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Analysis of The Impact of Traffic and Pedestrianization Environment in Malioboro

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ABSTRACT: The phenomenon of the increasing number of Malioboro tourists is known to be raising traffic problems in the area, annually. These problems ranges from congestion and increased vehicle exhaust emissions, to increasing side friction. This has placed pressure on the Yogyakarta city government, as they have been tasked to plan and improve traffic management, through the transformation of Malioboro into a pedestrianized area. Moreover, pedestrianization in urban centres has been widely practiced in big cities of various countries. This application also has an impact on the significant changes in traffic flow on roads, around the area. This study simulated a traffic flow scenario on roads around Malioboro, via the use of a VISSIM software, in order to determine the saturation level of the movement, as well as the resulting emissions. The collection of generation and attraction data were carried out through household interview or traffic surveys, around the research area. However, the data used were obtained from the traffic survey results. The VISSIM is known to be a Microscopic flow simulation software, which is often used for traffic models. In this simulation, the existing condition, i.e, the Malioboro road that was still opened for motorized vehicles, was compared with the area's scenario (closed from motorized vehicle), as well as several gyratory alternatives on the surrounding. In order to determine the emission data released due to transportation activities, a node was placed at several simulated intersections. Also, three alternatives were observed to have been compared, with recommendations stating that those having less traffic impacts should be used.

KEYWORDS: Pedestrianization; Traffic, Malioboro; Vissim; Simulation.

1 INTRODUCTION

Pedestrianization in urban centres is known to be widely practiced in the big cities of various countries, especially in Europe and America. This development is rarely found in the big cities of Asia, especially in developing countries. However, Bangkok is one of the big cities in Southeast Asia, specifically, the Khao San shopping centre which has successfully implemented pedestrianization (Kumar and Ross, 2006). In addition, this development has an economic impact, which increases its general acceptance, such as reducing the occurrence of noise and accidents (Shahideh, 2013). A previous study stated that more than 100 cities around the world have implemented pedestrianization, which had been found to increase income and maintain stability level at 49% & 25%, respectively. Meanwhile, cities in Austria, Germany, and Scandinavia were observed to have experienced an enhancement in turnover, which was more than 60% (OECD, 1978). Pedestrianization also encourages local people to buy utilities within their environment, attract more customers from a wider area, and improve community relations (Manzano et. al. 2014; Cakiroglu, 2012).

Based on the increasing traffic volume and emissions, the application of pedestrian facilities also has an impact on the surrounding roads, which further results in a very high density at the intersection. An increase in traffic volume at the intersection has been found to cause higher fuel consumptions, which then results into greater emissions (Gunawan and Budi, 2017). The increase in emission is not only due to higher number of vehicles, but also based on locomotives that stop or run at low speed. Moreover, the research on vehicles being operated by both Liquid gas and Pertamax fuels, also indicated that lower engine speed produced higher emissions (Esaputra et al., 2016).

Furthermore, Malioboro is a shopping centre area in Yogyakarta City, Indonesia, which is often crowded with domestic and foreign daily visitors (Cahya et. al., 2017). Increasing the number of these visitors also means higher requirements for accommodation and transportation. Presently, the crowd of the Malioboro area has been increased, with motorized vehicles (private and public) causing congestion and higher air pollution (Sugiyanto et. al., 2010). Therefore, this situation prompted the government to transform Malioboro into a pedestrian area (Pradipto et. al., 2014). Rezika (2016), conducted a study on the effectiveness of the pedestrianized area arrangement in Malioboro, with a view to prioritize pedestrians, non-motorized vehicles, and public transportation, via the modeling of three additional parking pocket points, namely Abu Bakar Ali, Yogyakarta Tourism Office, and the former Indra Cinema building. Also, Lestarini et al. (2019) conducted an evaluation study on the implementation of pedestrianization, in the Malioboro area. The modeling results of the Malioboro Street closure from motorized vehicles, are found to have impacted the increasing traffic volume from 4% & 8% to 20% & 31% on weekdays and holidays, respectively. Unfortunately, this study did not state an alternative solution. Therefore, this study aims to analyze the impact of traffic and pedestrianization environment, in Malioboro. This involves carrying out comprehensive traffic management, through the creation of changes in the environment, in order for congestion to be minimized.

The VISSIM software has been selected for modeling use, in this study. VISSIM is a Microscopic flow simulation software, which is often used for traffic models (Abou-Senna t. al. 2013). Each characteristic of vehicles and pedestrians is also to be simulated individually (Chen et. al. 2019). Also, the unique operational conditions contained in a transportation system, is to be simulated by VISSIM. According to the plan of the study, data is required to be added to the software, and analyzed. Additionally, various effectiveness calculations, such as delay, queue speed, travel time and stops, should also be added to the VISSIM software.

2 METHODOLOGY AND ANALYSIS

VISSIM is a computer program that is used for modeling traffic conditions. Several types of data were required, including those of road network and inter-zone attraction. However, the necessary data were obtained from primary and secondary surveys. The collection of generation and attraction data was carried out by household interview or traffic surveys, in the study areas. Meanwhile, in this study, the generation and attraction data were obtained from the traffic survey results.

2.1 Traffic Surveys

The purpose of the traffic count survey was to determine the volume of flow (Q) on the road, in the Malioboro area. The results based on the 1997 MKJI (Manual Kapasitas Jalan Indonesia = Indonesian Highway Capacity Manual), which was issued by the Directorate General of Highways, showed the volume of traffic flow (Q) during the peak hours in the morning, on weekdays, as indicated in Figure 1.

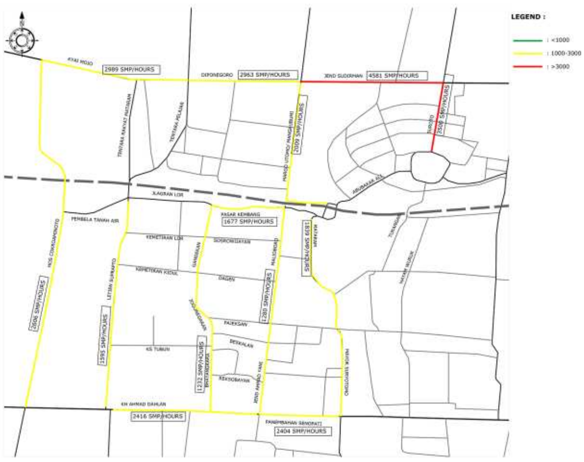


Figure 1. Traffic survey result image.

2.2 VISSIM 10.00 Program

According to PTV-AG (2015), VISSIM is a microscopic flow simulation software, used for urban traffic models. It was developed by PTV (Planung Transportasi Verkehr AG) in Karlsruhe, Germany, with the name coming from "Verkehr Stadten - SIMulationsmodell" (German for "Traffic in the city - simulation model"). The use of VISSIM started in 1992 and is presently known to be the global market leader. Moreover, the VISSIM simulation model was selected, in order to calibrate the road conditions.

VISSIM as a microscopic simulation or microsimulation, means that each vehicle and pedestrian characteristics were to be simulated individually. It also simulates the unique operational conditions contained in a transportation system. According to any study plan, data are often liable to be added to the software, as well as analyzed. Also, various effectiveness calculations, such as delay, queue speed, travel time, and stop, are eligible to be inputted into the VISSIM software. VISSIM has also been used to analyze networks of all sizes, ranging from individual junction distances to the entire metropolitan areas. According to PTV-AG (2015), VISSIM also provides animation capabilities, with enhancements in the 3-D simulation of different vehicle types (motorbikes, passenger cars, trucks, and trains). Also, video clips are liable to be recorded in the program, as well as the ability to dynamically change views and perspectives. Other visual elements, such as trees, buildings, transit facilities, and traffic signs, are also eligible to be incorporated into the 3-D animation.

2.3 VISSIM Result

In this simulation, the existing condition where Malioboro road was still opened for motorized vehicles, was compared with the area scenario (closed from motorized vehicles), as well as several gyratory alternatives on the surrounding. The simulated scenarios are presented in Table 1.

Table 1. Traffic flow direction change in gyratory scenario.

Road Name	Existing	1st Gyratory	2nd Gyratory	3rd Gyratory
HOS Cokroaminoto	Two Way	Two Way	Two Way	Two Way
Kyai Mojo	Two Way	Two Way	Two Way	Two Way
Jendral Sudirman	Two Way	Two Way	Two Way	Two Way
Pangeran Mangkubumi	One Way to South	One Way to South	One Way to South	One Way to South
Tentara Rakyat Mataram	Two Way	Two Way	Two Way	Two Way
Tentara Pelajar	Two Way	Two Way	Two Way	Two Way
Pembela Tanah Air	Two Way	One Way to East	One Way to East	One Way to East
Jlagran Lor	Two Way	One Way to West	One Way to West	One Way to West
Pasar Kembang	One Way to West	One Way to West	One Way to West	One Way to West
Letjend Suprapto	Two Way	One Way to South	One Way to South	One Way to South
Gandekan	One Way to North	One Way to North	One Way to North	One Way to North
Jogonegaran	One Way to North	One Way to North	One Way to North	One Way to North
Bhayangkara	One Way to North	One Way to North	One Way to North	One Way to North
Malioboro	One Way to South	Close	Close	Close
Mataram	Two Way	One Way to North	One Way to North	One Way to North
Suryotomo	Two Way	One Way to North	One Way to North	One Way to North
Senopati	Two Way	Two Way	Two Way	Two Way
KH A Dahlan (0 Km - Ngabean intersection)	Two Way	Two Way	One Way to East	Two Way
KH A Dahlan (Ngabean intersection – Wirobrajan intersection)	Two Way	Two Way	Two Way	Two Way
Abu Bakar Ali South Parking	Two Way	One Way to West	One Way to West	One Way to West
Abu Bakar Ali East Parking	One Way to North	One Way to North	One Way to North	Two Way

Also, the existing conditions via the Vissim simulation (after validation and calibration) and alternatives gyratory, are further shown in Figures 2, 3, 4, and 5. For the 3rd alternative, there was a special rule for locomotive flow (see Figure 5), which was shown to be allowing a two-way system (red and blue colours) to the North of Mataram street, via the control of a traffic signal.

Figure 2. Traffic flow on the existing condition of a road section.

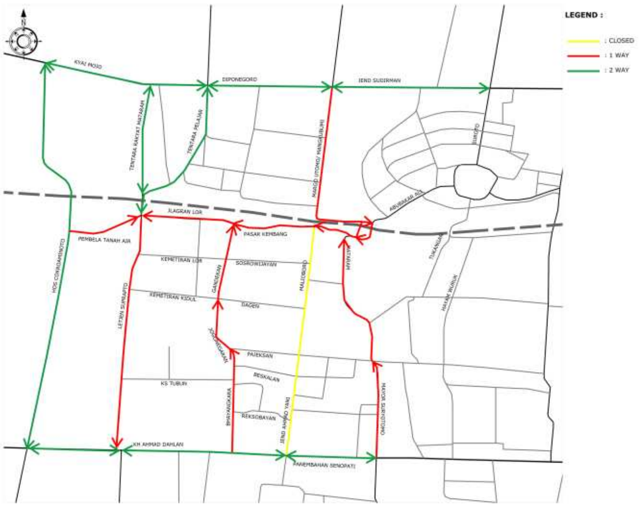


Figure 3. Traffic flow in 1st alternative gyratory scenario.

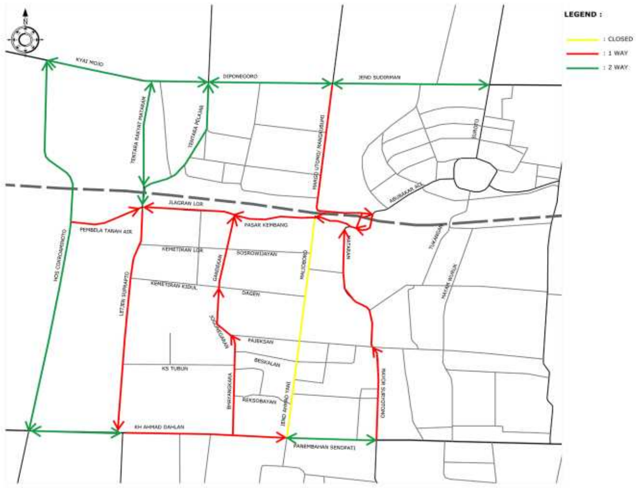


Figure 4. Traffic flow in 2nd alternative gyratory scenario.

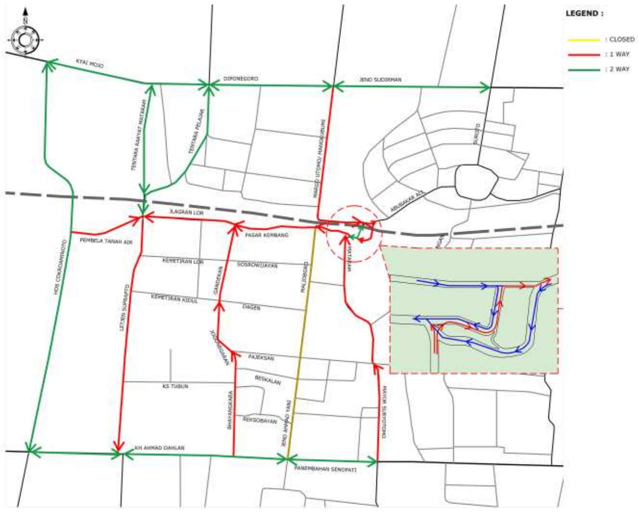


Figure 5. Traffic flow in 3rd alternative gyratory scenario

After running the Vissim in each scenario, the simulation results, which were in the form of traffic volume on roads and emissions generated by vehicles at several intersections, were obtained. Also, traffic flows had been simulated by Vissim, in order to determine the equilibrium of flow. The results of these traffic simulations are further shown in Table 2 and Figure 6.

Table 2. Traffic simulation result and the difference of the 3 gyratory scenario simulation.

No	Road Name	Existing Simulation Result	1st Gyratory Scenario Simulation Result*) and (%difference**))	2nd Gyratory Scenario Simulation Result*) and (%difference**))	3rd Gyratory Scenario Simulation Result*) and (%difference**))
1	Kyai Mojo	1890	1879 (-1)	2037 (8)	2120 (12)
2	P. Diponegoro	2668	3024 (13)	3177 (19)	3116 (17)
3	Sudirman	2981	2951 (-1)	3113 (4)	3344 (12)
4	Suroto	4678	5038 (8)	4849 (4)	4768 (2)
5	Mangkubumi	1237	850 (-31)	909 (-27)	1455 (18)
6	Malioboro	1342	0 (-100)	0 (-100)	0 (-100)
7	Mataram	1236	1128 (-9)	1534 (24)	1015 (-18)
8	P. Senopati	1712	**2880 (68)**	2276 (33)	2727 (59)
9	Centre of KHA Dahlan (Ngabean - PKU)	1918	2483 (29)	2039 (6)	2227 (16)
10	West of KHA Dahlan (Wirobrajan - Ngabean)	2438	2365 (-3)	2352 (-4)	2110 (-13)
11	HOS Cokroaminoto	1930	1951 (1)	2140 (11)	2023 (5)
12	Letjend. Suprapto	1149	1057 (-8)	1593 (39)	1149 (0)
13	Bhayangkara	1006	272 (-73)	140 (-86)	535 (-47)
14	ABA under the rail	1044	871 (-17)	1611 (54)	767 (-27)
15	Pasar Kembang	1017	1517 (49)	**2665 (162)**	1675 (65)
16	Kleringan	1209	832 (-31)	889 (-26)	1416 (17)
17	ABA Church	1252	1723 (38)	2346 (87)	1778 (42)
18	ABA Parking	896	444 (-50)	415 (-54)	357 (-60)
19	East of KHA Dahlan (PKU - 0 KM)	2109	2681 (27)	1886 (-11)	2411 (14)
20	Tukangan	1831	1505 (-18)	1166 (-36)	1258 (-31)
21	Hayam Wuruk	1649	2680 (63)	3122 (89)	**3193 (94)**

*) Traffic volume.

**) %Difference (increase or decrease) of Traffic volume of Gyratory scenario and existing traffic volume : positive value mean increase, while negative value means decrease.

Based on the data from Table 2, the roads that have experienced a decrease by more than 30% in the 1st gyratory scenario, were Mangkubumi, Bhayangkara, Kleringan, and the front of Portable Parking Structure of Abu Bakar Ali. Meanwhile, the roads that experienced an increase of more than 30% were the Panembahan Senopati, Pasar Kembang, Abu Bakar Ali in front of the Kotabaru Church, and Hayam Wuruk. Also, the highest increase of traffic volume was about 68%, which was detected at P. Senopati road.

In the 2nd gyratory scenario, the Jalan KHA Dahlan section was observed in the direction of the Ngabean intersection, to that of the KM Zero. From the data on Table 2, the roads that have experienced a decrease of more than 30% were the Bhayangkara, front of Portable Parking Structure of Abu Bakar Ali, and Tukangan. Meanwhile, those that experienced an increase of more than 30% were the Panembahan Senopati, Letjend. Suprapto, Abu Bakar Ali roads under the tracks, Pasar Kembang, Abu Bakar Ali in front of the Kotabaru Church, and Hayam Wuruk. Also, the highest increase of traffic volume was observed to be 162%, which was detected at Pasar Kembang road.

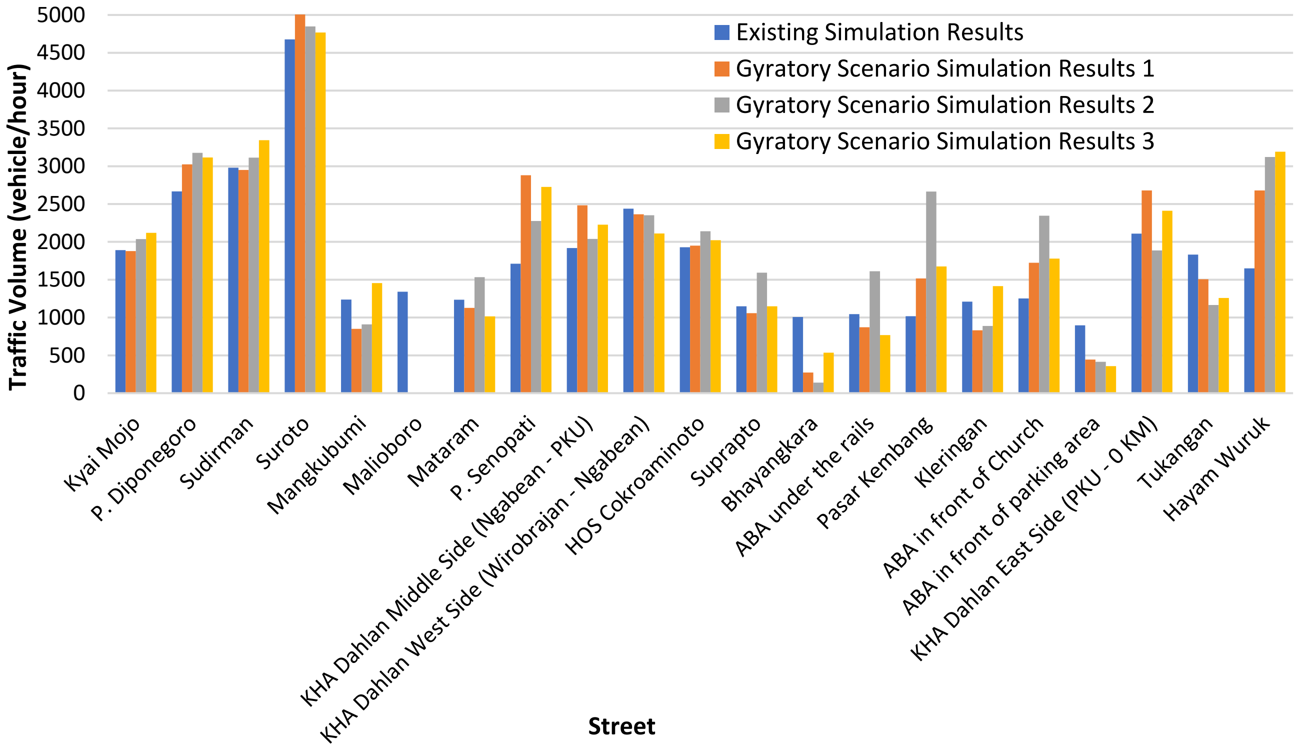


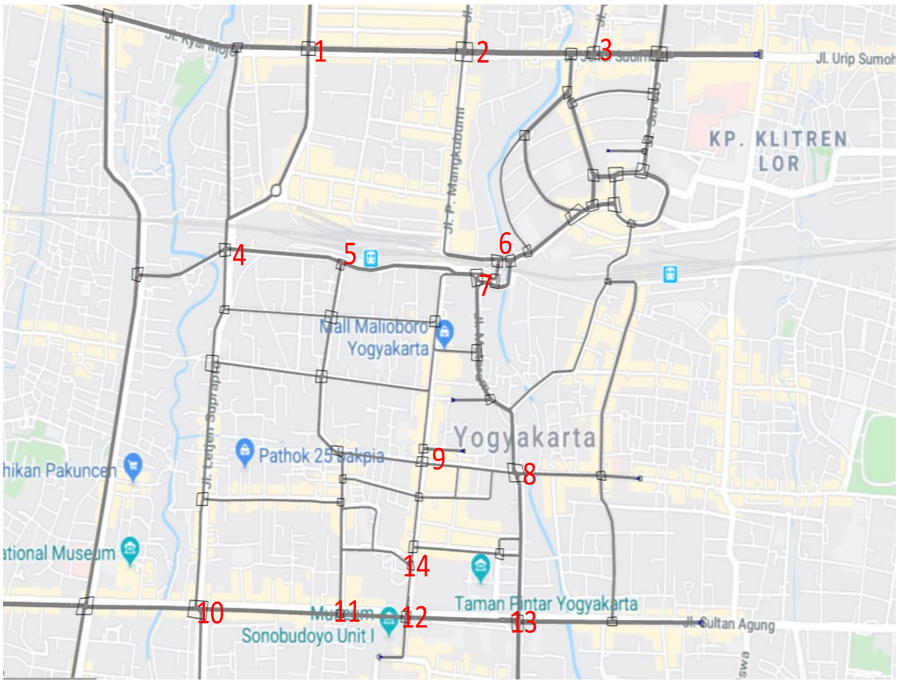
Figure 6. Traffic modeling result diagram.

From the data on Table 2, the roads that have experienced a decrease more than 30% in the 3rd gyratory scenario were the Bhayangkara, front of Portable Parking Structure of Abu Bakar Ali, and Tukangan. However, those that experienced an increase of more than 30% were the Panembahan Senopati, Pasar Kembang, Abu Bakar Ali in front of the Kotabaru Church, and Hayam Wuruk. Moreover, the highest increase of traffic volume was about 94%, and was detected at Hayam Wuruk road. These traffic modeling results are also shown in Figure 6.

From Figure 6, it was explained that the road in several scenarios, which consistently increased the volume of vehicles (after closure of Malioboro), were Jalan P. Diponegoro, Suroto, Senopati, KHA Dahlan (Sp Ngabean - PKU), HOS Cokroaminoto, Pasar Kembang, Abu Bakar Ali in front of Kotabaru Church and Hayam Wuruk. However, the roads that decreased the traffic volumes were the KHA Dahlan (Sp Wirobrajan - Sp Ngabean), Bhayangkara, front of the parking structure of Abu Bakar Ali, and Tukangan. Moreover, the roads in several scenarios, where the traffic volume fluctuated (down & up), included the Kyai Mojo (down in scenario 1, up in 2 & 3), Sudirman (down in scenario 1, up in 2 & 3), Mangkubumi (down in scenarios 1 & 2, up in 3), Mataram (down in scenarios 1 & 3, up in 2), Letjend. Suprapto (down in scenarios 1 & 3, up in 2), Abu Bakar Ali (down in scenarios 1 & 3, up in 2), Klerangan (down in scenarios 1 & 2, up in 3), and KHA Dahlan (Sp PKU - Sp Zero Km; down in scenario 2, up in 1 & 3).

2.3.1 Emission Simulation Result

In order to determine the emission data released due to transportation activities, a node was placed at several simulated intersections. The location of the intersections (light stop), which were attached to the node, are shown in Figure 7. Also, emissions were counted via the use of Vissim, with the diagrammatic representation shown in Figure 8. Furthermore, traffic closure of Malioboro road by the 3rd gyratory scenarios, were caused by a change (decrease or increase) in the CO emission conditions, at surrounding intersections and light stops.



Legend:
1. Pingit
2. Tugu
3. Sudirman. Mc Donald
4. Jlagran
5. Gandekan
6. Kleringan
7. Anim ABA
8. Melia
9. Pajeksan
10. Ngabean
11. PKU
12. 0 KM
13. Gondomanan
14. Ngejaman

Figure 7. Node / intersection data output of fuel and pollution consumption.

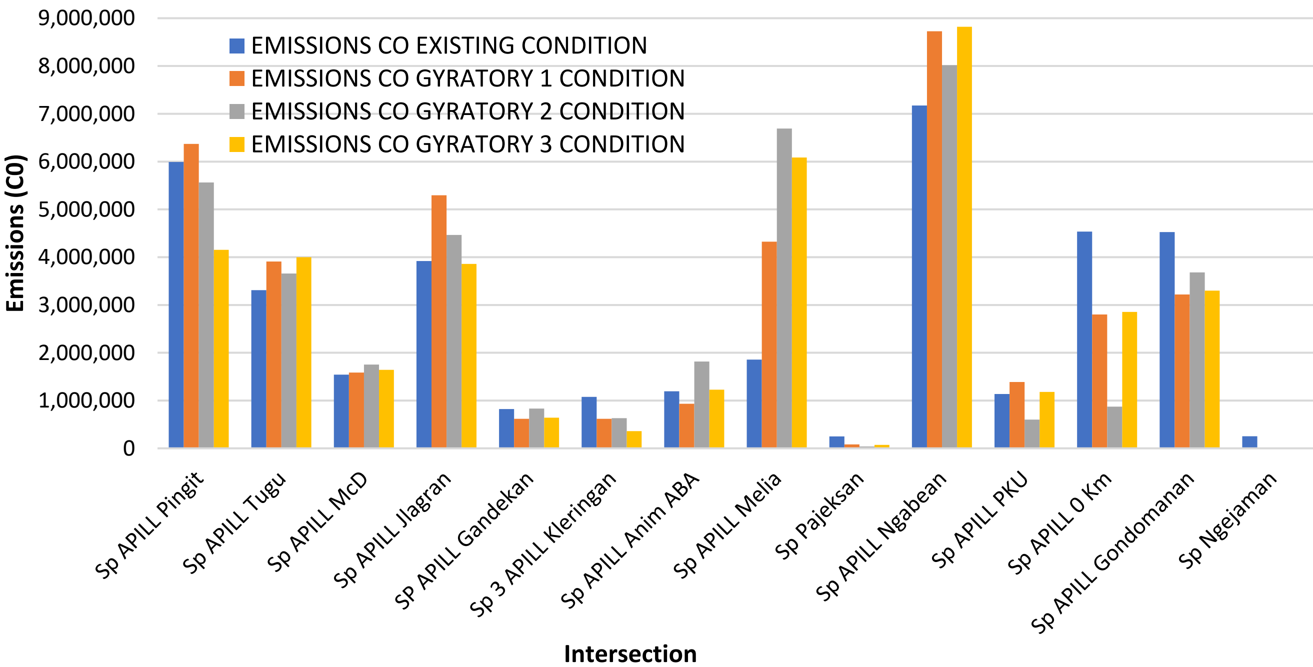


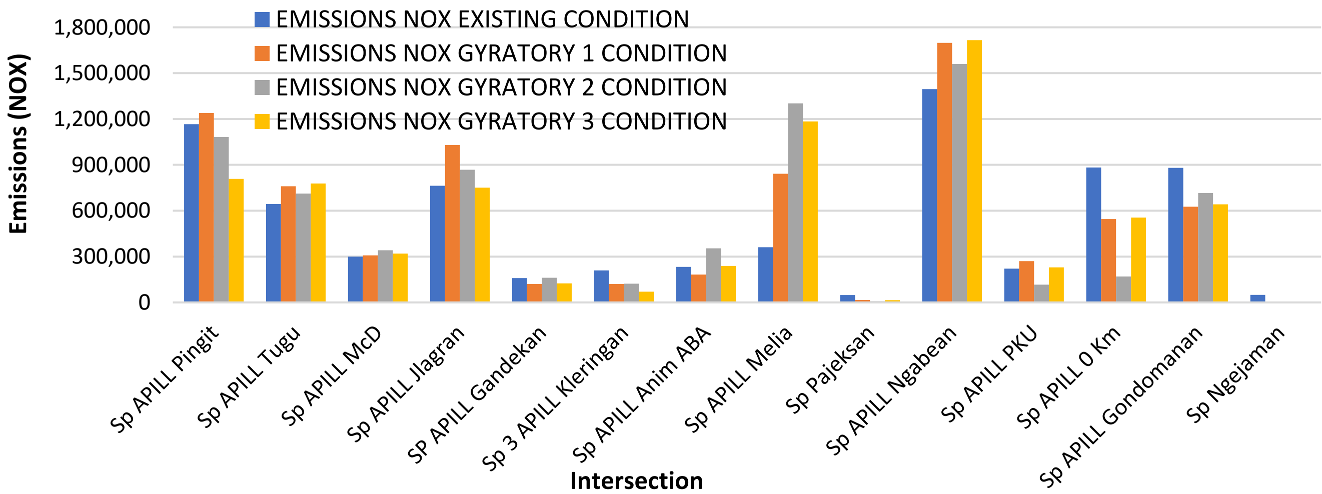
Figure 8. CO emission diagram.

Based on Figure 8, the intersection with CO emissions was consistently increased in all scenarios, at the Melia, Ngabean, and Tugu light stops. Also, the highest increase of the CO emission for the 3rd gyratory scenarios, was detected at the Melia intersection light stop. The CO emission condition at the intersections, increased at about 133%, 261%, and 228% for the 1st, 2nd, and 3rd gyratory scenarios, respectively. This condition was caused by the increase of traffic flow from Senopati, which was observed to continue till the Abu Bakar Ali or Hayam Wuruk roads. This reason was confirmed from Table 2, which indicated that the increase of traffic flow at Senopati and Hayam Wuruk roads were very high in all gyratory scenarios.

The CO emission condition at the Ngabean intersection also increased at about 18%, 11%, and 21%, for the 1st, 2nd, and 3rd gyratory scenarios. This condition was caused by the increase of traffic flow from the centre of KHA Dahlan and Letjend. Suprapto roads, which continued to the Wahid Hasyim way. Also, this reason was confirmed from Table 2, which indicated that the increase of traffic flow at the centre of KHA Dahlan road was high in all gyratory scenarios, compared to the Letjend. Suprapto, which was observed to be greater for the 2nd alternative only.

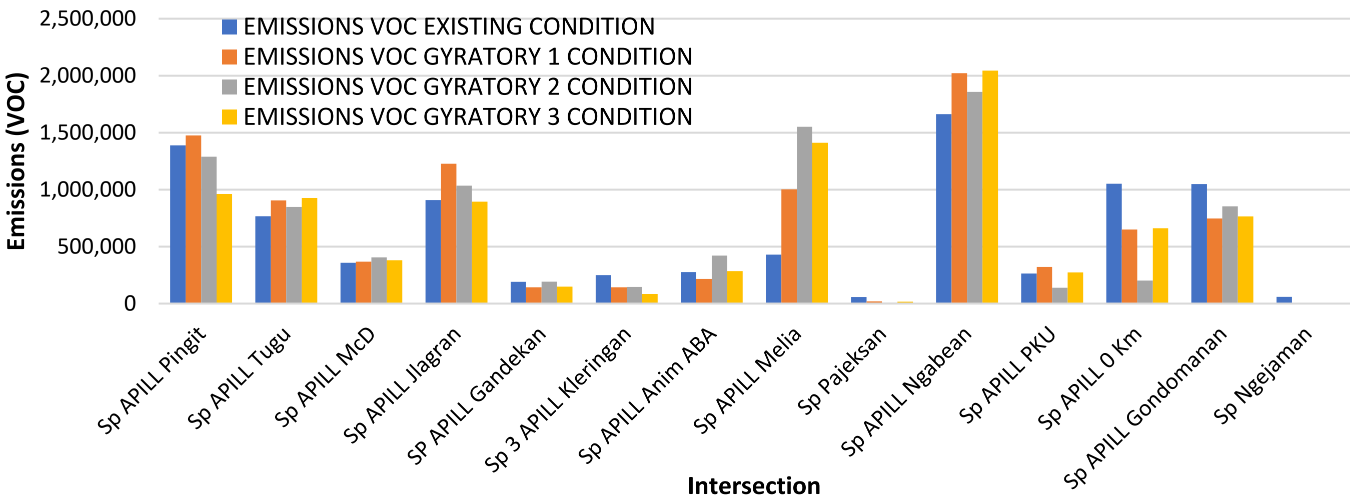
Furthermore, the CO emission condition at the Tugu intersection was found to be increased at about 22%, 12%, and 23%, for the 1st, 2nd, and 3rd gyratory scenarios, respectively. This condition was caused by the increase of traffic flow from P. Diponegoro, which continued to the Mangkubumi and Sudirman roads. This reason was also confirmed from Table 2, which indicated that the increase of traffic flow at P. Diponegoro road was high in all gyratory scenarios.

Based on the simulation of all scenarios for the emission of NOX and VOC, comparison with the existing condition, indicated similar results with the CO value, as shown in Figures 9, 10, and 11. The emission differences between the simulated scenarios and existing condition, was observed to be the positive correlation with the fuel consumption, as presented in Figure 11.



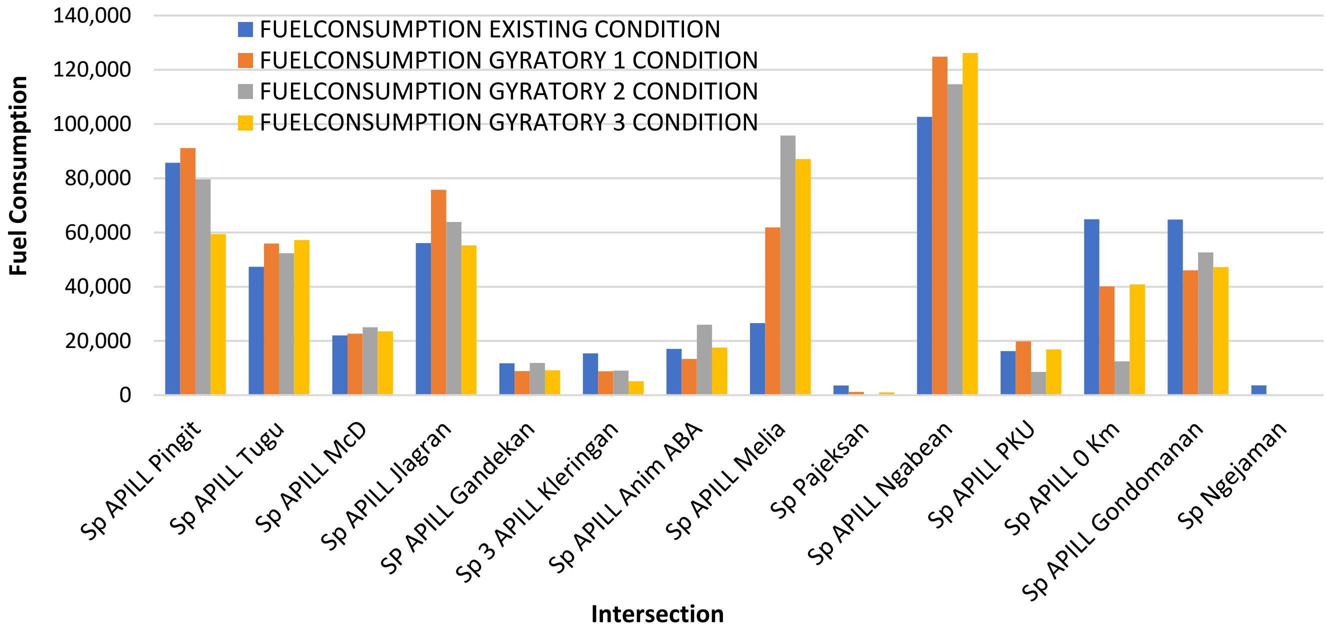
Sp APILL = signalized intersection; Sp = unsignalized intersection

Figure 9. NOX emission diagram.



Sp APILL = signalized intersection; Sp = unsignalized intersection

Figure 10. VOC emission diagram



Sp APILL = signalized intersection; Sp = unsignalized intersection.

Figure 11. Fuel consumption diagram.

From the data above, the intersections with the consistent increase in fuel consumption in all scenarios, was observed at the Tugu, Melia, and Ngabean light stops, which in turn increased the emission of CO, NOX and VOC, consequently.

3 CONCLUSIONS

The first alternative was concerned with making Mataram/Suryotomo, and Letjend. Suprapto roads one way, which in turn causes high traffic jams on KHA Dahlan road. The second alternative was concerned with making the KHA Dahlan road one-way, in order to reduce congestion on the KHA Dahlan road. However, this increases the flow through Pasar Kembang, with concerns of multiple violation occurrences on the KHA Dahlan road.The third alternative was concerned with continuing to make the KHA Dahlan road two-way. However, it was also concerned with making the Abu Bakar Ali road to Kotabaru into two directions, in order to reduce congestion on the KHA Dahlan, while also shifting some of the flow around Kotabaru.

The simulated results showed that all alternatives indicated the highest emissions in the Ngabean intersection light stop, which was observed to be caused by the most increased traffic volume. However, the highest increase of emission was detected in the Melia intersection light stop. Therefore, it is highly recommended to implement the third alternative, as it has been found to have less negative traffic impact.

DISCLAIMER

The authors declare no conflict of interest.

AVAILABILITY OF DATA AND MATERIALS

All data are available from the author.

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