



## The Calculation of Average Vehicles Emission from Environmental Audit in Toll-Road Surabaya-Gresik at Indonesia

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**Abstract :** The toll road Surabaya-Gresik by the length of 20,732 Km has been operated since March 8<sup>th</sup> 1993 and during the operation it did not have the Environmental Impact Assessment (EIA) study. Based on Ministry of Environment regulation No.14 year 2014, the activity in the toll road Surabaya-Gresik needs to be assessed by EIA study in form of Environmental Evaluation Document with based on Environmental Audit. Environmental Audit of toll road Surabaya-Gresik was created in year 2015 and the activity get the environmental feasibility letter as well as environmental permit. One of the negative impacts from the activity in operation stage is the degradation quality of air caused by vehicle emission. The method to calculate the average emission is conducted by using transportation data from year 2009 to 2014 by the unit of Passenger Car Unit (PCU)/month. Based on the original unit, conversions to PCU/hour as well as the average value calculation are conducted for CH<sub>4</sub>, CO, N<sub>2</sub>O, and CO<sub>2</sub> parameters. The result reveals the value of CH<sub>4</sub>, CO, N<sub>2</sub>O, CO<sub>2</sub> in Surabaya-Gresik line as 995 g/hour, 610902 g/hour, 202 g/hour, and 6108403 g/hour respectively. While on Gresik-Surabaya line as 2214 g/hour, 1358569 g/hour, 449 g/hour, 13584314 g/hour sequentially.

**Keywords :** Vehicle emission, CH<sub>4</sub>, CO, N<sub>2</sub>O, CO<sub>2</sub>.

### Introduction

The toll road of Surabaya Gresik has a length of 20,732 km and has been operated since March 8, 1993. During the operation, the management had not applied the environmental impact assessment (EIA) study. Based on Ministry of Environment regulation no 14/2010, the activity of Toll road Surabaya Gresik needs to be assessed by EIA study in form of Environmental Evaluation Document with based on Environmental Audit. One of the negative impacts from the activity in operation stage is the degradation quality of air caused by vehicle emission. In more detail, this toll road is located in East Java and it is divided into 4 sections: Dupak-Tandes with the length of 3,5 km; Tandes-Romokalisari with the length of 5,376 km; Romokalisari-Kebomas with the length of 7,524 km; and Kebomas-Manyar with the length of 4,332 km.

### Materials and Methods

Based on Environmental Audit study on the operation and maintenance of toll road Surabaya Gresik in year 2015, a total volume of traffic daily from January 2009 to September 2014 is collected. The details of the traffic data 2011-2013 are presented in Table 1.

**Table 1. Traffic Volume of toll road Surabaya- Gresik year 2011-2013**

Months	From Surabaya to Gresik			From Gresik to Surabaya		
	2011	2012	2013	2011	2012	2013
Jan	700353	687453	633731	1180423	1336532	1631858
Feb	624223	668963	609356	1099374	1277484	1537202
Mar	731608	708450	631199	1299776	1380993	1660615
Apr	699590	677637	665871	1193206	1367896	1667780
May	714701	724376	664943	1276666	1450353	1755121
Jun	696462	712863	640729	1298733	1476151	1723010
Jul	740174	706158	690430	1389057	1536331	1745314
Ags	632971	540396	488387	1234592	1536599	1636767
Sep	642473	634220	654623	1316904	1642779	1732283
Oct	730970	670113	681607	1330865	1669562	1803669
Nov	721044	631151	674771	1343172	1630397	1702747
Dec	720788	625756	680812	1355501	1646350	1708880

Source : East Java Environmental Agency<sup>2</sup>

The method of study is developed with the initial step of a conversion of Passenger Car Unit (PCU)/Month to PCU/hour. The calculation of emission is conducted by the formula<sup>3</sup>:  $Q = N_i \times FE_i \times L \times KI$ , where: Q = emission total (g/hour),  $N_i$  = total vehicle (PCU/hour),  $FE_i$  = vehicles emission factor (g/liter), L = road length (km), KI = vehicle fuel consumption (liter/100 km)

The emission factor value based on fuels and vehicle types are shown in Table 2. The specific energy consumption based on gasoline and diesel types for vehicle are shown in Table 3.

**Table 2. Vehicle emission factor based on fuel type**

Vehicle type / fuel	Emission Type (g/liter)			
	CH <sub>4</sub>	CO	N <sub>2</sub> O	CO <sub>2</sub>
Gasoline :				
Passenger vehicle	0.71	462.63	0.04	2597.86
Small commerce vehicle	0.72	295.37	0.05	2597.87
Large commerce vehicle	0.73	281.14	0.06	2597.88
Motorcycle	3.56	427.05	0.07	2597.89
Diesel :				
Passenger vehicle	0.08	11.86	0.16	2924.90
Small commerce vehicle	0.04	15.81	0.16	2924.90
Large commerce vehicle	0.24	35.57	0.12	2924.90
Locomotive	0.24	24.11	0.08	2964.43

Source :Laksono and Damayanti<sup>3</sup>

**Table 3. Specific energy consumption on vehicle**

Vehicle type	Specific energy consumption (liter/100 km)	
	Gasoline	Diesel
Passanger car	11.79	11.36
Large bus	23.15	16.89
Medium bus	13.04	13.04
Small bus	11.35	11.83
Minibus	10.99	10.99
Taxi	10.88	6.25
Large truck	15.82	15.82
Medium truck	15.15	15.15
Small truck	8.11	10.64
Motorcycle	2.66	2.66

Source :Laksono and Damayanti<sup>3</sup>

**Result and Discussion**

Based on Ministry of Energy and Resource publication<sup>4</sup>, a comparison prediction of gasoline and diesel use on transportation is about 4:3. The environmental audit study does not show the percentage detail of vehicles, whether they use the gasoline or diesel. Thus, the emission is calculated by using the similar assumption on total gasoline and diesel usage on vehicles that are 4:3. The total emission calculation can be performed by summing the emission from (4/7) Q of gasoline + (3/7) Q diesel<sup>5</sup>. The prediction calculation of total vehicle emissions from toll road Surabaya-Gresik line are shown from Table 4 to Table 7, while the total vehicle emissions from Gresik-Surabaya line are shown from Table 8 to Table 11.

**Table 4. Calculation of total CH<sub>4</sub> emissions by gas and diesel vehicles from Surabaya to Gresik**

Months	Ni (PCU/hour)	Fei (g/litre Gasoline)	Fei (g/litre Diesel)	L (km)	KI (litre/100km Gasoline)	KI (liter/100km Diesel)	Q Gasoline (g/hour)	Q Diesel (g/hour)	Total Emission CH <sub>4</sub> (g/ hour)
Jan 2011	972,71	0,71	0,08	20,732	11,79	11,36	1688	183	1043
Feb 2011	866,98	0,71	0,08	20,732	11,79	11,36	1505	163	930
Mar2011	1016,12	0,71	0,08	20,732	11,79	11,36	1763	191	1090
Apr 2011	971,65	0,71	0,08	20,732	11,79	11,36	1686	183	1042
May2011	992,64	0,71	0,08	20,732	11,79	11,36	1723	187	1065
Jun 2011	967,31	0,71	0,08	20,732	11,79	11,36	1679	182	1037
Jul 2011	1028,02	0,71	0,08	20,732	11,79	11,36	1784	194	1102
Ags2011	879,13	0,71	0,08	20,732	11,79	11,36	1526	166	943
Sep 2011	892,32	0,71	0,08	20,732	11,79	11,36	1549	168	957
Oct 2011	1015,24	0,71	0,08	20,732	11,79	11,36	1762	191	1089
Nov2011	1001,45	0,71	0,08	20,732	11,79	11,36	1738	189	1074
Dec2011	1001,09	0,71	0,08	20,732	11,79	11,36	1737	189	1074
Jan 2012	954,80	0,71	0,08	20,732	11,79	11,36	1657	180	1024
Feb 2012	929,12	0,71	0,08	20,732	11,79	11,36	1612	175	996
Mar2012	983,96	0,71	0,08	20,732	11,79	11,36	1708	185	1055
Apr 2012	941,16	0,71	0,08	20,732	11,79	11,36	1633	177	1009
May2012	1006,08	0,71	0,08	20,732	11,79	11,36	1746	190	1079
Jun 2012	990,09	0,71	0,08	20,732	11,79	11,36	1718	187	1062
Jul 2012	980,78	0,71	0,08	20,732	11,79	11,36	1702	185	1052
Ags2012	750,55	0,71	0,08	20,732	11,79	11,36	1303	141	805
Sep 2012	880,86	0,71	0,08	20,732	11,79	11,36	1529	166	945
Oct 2012	930,71	0,71	0,08	20,732	11,79	11,36	1615	175	998
Nov2012	876,60	0,71	0,08	20,732	11,79	11,36	1521	165	940
Dec2012	869,11	0,71	0,08	20,732	11,79	11,36	1508	164	932
Jan 2013	880,18	0,71	0,08	20,732	11,79	11,36	1528	166	944
Feb 2013	846,33	0,71	0,08	20,732	11,79	11,36	1469	159	908
Mar2013	876,67	0,71	0,08	20,732	11,79	11,36	1521	165	940
Apr 2013	924,82	0,71	0,08	20,732	11,79	11,36	1605	174	992
May2013	923,53	0,71	0,08	20,732	11,79	11,36	1603	174	990
Jun 2013	889,90	0,71	0,08	20,732	11,79	11,36	1544	168	954
Jul 2013	958,93	0,71	0,08	20,732	11,79	11,36	1664	181	1028
Ags2013	678,32	0,71	0,08	20,732	11,79	11,36	1177	128	727
Sep 2013	909,20	0,71	0,08	20,732	11,79	11,36	1578	171	975
Oct 2013	946,68	0,71	0,08	20,732	11,79	11,36	1643	178	1015
Nov2013	937,18	0,71	0,08	20,732	11,79	11,36	1626	177	1005
Dec2013	945,57	0,71	0,08	20,732	11,79	11,36	1641	178	1014
Average emission (g/hour)									995

**Table 5. Calculation of total CO emissions by gas and diesel vehicles from Surabaya to Gresik**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100 km) Gasoline	KI (lt/100k m) Diesel	Q Gasoline (g/hour)	Q Diesel (g/hour)	Total Emission CO (g/ hour)
Jan 2011	972,71	462,63	11,86	20,732	11,79	11,36	1099951	27170	640188
Feb 2011	866,98	462,63	11,86	20,732	11,79	11,36	980384	24217	570598
Mar 2011	1016,12	462,63	11,86	20,732	11,79	11,36	1149039	28382	668758
Apr 2011	971,65	462,63	11,86	20,732	11,79	11,36	1098753	27140	639490
May 2011	992,64	462,63	11,86	20,732	11,79	11,36	1122485	27727	653303
Jun 2011	967,31	462,63	11,86	20,732	11,79	11,36	1093840	27019	636631
Jul 2011	1028,02	462,63	11,86	20,732	11,79	11,36	1162492	28715	676588
Ags 2011	879,13	462,63	11,86	20,732	11,79	11,36	994123	24556	578594
Sep 2011	892,32	462,63	11,86	20,732	11,79	11,36	1009047	24925	587280
Oct 2011	1015,24	462,63	11,86	20,732	11,79	11,36	1148037	28358	668174
Nov 2011	1001,45	462,63	11,86	20,732	11,79	11,36	1132447	27973	659101
Dec 2011	1001,09	462,63	11,86	20,732	11,79	11,36	1132045	27963	658867
Jan 2012	954,8	462,63	11,86	20,732	11,79	11,36	1079691	26669	628396
Feb 2012	929,12	462,63	11,86	20,732	11,79	11,36	1050651	25952	611494
Mar 2012	983,96	462,63	11,86	20,732	11,79	11,36	1112668	27484	647589
Apr 2012	941,16	462,63	11,86	20,732	11,79	11,36	1064274	26289	619423
May 2012	1006,08	462,63	11,86	20,732	11,79	11,36	1137681	28102	662147
Jun 2012	990,09	462,63	11,86	20,732	11,79	11,36	1119599	27655	651623
Jul 2012	980,78	462,63	11,86	20,732	11,79	11,36	1109068	27395	645494
Ags 2012	750,55	462,63	11,86	20,732	11,79	11,36	848728	20964	493972
Sep 2012	880,86	462,63	11,86	20,732	11,79	11,36	996085	24604	579736
Oct 2012	930,71	462,63	11,86	20,732	11,79	11,36	1052457	25997	612545
Nov 2012	876,6	462,63	11,86	20,732	11,79	11,36	991265	24485	576931
Dec 2012	869,11	462,63	11,86	20,732	11,79	11,36	982791	24276	571999
Jan 2013	880,18	462,63	11,86	20,732	11,79	11,36	995317	24585	579289
Feb 2013	846,33	462,63	11,86	20,732	11,79	11,36	957034	23640	557008
Mar 2013	876,67	462,63	11,86	20,732	11,79	11,36	991340	24487	576974
Apr 2013	924,82	462,63	11,86	20,732	11,79	11,36	1045795	25832	608668
May 2013	923,53	462,63	11,86	20,732	11,79	11,36	1044337	25796	607820
Jun 2013	889,9	462,63	11,86	20,732	11,79	11,36	1006307	24857	585686
Jul 2013	958,93	462,63	11,86	20,732	11,79	11,36	1084366	26785	631117
Ags 2013	678,32	462,63	11,86	20,732	11,79	11,36	767044	18947	446431
Sep 2013	909,2	462,63	11,86	20,732	11,79	11,36	1028129	25396	598386
Oct 2013	946,68	462,63	11,86	20,732	11,79	11,36	1070509	26443	623052
Nov 2013	937,18	462,63	11,86	20,732	11,79	11,36	1059773	26177	616803
Dec 2013	945,57	462,63	11,86	20,732	11,79	11,36	1069260	26412	622325
Average emission (g/hour)									610902

**Table 6. Calculation of total N<sub>2</sub>O emissions by gas and diesel vehicles from Surabaya to Gresik**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100 km) Gasoline	KI (lt/100km ) Diesel	Q Gas- oline (g/hour)	Q Diese (g/hour)	Total Emi-ssion N <sub>2</sub> O (g/ hour)
Jan 2011	972,71	0,04	0,16	20,732	11,79	11,36	95	367	211
Feb 2011	866,98	0,04	0,16	20,732	11,79	11,36	85	327	188
Mar 2011	1016,12	0,04	0,16	20,732	11,79	11,36	99	383	221
Apr 2011	971,65	0,04	0,16	20,732	11,79	11,36	95	366	211
May 2011	992,64	0,04	0,16	20,732	11,79	11,36	97	374	216
Jun 2011	967,31	0,04	0,16	20,732	11,79	11,36	95	365	210
Jul 2011	1028,02	0,04	0,16	20,732	11,79	11,36	101	387	223
Ags 2011	879,13	0,04	0,16	20,732	11,79	11,36	86	331	191
Sep 2011	892,32	0,04	0,16	20,732	11,79	11,36	87	336	194
Oct 2011	1015,24	0,04	0,16	20,732	11,79	11,36	99	383	221
Nov 2011	1001,45	0,04	0,16	20,732	11,79	11,36	98	377	218
Dec 2011	1001,09	0,04	0,16	20,732	11,79	11,36	98	377	218
Jan 2012	954,8	0,04	0,16	20,732	11,79	11,36	93	360	208
Feb 2012	929,12	0,04	0,16	20,732	11,79	11,36	91	350	202
Mar 2012	983,96	0,04	0,16	20,732	11,79	11,36	96	371	214
Apr 2012	941,16	0,04	0,16	20,732	11,79	11,36	92	355	205
May 2012	1006,08	0,04	0,16	20,732	11,79	11,36	98	379	219
Jun 2012	990,09	0,04	0,16	20,732	11,79	11,36	97	373	215
Jul 2012	980,78	0,04	0,16	20,732	11,79	11,36	96	370	213
Ags 2012	750,55	0,04	0,16	20,732	11,79	11,36	73	283	163
Sep 2012	880,86	0,04	0,16	20,732	11,79	11,36	86	332	191
Oct 2012	930,71	0,04	0,16	20,732	11,79	11,36	91	351	202
Nov 2012	876,6	0,04	0,16	20,732	11,79	11,36	86	330	191
Dec 2012	869,11	0,04	0,16	20,732	11,79	11,36	85	328	189
Jan 2013	880,18	0,04	0,16	20,732	11,79	11,36	86	332	191
Feb 2013	846,33	0,04	0,16	20,732	11,79	11,36	83	319	184
Mar 2013	876,67	0,04	0,16	20,732	11,79	11,36	86	330	191
Apr 2013	924,82	0,04	0,16	20,732	11,79	11,36	90	348	201
May 2013	923,53	0,04	0,16	20,732	11,79	11,36	90	348	201
Jun 2013	889,9	0,04	0,16	20,732	11,79	11,36	87	335	193
Jul 2013	958,93	0,04	0,16	20,732	11,79	11,36	94	361	208
Ags 2013	678,32	0,04	0,16	20,732	11,79	11,36	66	256	147
Sep 2013	909,2	0,04	0,16	20,732	11,79	11,36	89	343	198
Oct 2013	946,68	0,04	0,16	20,732	11,79	11,36	93	357	206
Nov 2013	937,18	0,04	0,16	20,732	11,79	11,36	92	353	204
Dec 2013	945,57	0,04	0,16	20,732	11,79	11,36	92	356	206
Average emission (g/hour)									202

**Table 7. Calculation of total CO<sub>2</sub> emissions by gas and diesel vehicles from Surabaya to Gresik**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100 km) Gasoline	KI (lt/100km) Diesel	Q Gas-oline (g/hour)	Q Diesel (g/hour)	Total Emission CO <sub>2</sub> (g/ hour)
Jan 2011	972,71	2597,86	2924,9	20,732	11,79	11,36	6176682	6700621	6401227
Feb 2011	866,98	2597,86	2924,9	20,732	11,79	11,36	5505262	5972248	5705399
Mar 2011	1016,12	2597,86	2924,9	20,732	11,79	11,36	6452332	6999653	6686898
Apr 2011	971,65	2597,86	2924,9	20,732	11,79	11,36	6169953	6693321	6394253
May 2011	992,64	2597,86	2924,9	20,732	11,79	11,36	6303223	6837895	6532368
Jun 2011	967,31	2597,86	2924,9	20,732	11,79	11,36	6142366	6663394	6365664
Jul 2011	1028,02	2597,86	2924,9	20,732	11,79	11,36	6527879	7081608	6765191
Ags 2011	879,13	2597,86	2924,9	20,732	11,79	11,36	5582414	6055944	5785356
Sep 2011	892,32	2597,86	2924,9	20,732	11,79	11,36	5666216	6146855	5872204
Oct 2011	1015,24	2597,86	2924,9	20,732	11,79	11,36	6446705	6993549	6681067
Nov 2011	1001,45	2597,86	2924,9	20,732	11,79	11,36	6359164	6898582	6590343
Dec 2011	1001,09	2597,86	2924,9	20,732	11,79	11,36	6356906	6896133	6588003
Jan 2012	954,8	2597,86	2924,9	20,732	11,79	11,36	6062912	6577200	6283321
Feb 2012	929,12	2597,86	2924,9	20,732	11,79	11,36	5899842	6400297	6114323
Mar 2012	983,96	2597,86	2924,9	20,732	11,79	11,36	6248093	6778089	6475234
Apr 2012	941,16	2597,86	2924,9	20,732	11,79	11,36	5976341	6483286	6193603
May 2012	1006,08	2597,86	2924,9	20,732	11,79	11,36	6388550	6930461	6620798
Jun 2012	990,09	2597,86	2924,9	20,732	11,79	11,36	6287013	6820310	6515569
Jul 2012	980,78	2597,86	2924,9	20,732	11,79	11,36	6227879	6756160	6454285
Ags 2012	750,55	2597,86	2924,9	20,732	11,79	11,36	4765960	5170234	4939220
Sep 2012	880,86	2597,86	2924,9	20,732	11,79	11,36	5593430	6067894	5796772
Oct 2012	930,71	2597,86	2924,9	20,732	11,79	11,36	5909984	6411300	6124834
Nov 2012	876,6	2597,86	2924,9	20,732	11,79	11,36	5566363	6038531	5768721
Dec 2012	869,11	2597,86	2924,9	20,732	11,79	11,36	5518782	5986915	5719411
Jan 2013	880,18	2597,86	2924,9	20,732	11,79	11,36	5589117	6063216	5792302
Feb 2013	846,33	2597,86	2924,9	20,732	11,79	11,36	5374145	5830008	5569515
Mar 2013	876,67	2597,86	2924,9	20,732	11,79	11,36	5566786	6038991	5769160
Apr 2013	924,82	2597,86	2924,9	20,732	11,79	11,36	5872572	6370715	6086062
May 2013	923,53	2597,86	2924,9	20,732	11,79	11,36	5864388	6361836	6077580
Jun 2013	889,9	2597,86	2924,9	20,732	11,79	11,36	5650835	6130169	5856264
Jul 2013	958,93	2597,86	2924,9	20,732	11,79	11,36	6089167	6605683	6310531
Ags 2013	678,32	2597,86	2924,9	20,732	11,79	11,36	4307272	4672638	4463858
Sep 2013	909,2	2597,86	2924,9	20,732	11,79	11,36	5773372	6263100	5983255
Oct 2013	946,68	2597,86	2924,9	20,732	11,79	11,36	6011354	6521269	6229889
Nov 2013	937,18	2597,86	2924,9	20,732	11,79	11,36	5951065	6455865	6167408
Dec 2013	945,57	2597,86	2924,9	20,732	11,79	11,36	6004342	6513663	6222623
Average emission (g/hour)									6108403

**Table 8. Calculation of total CH<sub>4</sub> emissions by gas and diesel vehicles from Gresik to Surabaya**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100km) Gasoline	KI (lt/100km) Diesel	Q Gasoline (g/hour)	Q Diesel (g/hour)	Total Emission CH <sub>4</sub> (g/ hour)
Jan 2011	1639,48	0,71	0,08	20,732	11,79	11,36	2845	309	1758
Feb 2011	1526,91	0,71	0,08	20,732	11,79	11,36	2650	288	1638
Mar 2011	1708,02	0,71	0,08	20,732	11,79	11,36	2964	322	1832
Apr 2011	1657,23	0,71	0,08	20,732	11,79	11,36	2876	312	1777
May 2011	1773,15	0,71	0,08	20,732	11,79	11,36	3077	334	1902
Jun 2011	1803,8	0,71	0,08	20,732	11,79	11,36	3130	340	1934
Jul 2011	1929,25	0,71	0,08	20,732	11,79	11,36	3348	363	2069
Ags 2011	1714,71	0,71	0,08	20,732	11,79	11,36	2976	323	1839
Sep 2011	1829,03	0,71	0,08	20,732	11,79	11,36	3174	345	1962
Oct 2011	1848,42	0,71	0,08	20,732	11,79	11,36	3208	348	1982
Nov 2011	1865,52	0,71	0,08	20,732	11,79	11,36	3238	351	2001
Dec 2011	1882,64	0,71	0,08	20,732	11,79	11,36	3267	355	2019
Jan 2012	1856,29	0,71	0,08	20,732	11,79	11,36	3222	350	1991
Feb 2012	1774,28	0,71	0,08	20,732	11,79	11,36	3079	334	1903
Mar 2012	1918,05	0,71	0,08	20,732	11,79	11,36	3329	361	2057
Apr 2012	1899,86	0,71	0,08	20,732	11,79	11,36	3297	358	2037
May 2012	2014,38	0,71	0,08	20,732	11,79	11,36	3496	380	2160
Jun 2012	2050,21	0,71	0,08	20,732	11,79	11,36	3558	386	2199
Jul 2012	2133,79	0,71	0,08	20,732	11,79	11,36	3703	402	2288
Ags 2012	2134,17	0,71	0,08	20,732	11,79	11,36	3704	402	2289
Sep 2012	2281,64	0,71	0,08	20,732	11,79	11,36	3960	430	2447
Oct 2012	2318,84	0,71	0,08	20,732	11,79	11,36	4024	437	2487
Nov 2012	2264,44	0,71	0,08	20,732	11,79	11,36	3930	427	2428
Dec 2012	2286,6	0,71	0,08	20,732	11,79	11,36	3968	431	2452
Jan 2013	2266,47	0,71	0,08	20,732	11,79	11,36	3933	427	2431
Feb 2013	2135,01	0,71	0,08	20,732	11,79	11,36	3705	402	2290
Mar 2013	2306,41	0,71	0,08	20,732	11,79	11,36	4003	435	2473
Apr 2013	2316,36	0,71	0,08	20,732	11,79	11,36	4020	436	2484
May 2013	2437,67	0,71	0,08	20,732	11,79	11,36	4230	459	2614
Jun 2013	2393,07	0,71	0,08	20,732	11,79	11,36	4153	451	2566
Jul 2013	2424,05	0,71	0,08	20,732	11,79	11,36	4207	457	2600
Ags 2013	2273,29	0,71	0,08	20,732	11,79	11,36	3945	428	2438
Sep 2013	2405,95	0,71	0,08	20,732	11,79	11,36	4175	453	2580
Oct 2013	2505,1	0,71	0,08	20,732	11,79	11,36	4347	472	2687
Nov 2013	2364,93	0,71	0,08	20,732	11,79	11,36	4104	446	2536
Dec 2013	2373,44	0,71	0,08	20,732	11,79	11,36	4119	447	2545
Average emission (g/hour)									2214

**Table 9 Calculation of total CO emissions by gas and diesel vehicles from Gresik to Surabaya**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100 km) Gasoline	KI (lt/100km ) Diesel	Q Gas-oline (g/hour)	Q Diesel (g/hour)	Total Emi- ssion CO (g/ hour)
Jan 2011	1639,48	462,63	11,86	20,732	11,79	11,36	1853933	45794	1079016
Feb 2011	1526,91	462,63	11,86	20,732	11,79	11,36	1726640	42650	1004930
Mar 2011	1708,02	462,63	11,86	20,732	11,79	11,36	1931445	47709	1124129
Apr 2011	1657,23	462,63	11,86	20,732	11,79	11,36	1874009	46290	1090701
May 2011	1773,15	462,63	11,86	20,732	11,79	11,36	2005089	49528	1166991
Jun 2011	1803,8	462,63	11,86	20,732	11,79	11,36	2039746	50384	1187162
Jul 2011	1929,25	462,63	11,86	20,732	11,79	11,36	2181606	53888	1269727
Ags 2011	1714,71	462,63	11,86	20,732	11,79	11,36	1939009	47896	1128532
Sep 2011	1829,03	462,63	11,86	20,732	11,79	11,36	2068285	51089	1203772
Oct 2011	1848,42	462,63	11,86	20,732	11,79	11,36	2090212	51630	1216534
Nov 2011	1865,52	462,63	11,86	20,732	11,79	11,36	2109541	52108	1227784
Dec 2011	1882,64	462,63	11,86	20,732	11,79	11,36	2128904	52586	1239054
Jan 2012	1856,29	462,63	11,86	20,732	11,79	11,36	2099112	51850	1221714
Feb 2012	1774,28	462,63	11,86	20,732	11,79	11,36	2006373	49560	1167739
Mar 2012	1918,05	462,63	11,86	20,732	11,79	11,36	2168941	53575	1262356
Apr 2012	1899,86	462,63	11,86	20,732	11,79	11,36	2148371	53067	1250384
May 2012	2014,38	462,63	11,86	20,732	11,79	11,36	2277876	56266	1325757
Jun 2012	2050,21	462,63	11,86	20,732	11,79	11,36	2318393	57267	1349339
Jul 2012	2133,79	462,63	11,86	20,732	11,79	11,36	2412910	59601	1404349
Ags 2012	2134,17	462,63	11,86	20,732	11,79	11,36	2413331	59612	1404594
Sep 2012	2281,64	462,63	11,86	20,732	11,79	11,36	2580093	63731	1501652
Oct 2012	2318,84	462,63	11,86	20,732	11,79	11,36	2622158	64770	1526135
Nov 2012	2264,44	462,63	11,86	20,732	11,79	11,36	2560647	63251	1490334
Dec 2012	2286,6	462,63	11,86	20,732	11,79	11,36	2585702	63870	1504917
Jan 2013	2266,47	462,63	11,86	20,732	11,79	11,36	2562941	63307	1491670
Feb 2013	2135,01	462,63	11,86	20,732	11,79	11,36	2414287	59635	1405151
Mar 2013	2306,41	462,63	11,86	20,732	11,79	11,36	2608106	64423	1517956
Apr 2013	2316,36	462,63	11,86	20,732	11,79	11,36	2619359	64701	1524506
May 2013	2437,67	462,63	11,86	20,732	11,79	11,36	2756534	68089	1604343
Jun 2013	2393,07	462,63	11,86	20,732	11,79	11,36	2706102	66844	1574991
Jul 2013	2424,05	462,63	11,86	20,732	11,79	11,36	2741132	67709	1595379
Ags 2013	2273,29	462,63	11,86	20,732	11,79	11,36	2570651	63498	1496157
Sep 2013	2405,95	462,63	11,86	20,732	11,79	11,36	2720665	67203	1583467
Oct 2013	2505,1	462,63	11,86	20,732	11,79	11,36	2832782	69973	1648721
Nov 2013	2364,93	462,63	11,86	20,732	11,79	11,36	2674277	66057	1556469
Dec 2013	2373,44	462,63	11,86	20,732	11,79	11,36	2683910	66295	1562075
Average emission (g/hour)									1358569



**Table 10. Calculation of total N<sub>2</sub>O emissions by gas and diesel vehicles from Gresik to Surabaya**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100k m) Gasoline	KI (lt/100km) Diesel	Q Gas-oline (g/hour)	Q Diesel (g/hour)	Total Emi-sion N2O (g/ hour)
Jan 2011	1639,48	0,04	0,16	20,732	11,79	11,36	160	618	356
Feb 2011	1526,91	0,04	0,16	20,732	11,79	11,36	149	575	332
Mar 2011	1708,02	0,04	0,16	20,732	11,79	11,36	167	644	371
Apr 2011	1657,23	0,04	0,16	20,732	11,79	11,36	162	624	360
May 2011	1773,15	0,04	0,16	20,732	11,79	11,36	173	668	385
Jun 2011	1803,8	0,04	0,16	20,732	11,79	11,36	176	680	392
Jul 2011	1929,25	0,04	0,16	20,732	11,79	11,36	189	727	419
Ags 2011	1714,71	0,04	0,16	20,732	11,79	11,36	168	646	373
Sep 2011	1829,03	0,04	0,16	20,732	11,79	11,36	179	689	398
Oct 2011	1848,42	0,04	0,16	20,732	11,79	11,36	181	697	402
Nov 2011	1865,52	0,04	0,16	20,732	11,79	11,36	182	703	406
Dec 2011	1882,64	0,04	0,16	20,732	11,79	11,36	184	709	409
Jan 2012	1856,29	0,04	0,16	20,732	11,79	11,36	181	699	403
Feb 2012	1774,28	0,04	0,16	20,732	11,79	11,36	173	669	386
Mar 2012	1918,05	0,04	0,16	20,732	11,79	11,36	188	723	417
Apr 2012	1899,86	0,04	0,16	20,732	11,79	11,36	186	716	413
May 2012	2014,38	0,04	0,16	20,732	11,79	11,36	197	759	438
Jun 2012	2050,21	0,04	0,16	20,732	11,79	11,36	200	773	446
Jul 2012	2133,79	0,04	0,16	20,732	11,79	11,36	209	804	464
Ags 2012	2134,17	0,04	0,16	20,732	11,79	11,36	209	804	464
Sep 2012	2281,64	0,04	0,16	20,732	11,79	11,36	223	860	496
Oct 2012	2318,84	0,04	0,16	20,732	11,79	11,36	227	874	504
Nov 2012	2264,44	0,04	0,16	20,732	11,79	11,36	221	853	492
Dec 2012	2286,6	0,04	0,16	20,732	11,79	11,36	224	862	497
Jan 2013	2266,47	0,04	0,16	20,732	11,79	11,36	222	854	493
Feb 2013	2135,01	0,04	0,16	20,732	11,79	11,36	209	805	464
Mar 2013	2306,41	0,04	0,16	20,732	11,79	11,36	226	869	501
Apr 2013	2316,36	0,04	0,16	20,732	11,79	11,36	226	873	503
May 2013	2437,67	0,04	0,16	20,732	11,79	11,36	238	919	530
Jun 2013	2393,07	0,04	0,16	20,732	11,79	11,36	234	902	520
Jul 2013	2424,05	0,04	0,16	20,732	11,79	11,36	237	913	527
Ags 2013	2273,29	0,04	0,16	20,732	11,79	11,36	222	857	494
Sep 2013	2405,95	0,04	0,16	20,732	11,79	11,36	235	907	523
Oct 2013	2505,1	0,04	0,16	20,732	11,79	11,36	245	944	545
Nov 2013	2364,93	0,04	0,16	20,732	11,79	11,36	231	891	514
Dec 2013	2373,44	0,04	0,16	20,732	11,79	11,36	232	894	516
Average emission (g/hour)									449

**Table 11. Calculation of total CO<sub>2</sub> emissions by gas and diesel vehicles from Gresik to Surabaya**

Months	Ni (PCU/hour)	Fei (g/litre) Gasoline	Fei (g/litre) Diesel	L (km)	KI (litre/100km) Gasoline	KI (lt/100 km) Diesel	Q Gas-oline (g/hour)	Q Diesel (g/hour)	Total Emission CO <sub>2</sub> (g/ hour)
Jan 2011	1639,48	2597,86	2924,9	20,732	11,79	11,36	10410604	11293686	10789068
Feb 2011	1526,91	2597,86	2924,9	20,732	11,79	11,36	9695801	10518251	10048280
Mar 2011	1708,02	2597,86	2924,9	20,732	11,79	11,36	10845867	11765871	11240154
Apr 2011	1657,23	2597,86	2924,9	20,732	11,79	11,36	10523342	11415988	10905904
May 2011	1773,15	2597,86	2924,9	20,732	11,79	11,36	11259408	12214490	11668729
Jun 2011	1803,8	2597,86	2924,9	20,732	11,79	11,36	11454025	12425616	11870421
Jul 2011	1929,25	2597,86	2924,9	20,732	11,79	11,36	12250627	13289790	12695983
Ags 2011	1714,71	2597,86	2924,9	20,732	11,79	11,36	10888341	11811948	11284172
Sep 2011	1829,03	2597,86	2924,9	20,732	11,79	11,36	11614282	12599467	12036504
Oct 2011	1848,42	2597,86	2924,9	20,732	11,79	11,36	11737409	12733039	12164108
Nov 2011	1865,52	2597,86	2924,9	20,732	11,79	11,36	11845950	12850786	12276594
Dec 2011	1882,64	2597,86	2924,9	20,732	11,79	11,36	11954684	12968743	12389281
Jan 2012	1856,29	2597,86	2924,9	20,732	11,79	11,36	11787389	12787258	12215904
Feb 2012	1774,28	2597,86	2924,9	20,732	11,79	11,36	11266622	12222317	11676205
Mar 2012	1918,05	2597,86	2924,9	20,732	11,79	11,36	12179508	13212638	12622278
Apr 2012	1899,86	2597,86	2924,9	20,732	11,79	11,36	12064000	13087333	12502571
May 2012	2014,38	2597,86	2924,9	20,732	11,79	11,36	12791220	13876239	13256228
Jun 2012	2050,21	2597,86	2924,9	20,732	11,79	11,36	13018742	14123061	13492022
Jul 2012	2133,79	2597,86	2924,9	20,732	11,79	11,36	13549493	14698833	14042067
Ags 2012	2134,17	2597,86	2924,9	20,732	11,79	11,36	13551857	14701397	14044517
Sep 2012	2281,64	2597,86	2924,9	20,732	11,79	11,36	14488299	15717273	15015002
Oct 2012	2318,84	2597,86	2924,9	20,732	11,79	11,36	14724508	15973519	15259799
Nov 2012	2264,44	2597,86	2924,9	20,732	11,79	11,36	14379097	15598808	14901831
Dec 2012	2286,6	2597,86	2924,9	20,732	11,79	11,36	14519793	15751439	15047641
Jan 2013	2266,47	2597,86	2924,9	20,732	11,79	11,36	14391982	15612787	14915184
Feb 2013	2135,01	2597,86	2924,9	20,732	11,79	11,36	13557228	14707224	14050083
Mar 2013	2306,41	2597,86	2924,9	20,732	11,79	11,36	14645601	15887919	15178023
Apr 2013	2316,36	2597,86	2924,9	20,732	11,79	11,36	14708792	15956470	15243511
May 2013	2437,67	2597,86	2924,9	20,732	11,79	11,36	15479086	16792104	16041808
Jun 2013	2393,07	2597,86	2924,9	20,732	11,79	11,36	15195887	16484882	15748314
Jul 2013	2424,05	2597,86	2924,9	20,732	11,79	11,36	15392594	16698276	15952172
Ags 2013	2273,29	2597,86	2924,9	20,732	11,79	11,36	14435277	15659753	14960052
Sep 2013	2405,95	2597,86	2924,9	20,732	11,79	11,36	15277669	16573602	15833069
Oct 2013	2505,1	2597,86	2924,9	20,732	11,79	11,36	15907249	17256587	16485537
Nov 2013	2364,93	2597,86	2924,9	20,732	11,79	11,36	15017180	16291016	15563110
Dec 2013	2373,44	2597,86	2924,9	20,732	11,79	11,36	15071269	16349694	15619165
Average emission (g/hour)									13584314

Based on the calculation from Table 4 to Table 11, a summary and conversion to ton/hour are performed and shown in Table 12.

**Table 12. The calculation of emission prediction in toll road Surabaya-Gresik 2011-2013.**

Emission of toll road from Surabaya to Gresik				Emission of toll road from Gresik to Surabaya			
CH <sub>4</sub>	CO	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	CO	N <sub>2</sub> O	CO <sub>2</sub>
995	610902	202	6108403	2214	1358569	449	13584314
g/hour	g/hour	g/hour	g/hour	g/hour	g/hour	g/hour	g/hour
0.0010968	0.673404184	0.000222667	6.733361719	0.002440517	1.497565975	0.0004949	14.974142
ton/hour	ton/ hour	ton/ hour	ton/ hour	ton/ hour	ton/ hour	ton/ hour	ton/ hour

From Table 12, it can be seen that the average emissions of Gresik to Surabaya line are bigger than the Surabaya to Gresik line. The result of this observation is in Tons and it is relatively large. However, this result is comparable to other research. Razif and Santoso<sup>5</sup> predicted result of total CO, CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions from toll road Krian-Legundi-Bunder in year 2048, is 11578.35 ton/hour, 115771.72 ton/hour, 18.87 ton/hour, and 3.82 ton/hour. Ratanavaraha & Jomnonkwao<sup>6</sup> predicted 225.33 million tons CO<sub>2</sub> by 2030 using curve estimation (cubic), and 91.68 million tons using log-linear regression. Rodríguez *et al*<sup>7</sup> suggest that fragmented and highly constructed cities experience higher concentrations of NO<sub>2</sub> and that densely populated cities suffer from higher SO<sub>2</sub> concentration. Çapraz *et al*<sup>8</sup> said SO<sub>2</sub> was associated with the largest deaths from cardiovascular disease, respiratory disease and total mortality. Su *et al*<sup>9</sup> said that final regression models explained 81%, 86% and 85% of the variance in measured NO, NO<sub>2</sub> and NO<sub>x</sub> concentrations, respectively, and cross-validation analyses suggested a prediction accuracy of 87–91%. Yazdi *et al*<sup>10</sup> said that average CO emission factors were estimated to be in a range of 4 to 12 g/km, depending on traffic conditions and variations of these emission factors under real working condition with speeds were determined.

**Conclusions**

Based on the result, several conclusions are concluded as follow:

1. Prediction of average CH<sub>4</sub> emission from vehicle passed from toll road Surabaya to Gresik year 2011-2013 is 995 g/hour and for Gresik to Surabaya is 2214 g/hour.
2. Prediction of average CO emission from vehicle passed from toll road Surabaya to Gresik year 2011-2013 is 610902 g/hour and for Gresik to Surabaya is 1358569 g/hour
3. Prediction of average N<sub>2</sub>O emission from vehicle passed from toll road Surabaya to Gresik year 2011-2013 is 202 g/hour and for Gresik to Surabaya is 449 g/hour
4. Prediction of average CO<sub>2</sub> emission from vehicle passed from toll road Surabaya to Gresik year 2011-2013 is 6108403 g/hour and for Gresik to Surabaya is 13584314 g/hour

**References**

1. Ministry of Environment. (2010). Ministry of Environment Regulation No.14/2010: Environmental documents for business and or activity that has permit of business and or activity but has had environmental document.
2. East Java Environmental Agency (2015). Environmental evaluation document in operation and activity of toll road Surabaya-Gresik.
3. Laksono, B.A and Damayanti, A. (2015). Analysis of the Sufficiency of Angsana Trees (PterocarpusIndicus) in Absorbing Carbon Monoxide (CO) due to Motor Vehicles Activity on the Ahmad Yani Street Surabaya. Journal of Applied and Natural Sciences, Volume 7 No 2, March 2015, doi : <http://10.7813/2075-4124.2015/7-2/A.27>
4. Ministry of Energy and Resource. (2012). Study of Greenhouse Gases on Transportation Section. Central Data and Information of Energy and Mineral Resource.
5. Razif, M. And Santoso, I.B. (2016). Prediction of CO, CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O Vehicle Emissions from Environmental Impact Assessment (EIA) at Toll Road of Krian-Legundi-Bunder in East Java of Indonesia. International Journal of ChemTech Research 9(3) pp 653-664.
6. Ratanavaraha, V. & Jomnonkwao, S. (2015). Trends in Thailand CO<sub>2</sub> emissions in the Transportation Sector and Policy Mitigation. Transport Policy, Volume 41, July 2015, Pages 136-146.

7. Rodriguez, M.C., Courtade, L.D., Oueslati, W. (2016). Air Pollution and Urban Structure Linkages: Evidence from European Cities. *Renewable and Sustainable Energy Reviews*, Volume 53, January 2016, Pages 1-9.
8. Çapraz, O., Efe, B., Deniz, A. (2015). Study on the Association between Air Pollution and Mortality in Istanbul, 2007-2012. *Atmospheric Pollution Research*, Available online 12 October 2015.
9. Su, J.G., Jerrett, M., Beckerman, B., Wilhelm, M., Ghosh, J.K., Ritz, B. (2009). Predicting traffic-related Air Pollution in Los Angeles using a Distance Decay Regression Selection Strategy. *Environmental Research*, Volume 109, Issue 6, August 2009, Pages 657-670.
10. Yazdi, M.N, Delavarrafiee, M., Arhami, M. (2015). Evaluating near Highway Air Pollutant Levels and Estimating Emission Factors: Case study of Tehran, Iran. *Science of The Total Environment*, Volume 538, 15 December 2015, Pages 375-384.

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