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From Parking to Pollution: Investigating the Effect of 45^0 Parking on Environment

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***Abstract*—This study aims to examine the effect of managing side-road parking on environmental pollutions (i.e., NO2, CO, SO2, O, and noise). The study was conducted in Makassar, Indonesia, and four roads were selected as they were situated in the city center and surrounded by several business centers. Two roads were selected as the experimental roads and the rest as the control roads. The 450 parking technique was implemented, and the effect was evaluated using 2 (twice measures) x 4 (roads) experimental design. To evaluate the effect, this study measured air pollutions (using the Air Quality Measurement System), Noise (using Sound Level Meter), Vehicle Speed (Km/ hour), and Time of Road Occupancy (second). The results suggested that only the experimental roads showed a reduction in time of road occupancy. Meaning, managing parking effectively increased vehicles' speed. Also, the 450 parking technique was considered to be effective in reducing air pollutants and noise level. However, only CO that was consistently decreased as the result of the intervention. Although influenced by the parking technique, the other particulate emissions (SO2, NO2, and O3) and noise level might have been influenced by other variables. The parking intervention expanded the vehicles' moving space so that the time of occupancy was decreased and the engine combustion was more efficient. Parking management indirectly contributed to significant variance of air pollutants and noise. Discussion, implication, and limitations are included.**

***Keywords*—pollution; transportation; emission; parking; environment.**

I. INTRODUCTION

Air pollution has been identified as one of the major problems in many cities. People in many populated cities suffer from limited access to clean air [1]. Although many cities offer numerous attractions, opportunities, and luxury lifestyle, air pollution plays a pivotal role in reducing the quality of life. The immediate effect of contaminated air is unhealthy air supply [2] whereas air is an essential part of human life. Human's breathing system requires a certain amount of fresh air which is rich in oxygen and less carbon dioxide. Unfortunately, women and children who live in poverty are more vulnerable to unhealthy air supplies [3].

Considering the tremendous impact of polluted-air, many countries established their policies regarding a clean and safe environment. This also protects the environment from excessive pollutions which may endanger people's life. All significant factors affecting the climate, clean water, air, and environment have been investigated in some previous studies [4]. Concerning the clean air, there are several standards in which factories, vehicles, and residents should obey. The standards were used to conserve the environment and to avoid excessive use of toxic chemicals. Some chemicals can reduce the quality of the air and eventually increase air pollution.

A scientific finding suggested that traffic contributed a significant portion on noise and air pollution [5]. This study was conducted in Hong Kong where many city dwellers potentially were exposed by polluted air. Another finding also supported that reducing the number of car users by introducing bicycling could lower emissions caused by traffic [6]. This study also found that the subsequent effect of lower emissions would also positively impact the

environment as well as air quality. Regardless of the portion, traffic has a considerably large part in determining pollutants.

Although the effect of pollutants is detrimental to human, sustainable programs have been developed in several countries to reduce high air-pollution. For instance, a previous study successfully documented the reduction of 25% of CO2 after the implementation of environmental policies [7]. In China, for example, the government closely engaged in monitoring companies' activities to ensure that they emitted fewer air pollutants [8]. Another example came from Australia; a study performed a hypothetical model to predict the reduction of particulate matter by shifting passenger vehicles to alternative transports up to 40%. This study found that particulate matter would decline to 0.4 $\mu g/m^3$ and consequently increase the air quality [9].

Bearing the effect of traffic on air pollutants, managing traffic may offer a potential solution to reduce emissions as traffic flows directly impact pollution [10]. Many previous programs developed some intervention related to reducing the number of vehicles, reducing the vehicle occupancies, or shortening the travel distance. Unfortunately, these programs demanded higher costs and required a special agent to monitor the progress. A simple program, yet feasible to reduce pollutants is an alternative option. Managing traffic flow allows vehicles to perform at their optimum level which in return reduce road occupancy and air pollutants.

Traffic management can provide better air quality and reduce excessive emissions caused by motor vehicles [11]. By managing traffic properly allow, traffic flow would perform better and reduce air pollutants. Vehicle speed contributes significant effect on emission. A previous study found that traffic flow that had speed lower than 30 km/ hour potentially increased CO. The condition could be worse if the average speed reached 18 km/hour, it could increase CO by 40% (for diesel engine) or 60% (for petroleum engine) [12].

To optimize traffic flow, all traffic barriers should be managed. Side-way parking, in this regard, is one of the most observed barriers to the traffic flow. Unfortunately, parking still becomes an issue in many modern cities. Due to the growth of population and car ownership, governments in many cities are still struggling to manage to park effectively. The parking issue, then, rapidly impacts traffic flow as the drivers park their vehicles without implementing the best-parking practice. This is the case in one of the most populated cities in Indonesia.

This study initially conducted a pilot study to capture driver's perception in Makassar city. Given the fact that Makassar is one of the most populated cities in Indonesia, the study investigated how drivers perceive the side-road parking. The study found that of 164 randomly selected respondents, most of them agreed that the parking was poorly managed (31%), extremely disorganized (30%), and somehow managed (29%). Considering the results, nearly all respondents (90%) were not satisfied with the parking management.

Further, the study continued to investigate the cascading impact of disorganized parking. The results were as expected, 41% of respondents agreed that the side-way parking reduced the speed of traffic flow. Many respondents also suggested the side-way parking was often disturbing drivers (13%) and annoying (25%). Having considered the findings, it is plausible that many drivers were disturbed by the side-way parking in which reduced the traffic flows. On the other hand, some drivers would need side-road parking particularly around business area where some convenient stores are situated.

The increasing number of car users, as well as business areas, require an effective parking management. Better parking management should allow drivers to use side-road parking while still maintains smooth traffic flow. As mentioned earlier, traffic has a serious impact on emissions. Nearly a quarter of the total gas-related emissions were produced by vehicles and reducing the number of vehicles on the road could also lower the emissions [9]. Allowing cars or motor vehicles to move freely may lower the driving times and optimize the car's engine performance. Optimal engine performance potentially produces efficient combustion which consequently creates fewer emissions.

In particular, this study intended to examine the effect of managing side-road parking on environmental pollutions (i.e., NO2, CO, SO2, O, and noise). By implementing an effective parking strategy, it would allow the cars to run without obstacles and lower the number of emissions. After examining some criteria and road conditions, this study reached a conclusion suggesting that 45^0 parking could serve as an alternative parking strategy. Compared to the other parking positions (e.g., 180^0 and 90^0), the 45^0 angle opens more room for the traffic to flow, and it used less parking space. This later leads to better car performance and reduced pollution. However, a robust and systematic investigation is required to ensure the effect of the strategy.

II. Materials and Method

A. Setting

The study was conducted in Makassar city, the capital city of South Sulawesi and it is located in the center of Indonesia. Makassar had more 1.6 million population in 2013 and was listed as one of the major cities in Indonesia. As the top 5 cities in Indonesia and the biggest city in the eastern part of Indonesia, Makassar constructed many roads to support transportation. In this study, four roads (Somba Opu, Nusantara, Masjid Raya, and Jenderal Sudirman) were selected because they were located in the business center or public services. The roads had a significant amount of vehicles every day including in the weekend as opposed to other roads. For data collection purpose, 36-meter area of each road was selected as observation setting. The study was conducted in a week, starting from Monday through Sunday with three times observation a day.

B. Procedure

This study employed a test-retest experimental design with group comparison. To begin the data collection, eight observers were recruited from engineering Faculty in private and public universities where they were required to complete one-day training session on how to record vehicle speed and road occupancy. Two observers for each road perform their tasks in three different time slots (08.00 to 10.00, 12.00 to 14.00, and 17.00 to 19.00). There were required to repeat the observation for seven days in the same week. Researchers

also collaborated with the Environmental Department in South Sulawesi, Indonesia. The department measured the level of emissions at the same locations where the vehicle speed and road occupancy were documented.

In the following month, two roads were randomly selected as the experimental roads in which the 45^0 parking technique was implemented. The 45^0 parking technique is performed by directing drivers to park their vehicle according to 45^0 parking-angle. To ease the process, researchers and the team drew lines signal driver's parking position. The following image showed 450 parking-angle.

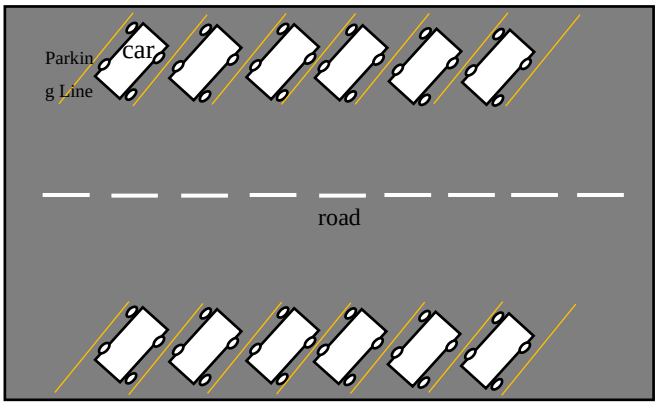

Fig. 1 450 parking technique

The observation procedure was repeated after the parking intervention to gather data regarding the vehicle speed and road occupancy as well as emissions and noise. A 2 x 4 ANOVA statistical test was performed to examine the effect of the parking model on the environment.

C. Measures

1) Air pollution: Air pollution level was measured using the Air Quality Measurement System (AQMS). The Department of Environment operated the measurement device in the City of Makassar. This device continuously measured the air quality and yielded air pollution data every 30 seconds. The data included Sulfur Dioxide (SO2), Nitrogen Dioxide (NO2), Ozone (O3), and Carbon Monoxide (CO). In this study, the air quality was monitored in three different time slots (08.00 to 10.00, 12.00 to 14.00, and 17.00 to 19.00), immediately after each two-hour vehicle observation on the roads.

2) Noise: Noise was measured using the Sound Level Meter (SLM); this device produced a number of noise level with the measurement unit of dBA (Decibel). The noise was measured in the three different time slots (08.00 to 10.00, 12.00 to 14.00, and 17.00 to 19.00) in seven consecutive days, during the vehicle speed and road occupancy observation.

3) Vehicle Speed: To measure average vehicle speed, one observer counted the number of vehicles passed the area of observation during the observation time. This observer also coded three types of motor vehicles; they were light vehicles (LV), heavy vehicles (HV), and motorcycles (MC). Then, the other observer measured the time spent by each vehicle from entrance to the exit of the observed area. The observation yielded duration (in second) for each vehicle to pass the observed area. The travel distance of the observed area (36 m) was divided by time spent to complete the trip from entrance to exit producing vehicle speed (km/hour).

4) Time of Occupancy: The time of road occupancy was measured using the duration needed (in second) for each vehicle to complete the trip. In other words, how long each vehicle stayed in the observed area. For this measure, one of the observers recorded the travel time of each vehicle between the entrance and exit point.

III. Results and Discussion

A. The Influence of 450 Parking on the Environment

This study compared the changes in the road occupancy and the environment after the 450 parking technique had been implemented. The researchers measured the condition of the road occupancy and the environmental condition before and after the implementation of the side-road parking.

Fig. 2 The condition of the roads before the intervention

Fig. 3 The parking position before the intervention

Fig. 4 The 450 parking technique

Fig. 5 The 450 parking position

Fig. 6 The 450 parking technique open more spaces on the road

To control the effects of other confounding variables such as the road conditions, other street situations, as well as street sizes, the research experiment was designed by examining the pretest-posttest and control-experiment. Thus, the researchers could investigate the conditions of the pretest and post-test from the controlled groups and experiment groups. The intervention should offer successful significant changes in the road occupation and reduce air pollution as well as noise level. To empirically evaluate the environment quality using the intervention, this study employed statistical analysis using data from air quality, noise level and road occupancy. The following graphs and statistical analysis used a 2 x 4 ANOVA (Analysis of Variance) technique:

1) The Changes of the Road Occupancy

After the implementation of the more-organized parking model using the 45^0 technique, the researchers found a significant change in the Time of Occupancy of the observed roads. The significant change occurred between the experimental roads and the control roads. Jenderal Sudirman *Street* and *Nusantara Street* as the experimental roads exhibited a lower average Time of Occupancy after the intervention. The Time of Occupancy in the Nusantara was reduced from 167 seconds to 102 seconds after the intervention. The same results were found in the Jenderal Sudirman Street where it was reduced from 189 seconds to 111 seconds. Meanwhile, Somba Opu Street and Masjid Raya Street demonstrated non-significant changes. It confirmed that parking management decreased the Time of Road Occupancy. The following table 1 shows statistical results of the effect of parking on the Time of Road Occupancy:

TABLE I
THE EFFECT OF THE PARKING TECHNIQUE ON THE ROAD OCCUPANCY

Sources	Type III Sum of Squares	Df	Mean Square	*F*	*p*
Corrected Model	242705[a]	7	34672	15	.000
Intercept	3928993	1	3928993	1716	.000
Location	87790	3	29263	12	.000
Condition	55946	1	55946	24	.000
Location * Condition	69269	3	23089	10	.000
Error	462422	202	2289		
Total	4902830	210			
Corrected Total	705127	209			
a. R^2= .344 (Adjusted R^2= .321)					

Also, the effect of the experimental parking model is shown in the graphic below. The graphic (figure 7) demonstrates the drastic declines of Time of Occupancy found in Nusantara street and Jenderal Sudirman street. The vehicle flow runs more smoothly on both roads. However, the road condition in Somba Opu Street and Masjid Raya streets stayed the same.

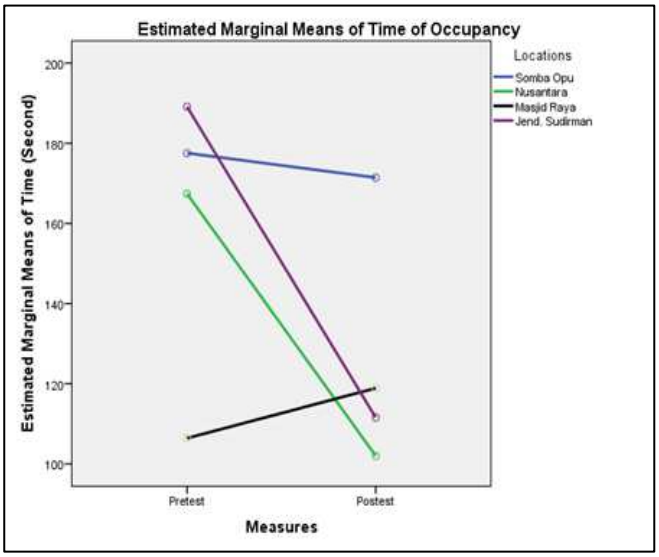

Fig.7 The changes of Time of Occupancy in each road

2) The Change of Sulphur Dioxide (SO2) after the Implementation of 450 Parking

First, there was a change on Sulphur Dioxide (SO_2) in the roads that received the parking intervention; Jenderal Sudirman Street and Nusantara Street. In Nusantara Street, there was a decrease in SO_2 from 68.59 to 63.26 meanwhile in Jenderal Sudirman Street; the change was from 69.95 to 61.95. Even though both streets showed clear changes, the same condition was also found in Masjid Raya Street which dropped from 75.38 to 70.57 whereas Somba Opu Street

displayed no significant changes. It indicated the existence of other factors during the observation which potentially caused a decrease in SO_2 in Masjid Raya Street.

TABLE II
THE EFFECT OF PARKING MODEL IMPLEMENTATION ON SULFUR DIOXIDE

Sources	Type III Sum of Squares	Df	Mean Square	*F*	*p*
Corrected Model	3495 [a]	7	499	9.82	.000
Intercept	914742	1	914742	17999.95	.000
Location	1008	1	1008.33	19.84	.000
Condition	1982	3	660.84	13	.000
Location*Condition	336	3	112.12	2.20	.089
Error	10265	202	50.81		
Total	996395	210			
Corrected Total	13760	209			
a. R^2= .254 (Adjusted R^2= .228)					

Further detail on the change of SO_2 is demonstrated in figure 8. The graphic displays that the decreasing changes of SO_2 found in all observed roads. However, even though all roads demonstrated the decreasing trend, the experimental roads had drastic changes. Meaning, other possible factors were determining the decreasing number of SO_2 during the observation, but unavoidably, the effect of the intervention emphasized the decreasing rate of SO_2.

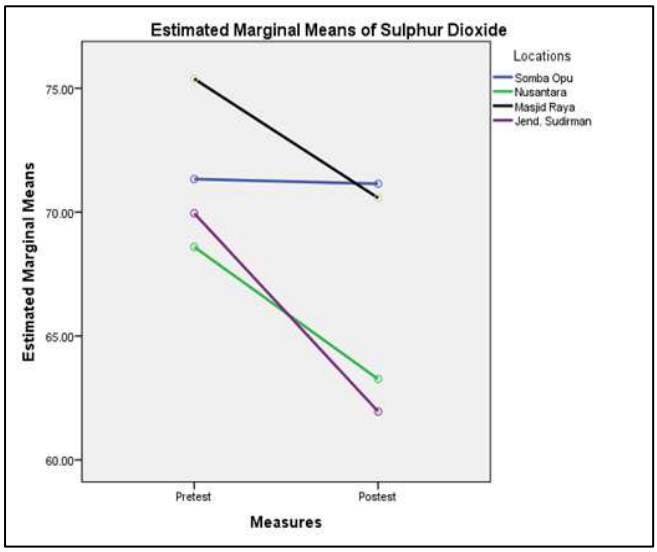

Fig.8 The changes of SO2 in all four observed roads

3) The Change in Nitrogen Dioxide (NO2) after the implementation of 450 parking

The changes in NO_2 were also detected during the observation. The decrease was only found in one of the experimental roads. Jenderal Sudirman Street had a decrease of NO_2 from 16.76 to 11.67 whereas no significant change was found in Nusantara Street. On the contrary, Masjid Raya Street which did not receive any intervention demonstrated a decrease in NO_2. This case hinders the conclusion to confirm that the decrease in NO_2 was triggered merely by the side-road parking. Thus, other unobserved factors might contribute to the decrease of NO_2.

TABLE III
THE EFFECT OF PARKING MODEL IMPLEMENTATION ON NITROGEN DIOXIDE

Sources	Type III Sum of Squares	df	Mean Square	*F*	*p*
Corrected Model	1738 [a]	7	248.31	6.54	.000
Intercept	50181	1	50181.33	1322.94	.000
Location	29	1	29.63	.78	.378
Condition	1356	3	452.11	11.91	.000
Location * Condition	369	3	123.31	3.25	.023
Error	7662	202	37.93		
Total	61888	210			
Corrected Total	9400	209			
a. R^2= .185 (Adjusted R^2= .157)					

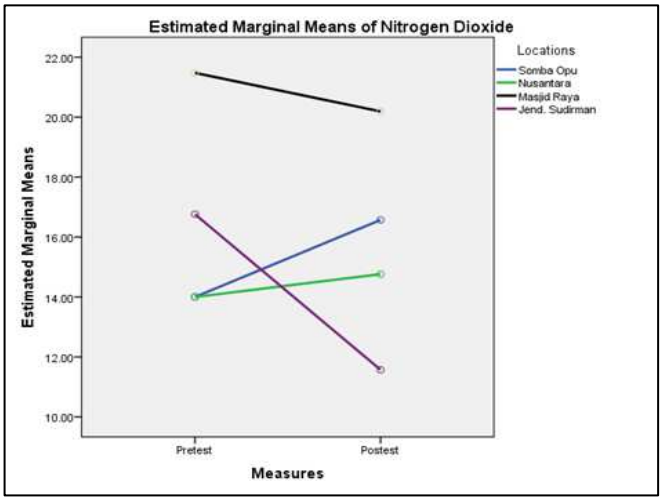

Fig. 9 The changes of NO2 in all four roads

Figure 9 points to the significant change of NO_2 found in Jenderal Sudirman Street, although it is still unclear to conclude that parking management could be the primary determinant factor. This confusion emerges since the other experimental road (i.e., Nusantara street), showed no significant decrease. On the contrary, Masjid Raya Street that received no intervention displayed a decrease in NO_2.

4) The Changes in Ozone after Implementing the 45^0 Parking

Next discussion reveals the change in the Ozone level after the implementation of 45^0 parking. In Nusantara and Jenderal Sudirman streets, the quantity of Ozone was reduced dramatically. The decrease was from 31.02 to 26.22 in Nusantara Street and from 34.75 to 29.03 in Jenderal Sudirman Street. However, Masjid Raya Street that received no intervention also showed a decrease from 40.08 to 35.30. It indicated other factors that reduced the level of Ozone other than the parking intervention.

Figure 10 indicates the decreasing trend in the three streets (Nusantara, Jenderal Sudirman, and Masjid Raya) and an increase of Ozone level in Somba Opu Street. Even though the researchers assume that parking intervention could reduce the Ozone level, other possible factors influenced the reduction. Therefore, it leads to the conclusion that parking management evidently could reduce the Ozone level by still considering the presence of other possible factors.

TABLE IV
THE EFFECT OF PARKING INTERVENTION ON OZONE

Sources	Type III Sum of Squares	df	Mean Square	*F*	*p*
Corrected Model	3461[a]	7	494	6.31	.000
Intercept	207571	1	207571	2652.11	.000
Location	647	1	647	8.27	.004
Condition	2390	3	796	10.18	.000
Location * Condition	272	3	90	1.16	.326
Error	15809	202	78		
Total	234706	210			
Corrected Total	19271	209			
a. R^2= .180 (Adjusted R^2= .151)					

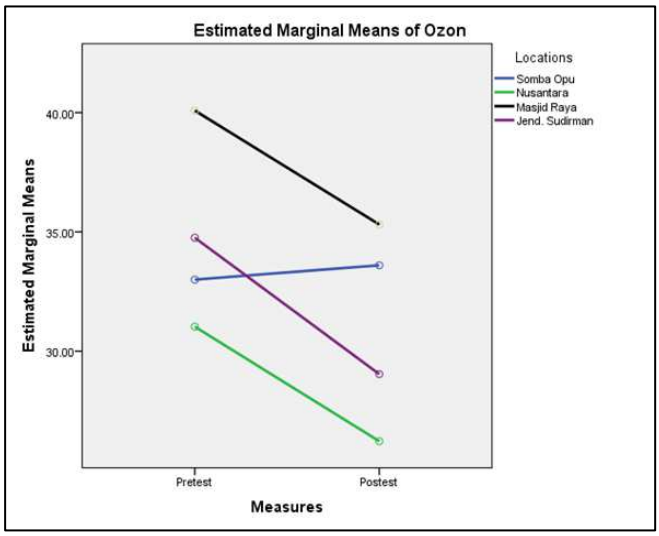

Fig. 10 The Change of Ozone in all four roads

5) The Change of Carbon Monoxide (CO) after implementing the 450 parking

The fluctuation of CO was also investigated. The results found a significant change before and after the implementation of the intervention in Nusantara and Jenderal Sudirman streets (p< 0.05). The average of CO in Nusantara Street decreased from 3326 to 3020; meanwhile in Jenderal Sudirman Street was from 3602 to 2961. The same results were not found in Masjid Raya and Somba Opu streets.

TABLE V
THE TEST OF THE EFFECT OF PARKING MODEL IMPLEMENTATION ON CARBON MONOXIDE

Sources	Type III Sum of Squares	df	Mean Square	*F*	*p*
Corrected Model	25514886 [a]	7	3644983	6.90	.000
Intercept	2318130816	1	2318130816	4388.95	.000
Location	2081191	1	2081191	3.94	.048
Condition	19129023	3	6376341	12.07	.000
Location * Condition	3657843	3	1219281	2.30	.078
Error	106691057	202	528173		
Total	2580487807	210			
Corrected Total	132205944	209			
a. R^2= .193 (Adjusted R^2= .165)					

As previously stated, only Nusantara and Jenderal Sudirman streets showed a decline in CO (see figure 11). Thus, it strongly suggests that the intervention reduced the level of CO so that it concluded that the intervention had a significant effect on the decline of CO.

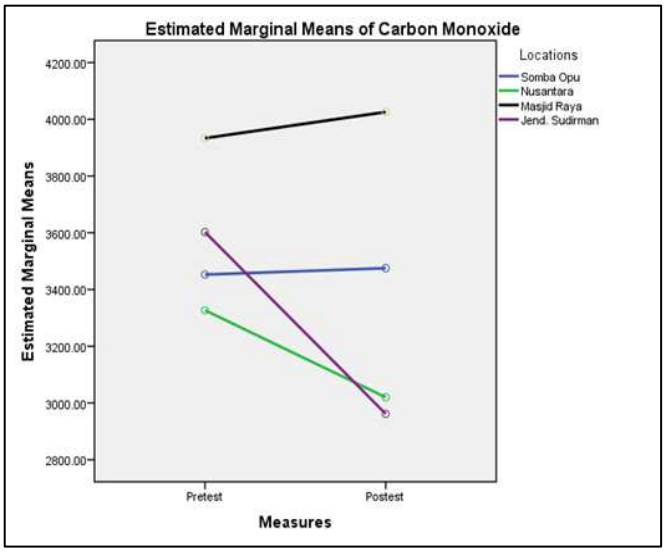

Figure 11. The changes of CO in all four roads

6) The Change in the Noise after the 450 Parking Implementation

The noise level showed significant changes in only one road. Between the two experimental roads, the decline was only found in Jenderal Sudirman Street whereas Nusantara showed no significant change. The result of the statistical test (table 6) indicated no significant change before and after the intervention in Nusantara (p> 0.05). Although it was only in a control condition and no intervention was added, Somba Opu Street exhibited a substantial increase in the noise level.

TABLE VI
THE TEST OF THE EFFECT OF PARKING ON THE NOISE LEVEL

Dependent Variable: Noise					
Sources	Type III Sum of Squares	df	Mean Square	*F*	*p*
Corrected Model	1251.386[a]	7	178.769	4.698	.000
Intercept	900442.347	1	900442.347	23664.288	.000
Condition	13.170	1	13.170	.346	.557
Location	982.505	3	327.502	8.607	.000
Condition * Location	256.495	3	85.498	2.247	.084
Error	7686.238	202	38.051		
Total	982291.000	210			
Corrected Total	8937.624	209			
a. R Squared = .140 (Adjusted R Squared = .110)					

The following figure 12 shows the change in the noise level in all four roads. The results suggested that the 45^0 parking technique influenced the decline in the noise level in one of the experimental roads. On the contrary, there was a control road that demonstrated a substantial increase in the noise level. The results seemed to suggest that the parking

intervention may not be solely influenced by one single factor. In other words, parking was not the only predictors for noise levels.

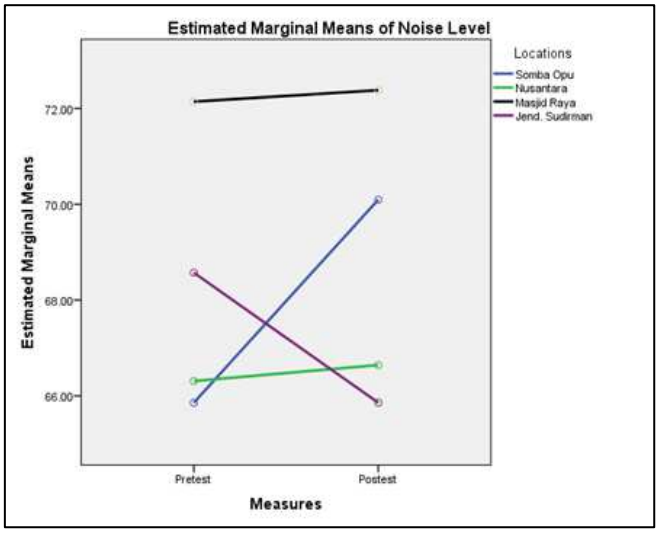

Fig 12 The comparison of the noise level in four roads

B. Discussion

Previous research found several causes of driving anger on the road. Several causes ignite the anger of car drivers and bike riders. Slow driving and traffic obstructions slow down vehicle speed and tend to make drivers angry [13]. Side-road parking can obstruct the vehicle speed that makes drivers angry. This leads to a negative perception of the side-way parking since it has been judged as one of the traffic obstructions.

Another research stated that others heavily influenced drivers' behaviors. In other words, vehicles would slow down when other vehicles in front of them were slowing down because they followed the "leading" vehicle [14]. This condition would continuously create a long traffic jam. The side-way parking can block the first vehicle followed by other vehicles at the back consecutively. Therefore, drivers negatively perceive that side-way parking is the cause of the traffic jam if this undesired condition is neglected without a room to improve.

It is claimed that, unavoidably, one traffic jam spot could be expanded then influence other connected traffic spots [15]. It is further suggested that the searching for the solution could be explored by using computer-simulated theories or analysis. From the aforementioned computer simulation, it is detected that traffic jam could have been badly developed over the network if it was not cleared out within a short time. The traffic jam prompted by the side-way parking was not only influenced the street where the vehicle parked but also could be extended to other connected roads over the network.

The intervention was intended to comprehend the effect of side-way traffic obstructions, including the road occupancy and its effect on the pollutants and the noise on the roads. The intervention conducted in this current study was designed to compare the road conditions before and after the parking change on the side-way. The researchers also compared its effect in the experimental roads and control roads. The evaluation design of the intervention was carefully selected to be able to accurately evaluate the changes in the road conditions as well as the pollutants after the parking intervention.

The 45^0 parking was chosen since this parking method was expected to be able to leave more space on the roads, compared to the unmanaged parking methods. After the 45^0 parking was applied, drivers would manually position their vehicles by following the preceding cars already parked in the set position. This kind of parking management allowed more space so that vehicles could pass more smoothly during the observation. The researchers also examined the significant changes of several variables; they were the time of occupancy, occupancy percentage, SO_2, NO_2, Ozone, CO and level noise. The results yielded in different reactions in each observed variable.

First, it was found that time of occupancy was decreased in both of the 45^0 parking-intervened roads. It indicated that if parking was managed by using the 45^0 technique, it left more space on the lanes and made the traffic run more smoothly since the passing vehicles would have shorter time travel. When the traffic runs smoothly, vehicles will need a shorter duration to pass the roads. If the side-way parking is blocking half of the roads, moving vehicles will require a longer time to pass by. It leads to the high time of occupancy, as found on the control roads. The time of occupation on both the control roads did not show significant change.

Furthermore, it was also found that the percentage of occupancy also increased in the 45^0 parking-intervened roads. The percentage of occupancy increased not only because of the duration of the moving vehicles on the roads but also of the high number of vehicles at some specified time. The percentage of occupancy in the experimental roads increased due to the high number of vehicles that passed by the roads. Since the time of road occupancy at the experimental roads declined, it can be argued that the percentage of occupancy was high because of more passing vehicles.

Unlike the experimental roads, Somba Opu Street showed no significant change; meanwhile Masjid Raya Street had a lower percentage of occupancy. Other factors could influence the lower percentage of occupancy in Masjid Raya Street during the observation. For example, there was a decline in the number of parking vehicles in Masjid Raya Street as well as the number of passing vehicles during several days of observation.

The parking management also influenced the changes of several pollutants and noise as other variables. The change of each variable on the environmental pollution tended to vary. Some variables on the experimental roads decreased but there were also several decreasing levels found on the non-experimental roads. In some conditions, the experimental roads also showed increasing pollutant levels. It requires further explanation to comprehend the change after the implementation of the intervention.

The results of the SO_2 level detected decreasing number on both experimental roads. However, Masjid Raya Street that received no intervention also showed a decline even though it was not as high as both experimental roads. It indicates that other conditions must have determined the SO_2 level although the road received no parking intervention. The condition of SO_2 level on the surrounding environment was not only influenced by airborne pollutant emissions from traffic vehicles but also by other pollutants such as

manufacture machines and other variables that were not observed in this study.

The result also explored the change in NO_2 in the observed roads. NO_2 was decreased only in one of the experimental roads (Jenderal Sudirman Street) while Nusantara Street showed no decrease. Other contributing factors must have determined the decrease found in Jenderal Sudirman Street but they were not the focus or the variables of the research. For example, Nusantara Street was an industrial area where several factories must have contributed significantly to the number of NO2 so that the decline of air pollutant emissions from vehicles might not affect the NO2 level on the area.

Somba Opu Street that received no intervention showed an increasing trend on NO_2. Somba Opu Street had a similar characteristic as Nusantara Street since both of them were busy streets occupied with shops and home industries. Without the parking intervention, the level of NO_2 could increase at any times. Therefore, after receiving the intervention, even though Nusantara Street showed no decline, the intervention still somehow managed to reduce NO_2 so that it did not increase significantly.

Furthermore, the decline in Ozone was found not only in the experimental roads but also in Masjid Raya Street whereas Somba Opu Street was quite stable. It indicates that the Ozone level was decreased in both experimental locations since the emission was not concentrated in the areas after the traffic became smoother. However, the Ozone level in Masjid Raya Street was declined due to the road character that had a dynamic pollutant change. Thus, other possible variables that reduced the Ozone level in Masjid Raya, although the street received no intervention, were still in questions

CO was declined in both experimental streets, which were Jenderal Sudirman Street and Nusantara Street. On the contrary, no change of CO level was found in non-experimental roads (Somba Opu Street and Masjid Raya Street). This finding confirmed to the prior expectation, claiming that the decline in CO level was only found in the experimental roads whereas the non-experimental roads showed stable levels. The results ascertained that the intervention helped the traffic to run smoothly, so that engine combustions were more efficient, leading to the reduction of CO emission. Therefore, parking management was a determinant factor in reducing the level of CO in the air.

Different results were found for the noise level. The noise reduction only occurred in Jenderal Sudirman Street as the result of the intervention while Nusantara Street did not demonstrate any significant decrease. In contrast, Somba Opu Street showed a significant increase in the noise whereas Masjid Raya Street managed to be stable. Due to the various results, it is unlikely to claim that parking management reduced the noise level. Even though one of the observed roads had a lower noise level, the other three roads did not give the same results. Moreover, Somba Opu Street that received no intervention had a higher noise level.

Noise is not only caused by vehicles. For example, Somba Opu as a trade and creative industry area attracted a mass of people at the same time required various heavy machines to work; the vehicle machine was just one of the factors contributing to the noise. A similar situation was found in Nusantara Street. Even though it received the intervention, traffic vehicle was not the only source of noise pollution. Thus, the decreasing percentage of occupancy did not lead to noise reduction.

It should be noted that the researchers were aware that Masjid Raya Street was always positioned at the highest average of environmental pollution among the other three roads. The pollution movement and the noise on the road were not stable and must have been determined by other diverse variables. Those possible variables could determine the fluctuation of the pollutant level or environmental pollution. Air pollutant emission from traffic vehicles was just one factor among other possible variables that contribute to environmental pollution. The parking intervention succeeded in reducing several air pollutants. However, the change of the pollutant levels was not merely determined by the passing vehicles. Thus, further study is highly required.

Based on the intervention and the measurement, it could be summarized that parking management could be a determinant of the traffic flow. It led to more efficient engine combustion at the same time reduced the pollution level concentrated in a particular road. Further, parking management could reduce several air pollutant levels from vehicles. Unfortunately, even though the parking management had potential in reducing the pollutant levels, the pollution was not only generated from the traffic emissions. The condition on some roads demonstrated that other unobserved factors could increase air pollution and noise level.

Previous research stated that the effect of air pollutant emissions from traffic vehicles could prompt the CO concentration. Even though other pollutant concentrations could grow, the increase of CO was mainly determined by traffic emissions. It was by another study claiming that high-concentrated CO was found at the dense and jammed traffics [16]. It emphasizes the current finding where CO was found lower in the experimental roads only. On the contrary, the non-experimental roads showed a relatively stable level of CO. Different from CO, another pollutant level such as NO_2 was highly influenced by diverse variables. As stated by Han and Naeher [16], NO_2 could be produced from traffic emission or chemical reactions in the atmosphere. Thus, even though the current study found a decrease in NO_2 on the experimental roads, it was not sufficient to claim that the lower traffic emission was the only reason for the decrease in NO_2.

Previous research investigated that a narrow lane and a high-concentrated emission in a particular area could deteriorate the pollution contamination. Based on the prior finding, if the airflow in some roads were blocked, the concentration levels of CO and NO_2 could increase faster [17]. It happened when vehicles attempted to pass by the obstructions due to the side-way parking. The street-occupying vehicles and densely tall buildings blocked the air circulation in busy streets. This condition leads to a high-concentrated emission such as CO and NO_2.

The disorganized condition created by side-way parking can deteriorate the environmental contamination. Previous research found that if the traffic speed was less than the average of 30 km/hour, it could increase CO production,

where 18 km/h speed could reach to 40% (for diesel-based machines) or 60% (for petroleum-based machines) higher than the free running vehicles [12]. The study also discovered that all vehicles attempting to pass the side-way barriers moved less than 18 km/h. After an intervention, both experimental locations showed a decrease in the travel time, signifying that vehicles moved faster. Thus, it can be concluded that the increasing speed influenced the efficient engine combustion so that CO production could be decreased and CO concentration on the roads could be reduced as well.

1) Controlling Environmental Pollution through the 450 Parking Intervention

Pollution that contaminates environment has been long examined not only in Indonesia but also in numerous international forums. One of the contributing factors to air pollution was the traffic emission that could also be influenced by traffic management [11]. Aside from the types of vehicles, traffic management can be a determinant in increasing CO levels as has been currently found and discussed in this study.

The researchers have examined the effectiveness of reducing air pollution through parking management. The 45^0 parking method was applied to lower the narrowing street space and to accelerate the traffic flows. The slow speed creates street density so that the vehicles cannot combust the engine perfectly. It accumulates the traffic emission such as CO and NO_2 that are produced excessively compared to faster moving vehicles, thus consequently forming air pollution.

After conducting the evaluation and analysis, the researchers argue that parking management contributes to the intensity of particulate emissions such as CO. Even though the declines were also found in SO_2, NO_2, O^3, and Noise, the researchers assume that other variables significantly determined the intensity fluctuation of SO_2, NO_2, O^3, and Noise. These conclusions were reached through the observation in the non-experimental roads that sometimes showed declines in spite of receiving no intervention. Thus, the researchers claim that parking management could lower the pollution intensity for SO_2, NO_2, O^3, and Noise although parking management could not have been the sole cause of the pollutant dynamic.

This current study obviously proved that parking management could leave more space for vehicles to pass by the roads. The research also showed that side-way barriers did not only increase the pollutant but also triggered negative emotional driving conditions. Unmanaged parking method did not only emanate air pollution but also influenced drivers' emotional condition and mental health. A measurement on emotional driving condition and proved that street obstructions could trigger negative emotional conditions such as anger has been established [13].

The current result provides important information that systematically simple parking management with 45^0 declivities could reduce the intensity of air pollution and allow for effectively in the street usage for drivers. Thus, the result requires further development to comprehend deeply on the transportation management method so that it can reduce the air pollution generated from the traffic emission due to the inefficient engine combustion.

2) Limitation and Further Research

The researchers have perused numerous studies, collected some data, conducted analysis and managed several interpretations to reach the research results. Even then, at the end of the research, several limitations demand additional examinations. Here are the limitations and the potentials that can be investigated deeper:

The researchers assume that other possible variables influenced environmental pollution; traffic emission was just one of the factors. Based on the result, parking management was not the only treatment that could reduce the intensity of pollution. Therefore, it is suggested for further research to investigate other factors that contribute to air pollution. For example, roads that are occupied with densely high buildings and street locations in industrial areas can generate severe pollution. However, advanced research is required to prove the hypothesis.

Second, roads have their own distinct conditions that distinguish them from one to another, thus, the parking method best applied is not always the 45^0 method. The researchers chose this technique by considering the contour of Nusantara and Jenderal Sudirman streets. The use of the technique allowed more street space so that it eased the drivers to park their vehicles. However, any kind of parking methods will not work when applied in different roads such as Somba Opu Street. Its wide is only three meters meanwhile the road has already been occupied crowdedly with shops and home industries. This case requires further research to investigate which method works best to reduce the contamination in similar road condition.

One of the unobserved studies is the health level of the nearby population who live in an area that is consistently contaminated by high traffic emission. This is crucial to understand and conduct preventive treatments if the people are exposed to the contamination that threats their health. The data analysis result of the current study showed that emission was still below the dangerous level. However, further research is highly needed to examine the effect of parking management, pollution and people's health condition in a long time.

Lastly, even though the researchers measured the emission accumulated in the roads, the emission from individual vehicles was not calculated. It would take more complex procedures such as stopping each vehicle to measure its emission. The current research was aided by the local environmental department to access some data on environmental pollution as needed. It restricts the reliability to accurately identify if the emission was generated from vehicles or other factors.

Based on the above explanation, the researchers need to investigate an experiment to distinguish the emission from each vehicle in various areas. It can emphasize the different levels of contamination produced by different vehicles in some conditions. The researchers have examined the effect of percentage of occupancy on several pollution variables. However, the researchers could not control other possible variables that might contribute to reducing the air quality at the same time. Therefore, further research is required to

examine the effect of particulate emission by controlling or involving other variables.

IV. Conclusion

The intervention attempted to manage side-way parking by using the 450 methods showed a significant effect in reducing the level of several particulate emissions. Nevertheless, it was only CO that was accurately decreased as the result of the intervention. Other airborne particulate emissions (SO2, NO2, and O3) might have been influenced by other variables. The parking intervention expanded the vehicles' moving space so that the time of occupancy was decreased and the engine combustion was more efficient. Thus, the perfect combustion quality reduced pollutant production in the air. Therefore, there were some influences of parking management on the traffic emission.

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