high tempered in a diesel

machine. this affect badly to the breath matter also children development. The Pb contain in smoke at vehicles will affect to the breath. While smoke will affect hearth and breath.

2.2 Air-Quality Standard

The ministry of environment states that the limitation of air ambient quality as seen in Table 2 as bellow:

Table 2. Air-Quality Standard

Parameter	Time	Air-Quality Standard	Method of Analysis	Equipment
Sulfur Dioxide (SO2)	24 hours	0.1 ppm	Pararosalinin	Spektrofotometer
Carbon Monoxide (CO)	8 hours	20 ppm	NDIR	NDIR Analyzer
Nitrogen Oxide (NOx)	24 hours	0.05 ppm	Saltzman	Spektrofotometer
Oxidant	1 hour	0.1 ppm	Chemiluminescent	Spektrofotometer
Particle	24 hours	0.26 µg/m3	Gravimetric	Hi - Vol
Bauxite (Pb)	24 hours	0.06 µg/m3	Gravimetric	Hi - Vol
Hydrogen Sulfide (H2S)	0.5 hour	0.03 ppm	Mercurythiocyanate	Spektrofotometer
Amonia (NH3)	24 hours	2 ppm	Nessler	Spektrofotometer
Hydrocarbon (HC)	3 hours	0.24 ppm	Flame ionization	GC

From: The ministrv of environment (1998)

NDIR = Non Dispersive Infared
Hi-Vol = High Volume Sampling Method
GC = Gas Caromatograph

2.3 Emission Pollutant Measurement

There are two kinds to measure pollutan emission :

1. Measurement using tools
   Some tools are used to measure pollutant emission could be described as follows:
   a. Spektrofotometer to measure Nitrogen Oxide (NOx) content with pararosanilin analys method and 24 hours measuring period.
   b. Non Dispersive Infared Analyzer (NDIR analyzer) to measure Carbon Monoxide (CO) content with NDIR analysis method and 8 hours measuring period.
   c. High Volume Sampling Method (Hi-Vol) to measure Bauxite (Pb), dust and smoke ontent with gravimetric ekstraktif analysis method and 24 hours measuring period.
2. Measur ment use formula
   The Rgression Formula in L.E. Reed dan C.F. Barrett's research, are:
   $C = k_1 + 0{,}00032\ V + 0{,}0000005\ V^2$
   $N = k_2 + 0{,}036\ T + 0{,}00004\ ^{T2}$
   $S = k_3 + 0{,}022\ R$
   $L = k_4 + 0{,}000249\ P$
   Where
   K = Correction Factor
   C, N, S, L = Concentration of CO, N02, S and Pb
   V = Total Volume vehicles pass in 3 hours
   T = Traffic Flow per hour
   R = Volume of diesel oil vehicles in 3 hours
   P = Volume of gasoline vehicles in 3 hours

3. METHODOLOGY

3.1 Survey Method

The period of survey in this study be devided into four days (Wednesday, Friday, Saturday and Sunday) during peak hours: (06:30 - 09.30 A.M); (12:30 A.M. - 3.30 P.M) and (4.30 P.M.- 7.30 P.M). The area of study located in RA Kartini Bandar Lampung with five observed point to find the total numbers of vehicles passed by and the kind of vehicle. The primary data that collected are number and type of vehicles while secondary data are standard of gas emission output in Bandar Lampung .

3.2 Procedure Of Analysis

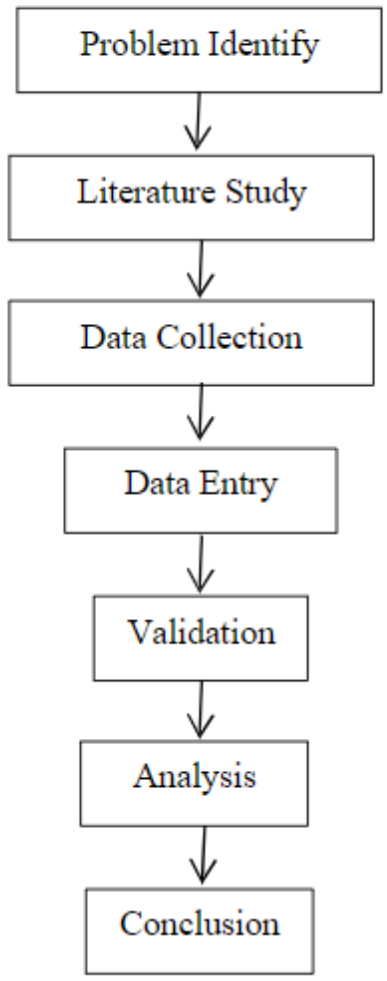

Figure 1. Flow Chart of Study

4. DATA PRESENTATION AND ANALYSIS

4.1 Secoudary Data Presentation

The secondary data was taken from PP. No 41 and previous research by Bapedalda. The research was carried out at Terminal Pasar Bawah, Terminal Rajabasa and Terminal Panjang and provide three points of observation of each location.

Table 3. Air-Quality Standard

No.	Parameter	Time	Standar (µg/m3)	Analysis Method	Equipment
1.	Sulfur Dioxide (S02)	1 hour	900	Pararosanilin	Spektrofotometer
		24 hours	365		
		1year	60		
2.	Carbon Monoxide (CO)	1 hour	30.000	NDIR	NDIR Analyzer
		24 hours	10.000		
3.	Nitrogen Dioxide (N02)	1 hour	400	Saltzman	Spektrofotometer
		24 hours	150		
		1year			
4.	Oxidant (03)	1 hour	235	Chemiluminescent	Spektrofotom eter
		1year	50		
5.	Hydrocarbon (HC)	3 hours	160	Flame ionization	Gas Chromatografi
	Particle< 10 um (PM 10)	24 hours	150	Gravimetric	Hi -Vol
6.	Particle< 2.5 um (PM2.5)	24 hours	65	Gravimetric	Hi - Vol
		1 hour	15		
7.	Dust (T SP)	24 hours	230	Gravimetric	Hi- Vol
		1year	90		
8.	Bauxit (Pb)	24 hours	2	Gravimetric	Hi-Vol
		1year	1	Ekstraktir pengabuan	AAS

From PP N0. 41 Tahun 1999

Table 4. Air-Quality

No.	Parameter	Unit	Results in each point			Max. Tolerance	Method
			1	2	3		
			Terminal Pasar Bawah				
1.	Carbon Monoxide (CO)	µg / Nm3	5150	7993	5112	2260	NDIR Analyzer
2.	Bauxit (Pb)	µg / Nm3	0,2681	3.0672	0.2181	0,06	Reflux-AAS
3.	Particle	µg / Nm3	0.5397	0,3671	0,355	0,26	Gravimetric
4.	Nitrogen Dioxide (N02)	µg / Nm3	-	98.27	-	92,5	Gries Saltzman
			Terminal Rajabasa				
1.	Carbon Monoxide (CO)	µg / Nm3	4957	4388	4422	2260	NDIR Analyzer
2.	Bauxit (Pb)	µg / Nm3	0.5924	5.0172	0.4292	0.06	Reflux-AAS
3.	Particle	µg / Nm3	0.125	0,2541	0,092	0.26	Gravimetric
			Terminal Panjang				
1.	Carbon Monoxide (CO)	µg / Nm3	3285	1807	2019	2260	NDIR Analyzer
2.	Particle	µg / Nm3	0,1382	0,1285	0,0681	0,26	Gravimetric

From Bapedalda (2002)

Table 5. Air-Quality in Pasar Bawah

No.	Parameter	Unit	Results in each point			Max. Tolerance	Method
			1	2	3		
			Terminal Pasar Bawah				
1.	Carbon Monoxide (CO)	µg / Nm3	39640	28300	44300	10000	NDIR Analyzer
2.	Bauxit (Pb)	µg / Nm3	1,57	1,42	1,7	2	Reflux-AAS
3.	Particle	µg / Nm3	243,26	238.7	153	150	Gravimetric
4.	Nitrogen Dioxide ($N0_2$)	µg / Nm3	229,1	193,9	179	150	Gries Saltzman
5.	Sulfur Dioxide ($S0_2$)	µg / Nm3	133,9	138,8	4,5	365	Pararosalinin
6.	Hydrocarbon (HC)	µg / Nm3	135,5	23,2	-	160	Gas Analyzer
7.	Hydrogen Sulfide (H_2S)	µg / Nm3	25	25	25	0,02	Methylene
8.	Amonia (NH_3)	µg / Nm3	<10	<10	<10	2	Indophenols Blue
9.	Noise	DB	80,6				Sound Level Metre

From Bapedalda (2003)

Table 6. The Number of Vehicle

No.	Year	Vehicle		Total
		2 wheels (Motorcycle)	4 wheels (car)	
1.	1999	50285	33431	83716
2.	2000	54085	34027	88112
3.	2001	56935	36458	93393
4.	2002	60565	39478	100043
5.	2003	71347	39639	110986

From Samsat (2003)

This Table shown that growth factor of motorcycle is 9,25% each year and 4,4% for car.

4.2 SECONDARY DATA ANALYSIS

The growth factor (4,4%) was used to predict total number of car in 2004, up to 41384. So, the vehicle' growth factor since 2002 until 2004 is 4,83%. After that, validation regression formula have been done to achieve the real condition in Bandar Lampung.

We have to change the different unit of that air quality standars become the same unit.

20 ppm = 2260 µg/ m^3 = 26.666,67 µg/Nm^3

1 ppm = 113 µg/ m^3 = 1333,33 µg/Nm^3

1 µg/ m^3 = 11.7994 µg/^{Nm3}

So we can create the convertion of unit from the other pollutant with the same procedure .

1. Nitrogen Dioxide (N02)
   1 ppm = 3000 µg/ m^3 = 1850 µg/ Nm^3
   1 µg/ m^3 = 1,62162 µg/Nm^3
2. Bauxite (Pb)
   1 µg/ m^3 = 33.333 µg/ Nm^3
3. Particle
   1 µg/ m^3 = 576 µg/ Nm^3

Validation of Regresion Formula for CO

1. First. calculate the number of vehicle passed by study area in 2002.
   V 2002 = V 2004 - (i X V 2004)
   = 5354 - (4.83% x 535-1-)
   = 5095

Where:

V 2002 = Total numbers of vehicle for 3 hours in 2002
V 2004= Total numbers of vehicle for 3 hours in 2004 which is minimum from survey

i = Growth factor

2. Calculate corection factor rate value for regression formula of CO with substitute V 2002 and V2004.
   a. C = X + 0,00032V + 0.0000005V2
   20 = X + 0,00032(5095) + 0,0000005(5095)2
   20 = X + 1.603-1- + 17.9795125
   20=X+l-l-.61
   X = 20- 1-1-.61 = 5,39
   Where
   C = Air Quality Ambien for CO
   V = Total numbers of vehicle in 2002
   X = Correction Factor Value
   b. C = X + 0.00032V + 0.0000005V2
   20 = X + 0.00032(535-1-) + 0.0000005(535-1-)"
   20 = X + 1.71328 + 1-1-.332658
   20 = X + 16.046
   X = 20 - 16,046= 3.954
   Where
   C = Air Quality Ambien for CO
   V = Total numbers of vehicle in 2004
   X = Correction Factor Value
   So Correction Factor Mean Value= X = (5.39 + 3.95-1-) x 0.5 = -1-.672
   Correction Factor Mean Value= X was substituted on formula as bellow
   C = 0.00032V + 0,0000005V2 + 4,672
3. Steps as explained above were repeated for every different pollutant. The regresion formula of others pollutant as bellow.
   a. $N = 0{,}00004T^2 + 0.0036T + 74{,}181$
   Which is use air quality standard for $N0_2$ = 92.5 µg/m3 and the minimum T from survey= 741
   b. S = 0.00022R + 0,02
   Which is use air quality standard for Particle = 0.26 µg/ m^3 and the minimum R from survey =1119
   c. L = 0,00000249P+ 0,04975
   Which is use air quality standard for Pb = 0.06 µg/m3 and the minimum L from survey = 4235

4.3 SURVEY DATA RESULT

As already surveyed, the pollutant emission content produced by vehicle used gasoline and diesel oil which was carried out on JI RA Kartini on Wednesday, Friday, Saturday and Sunday provided result of number of vehicle during survey period, type of vehicle also type of fuel

Table 7. The Number of Vehicle from Survey

Type of Vehicle		Day			
First Point		Wednesday	Friday	Saturday	Sunday
Gasoline	Private Car	7140	6476	7310	6233
	Public Transport	3600	3396	3594	3384
	Freight Transport	576	519	517	379
	Total	11346	10391	11794	9996
Diesel Oil	Private Car	2775	2756	2773	2747
	Public Transport	94	82	94	107
	Freight Transport	1400	1254	1174	944
	Total	4269	4092	4041	3798
Second Point					
Gasoline	Private Car	6633	6042	6700	5673
	Public Transport	6666	6561	6674	6550
	Freight Transport	559	502	500	362
	Total	13858	13105	13804	12585
Diesel Oil	Private Car	2558	2522	2585	2539
	Public Transport	84	63	84	94
	Freight Transport	1532	1376	1306	1076
	Total	4174	3961	3975	3907

From : Survey (2004)

Table 8. Data of Regression Formula for Pollutant of CO, S and Pb

Measurement Time	Morning	Day	Night	Average
Wednesday				
The number of total vehicles passing in 3 hours period (V)	9095	6330	5991	7138
The number of diesel oil vehicles passing in 3 hours period (R)	2449	1618	1182	1749
The number of gasoline vehicles passing in 3 hours period (P)	6646	4712	4809	5389
Friday				
The number of total vehicles passing in 3 hours period (V)	8404	6352	5354	6703
The number of diesel oil vehicles passing in 3 hours period (R)	2233	1673	1119	1675
The number of gasoline vehicles passing in 3 hours period (P)	6171	4679	4235	5028
Saturday				
The number of total vehicles passing in 3 hours period (V)	8518	5981	6764	7087
The number of diesel oil vehicles passing in 3 hours period (R)	2203	1457	1361	1673
The number of gasoline vehicles passing in 3 hours period (P)	6315	4524	5403	5414
Sunday				
The number of total vehicles passing in 3 hours period (V)	6474	6108	7013	6531
The number of diesel oil vehicles passing in 3 hours period (R)	1583	1524	1671	1592
The number of gasoline vehicles passing in 3 hours period (P)	4891	4584	5342	4939

Table 9. Data of Pollutant Content (CO, S and Pb)

Measurement Time	Morning	Day	Night	Average
Wednesday				
CO Content (ppm)	48.94191	26.73205	24.5352	33.403
Degree of Smoke (μg/ m3)	0.55878	0.37596	0.28004	0.40493
Pb Content (μg/ m3)	0.066299	0.0614829	0.06172	0.06317
Friday				
CO Content (ppm)	42.67489	26.878592	20.7179	30.0905
Degree of Smoke (μg/ m3)	0.51126	0.38806	0.26618	0.3885
Pb Content (μg/ m3)	0.065116	0.0614007	0.0603	0.06227
Saturday				
CO Content (ppm)	43.67592	24.472101	29.7123	32.6201
Degree of Smoke (μg/ m3)	0.50466	0.34054	0.31942	0.38821
Pb Content (μg/ m3)	0.065474	0.0610148	0.0632	0.06323
Sunday				
CO Content (ppm)	27.70002	25.280392	31.5072	28.1626
Degree of Smoke (μg/ m3)	0.36826	0.35528	0.38762	0.37039
Pb Content (μg/ m3)	0.061929	0.0611642	0.06305	0.06205

Table 10.Traffic Volume (smp/hour)

	Time Measurement Morning			Time Measurement Day			Time Measurement Night			Average
First Point	**06.30-07.30**	**07.30-08.30**	**08.30-09.30**	**11.30-12.30**	**12.30-13.30**	**13.30-14.30**	**16.30-17.30**	**17.30-18.30**	**18.30-19.30**	
Wednesday	2409	2880	2973	1858	1484	1599	1447	1074	1872	1955
Friday	2221	2623	2689	2228	1307	1440	1326	843	1675	1817
Saturday	2224	2623	2676	1633	1365	1497	1887	1414	1775	1899
Sunday	1738	1759	1920	1692	1381	1557	1762	1767	1875	1717
Average/day	2148	2471	2565	1853	1384	1523	1606	1275	1799	
Second Point										
Wednesday	2754	3203	3257	2132	1794	1901	1751	1339	1922	2228
Friday	2561	2919	2970	2531	1566	1724	1629	1177	1873	2106
Saturday	2649	2946	2960	1907	1675	1799	2100	1659	1826	2126
Sunday	2165	2108	2224	1974	1692	1861	2010	2016	1941	1999
Average/day	2532	2794	2853	2136	1682	1821	1873	1548	1891	

Table 11. NO_2 Content (μg/ Nm^3)

	Time Measurement Morning			Time Measurement Day			Time Measurement Night			Average
First Point	**06.30-07.30**	**07.30-08.30**	**08.30-09.30**	**11.30-12.30**	**12.30-13.30**	**13.30-14.30**	**16.30-17.30**	**17.30-18.30**	**18.30-19.30**	
Wednesday	[illegible]	[illegible]	296.481	128.48104	[illegible]	[illegible]	97.48064	77.48724	146.9644	155.81644
Friday	[illegible]	[illegible]	[illegible]	163.55816	[illegible]	95.94084	88.04424	69.46824	126.186	141.40653
Saturday	[illegible]	[illegible]	245.518	110.01316	91.03764	100.4542	139.30536	99.42376	[illegible]	145.83213
Sunday	[illegible]	113.3438	139.9562	114.042	[illegible]	104.3404	123.48916	126.597	147.386	[illegible]
Average/day	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	102.1081	112.0799	[illegible]	[illegible]	
Second Point										
Wednesday	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Friday	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saturday	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sunday	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average/day	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

The highest CO content is 48,94191 ppm on Wednesday in the morning and the lowest is 20,7179 ppm on Friday in the night. The mean of CO content each day is 31,06905 ppm. The comparison between pollution of CO from survey and air-quality standard achieved up to 55,345%.

The highest N02 content is 354,2352 µg/m3 at the second observed point on Wednesday in the morning from 8.30 AM until 09.30 AM and the lowest is 69,46824 µg/1113 on Friday in the night at first observed point from 5.30 PM until 6.30 PM. The mean of 02 content each day is 156,59 µg/m3 . The comparison between pollution of N02 and from survey and air-quality standard achieved up to 69,2864%.

The highest Smoke content is 0,55878 µg/m3 on Wednesday in the morning and the lowest is 0,026618 µg/m3 on Friday in the night. The mean of Smoke content each day is 0,388 µg/m3 . The comparison between pollution of Smoke and from survey and air-quality standard achieved up to 49,23%.

The highest Pb content is 0,066299 µg/m3 on Wednesday in the morning and the lowest is 0,0603 µg/m3 on Friday in the night . The mean of Pb content each day is 0,06268 µg/m3. The comparison between pollution of Smoke and from survey and air-quality standard describe the worst value up to 4,467%.

5. CONCLUSSION AND RECOMMENDATION

5.1 Conclussion

Based on the analysis of the calculation use regression formula for primary and secondary data, conclusion can be drawn as the following:

1. Carbon Monoxide Pollutant Content Consentrate produced by vehicles that passing by JI. RA. Kartini Bandar Lampung achieved up to 55,345% equals to 31,06905 ppm. That means the pollution of CO on that area more than air-quality standard (20 ppm).
2. The Natrium Dioxide Pollutant Content achieved up to 69,2864% equals to 156,59 µg/m3. That means the pollution of N02 on that area more than air-quality standard (92, µg/m3).
3. The Smoke Pollutant Content achieved up to 49,23% equals to 0,388 µg/m3.That mean the pollution of Smoke on that area more than air-quality standard (0,26 µg/m3).
4. The last results is Pb Pollutant Content achieved up to 4,467% equals to 0,06268 µg/m3. That means the pollution of Pb on that area more than air-quality standard (0,06 µg/m3).
5. Density of traffic on JI. RA. Kartini especially at the appointed survey area on Jaka Uta.ma intersection should be given more intention by local government.
6. Regression formula effectiveness in this research only for determining the pollutant content of Carbon Monoxide, Nitrogen Dioxide, Smoke, and Bauxite in study area.

5.2 Recommendations

For more practical result, further advance research is required. It's important to reducing environmental problems caused by automobile traffic. Traffic department should supervise all vehicles in the test of emission content at the end of license plate's time.

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