Evaluation Of Type 322 Un-Signalized Intersection Performance

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Abstract.

Currently the world is trying to improve air quality which has an impact on climate change. Including Indonesia contributing to various international forums that discuss greenhouse gas emission reduction programs, including in the transportation sector. The Batua Raya-Toddopuli-Borong Raya intersection is an alternative intersection for travelers from Makassar City to Sungguminasa City or Maros City, and vice versa. The aim of this research is to obtain the delay and the relationship between the delay and the emission load at the un-signalized intersection of the Batua Raya-Toddopuli-Borong Raya road, Makassar, SIDRA INTERSECTION 8 Software is used to calculate the value of the delay and emission load. Delays that occur on weekdays are higher than holidays, seen on Monday morning at peak hours 17.00-18.00 there is a very high intersection delay of an average of 3888.52 seconds. The relationship between traffic delays and NOx emissions, which has an effect of 84.32%, each second addition of the delay value can increase HC emissions by 0.0000005 kg/hour. The relationship between traffic delays and CO emissions, which has an effect of 95.56%. The relationship between traffic delays and HC emissions, which has an effect of 93.76%. The relationship between traffic delays and CO2 emissions, which has an effect of 93.64%. The addition of delay time at the intersection increases the emission value and reduces the quality of the intersection level of service.

Keywords: *un-signalized intersections, delays, emission loads, SIDRA INTERSECTION 8.*

I. INTRODUCTION

Currently the world is trying to improve air quality which has an impact on climate change. Including Indonesia contributing to various international forums that discuss greenhouse gas emission reduction programs, including in the transportation sector. However, there are still fuel combustion products for motorized vehicles which are one of the contributing factors to climate change, especially in densely populated urban areas. This is especially the case on urban roads, both at intersections and on sections that have large delays or queues. One of them is that the Batua Raya-Toddopuli-Borong Raya intersection is an alternative intersection for travelers from Makassar City to Sungguminasa City or Maros City, and vice versa, so that this intersection is a "busy" intersection and there is often an increase in travel time at certain time. Geometrically, this intersection consists of 3 arms, each of which consists of 2 lanes and 2 directions, the width of the Toddopuli arm is 4.2 m, the Borong Raya arm is 4.75 m, and the Batua Raya arm is 4.25 m. The type of intersection is 322, the number of arms is 3, the number of lanes on the minor approach (Toddopuli) is 2, and the number of lanes on the major approach (Batua Raya and Borong Raya) is 2. At un-signalized intersections, vehicle interactions are complex. In general, every vehicle moves without following any rules. Thus it is very difficult to find critical gaps and capacities because the distances between vehicles are different [1] [2]. The aim of the study was to determine the delay and the relationship between the delay and the emission load at the un-signalized intersection of the Batua Raya-Toddopuli-Borong Raya road, Makassar.

Some previous research regarding delays at un-signalized intersections and vehicle emissions, namely research on un-signalized intersections in Banda Aceh has a level of service at the Punge intersection categorized B, namely characteristic stable flow (speed is slightly limited by traffic, service volume is used for out-of-town route design). Based on calculations, the Punge intersection has a very high degree of saturation value of 1.851 and exceeds the ideal degree of saturation which is 0.85 [3]. The results of the delay analysis of the Manukan Wetan intersection in Surabaya City are 13.98 seconds/pcu with service level D [4]. Research at 5 un-signalized intersection locations in Zurich with results predicting delays in the flow

of different vehicles up to 4 seconds/vehicle, and can also identify the estimated flow will experience major delays [5]. The effect of driving time (turning) on delays, namely service delays for turning vehicles is highly dependent on the number of conflicting vehicles (NS), conflicting flow rates (VC), and volume of turn requests per hour (VD) [6].

The concentration of the PM 2.5 value in vehicle emissions is affected by environmental and meteorological conditions, such as wind speed, humidity, and temperature [7]. Estimated traffic flow on the Fifth expressway section, Jingfu National Highway, and Jingzhou National Highway using the MFD method have deviations of -25.5%, -26.5%, and -13.4%, and the average deviation of NOX emissions, respectively, -27.7%, -12.9%, and -12% [8]. The emission distribution of the 93 HDDT (heavy duty diesel trucks) measured is even more skewed: about half of the fleet average NOx and CO emission factors and more than 60% of the fleet average PM2.5, UFP, and BC emission factors will be reduced by eliminating the 5% HDDT with the highest emission. In addition, high BC, PM2.5, and NOx emissions tend to cluster among the same vehicle [9]. Emission levels increase when speed and acceleration are also high, and speeds of 30 to 50 km/h and acceleration of less than 0.5m/s2 can result in lower emissions [10]. At a vehicle speed of 60-69% there is a high emission level [11]. Vehicle emissions will decrease by 30% if road capacity increases, if the vehicle speed is 140 km/hour, vehicle emissions will increase by 25% [12] .Total PM10 and NOx emissions in Malaysia are lower compared to other countries that are members of the Organization for Economic Co-operation and Development, but CO2 emissions are higher compared to Japan, Korea and other European countries [13]. Increasing vehicle fuel consumption causes emissions to increase [14]. Reducing PM 2.5 emissions increases health and climate benefits. [15].

II. METHODS

Calculation of delay and emission values in this study uses SIDRA 8.1 software. Day observations were obtained for 1 week, and 3 days which had the highest volume were selected to proceed to the delay and emission analysis. Observation hours during morning peak hours are 07.00-09.00, afternoon 12.00-14.00, and evening 16.00-17.00, observation days are 2 working days and 1 working day off.

Fig 1. Location map of the Batua Raya-Toddopuli-Borong Raya intersection

III. RESULT AND DISCUSSION

Traffic volume during peak hours on Monday (first day of work) has the highest value when compared to other observation days, this is because on this day, people begin to move from work, school and other activities, thus the volume of vehicles there are more in the study locations, while on the day approaching the weekend (Thursday) the peak volume has decreased, on the other hand, the volume of vehicles on holidays (Saturday) because on this day people do shopping and recreational activities in the city to enjoy the holidays. The total traffic volume during peak hours on Thursday morning was 3192.5 pcu/hour,

afternoon was 3072.1 pcu/hour, and in the evening was 3903.5 pcu/hour, for Saturday morning peak hours there were 3137.1 pcu/hour, during the day there are 3100.7 pcu/hour, and in the afternoon there are 3476.3 pcu/hour. On Monday, rice peak hours occur at 08.00-09.00 with a volume of 3268.6 cur/hour, during the day at 13.00-14.00 the volume is 3288.2 pcu/hour and 3987.7 pcu/hour in the afternoon. The total traffic at the Batua Raya - Toddopuli - Borong Raya intersection is presented in Figure 2 and the traffic conditions at the Batua Raya - Toddopuli - Borong Raya intersection at the time of observation is presented in Figure 3.

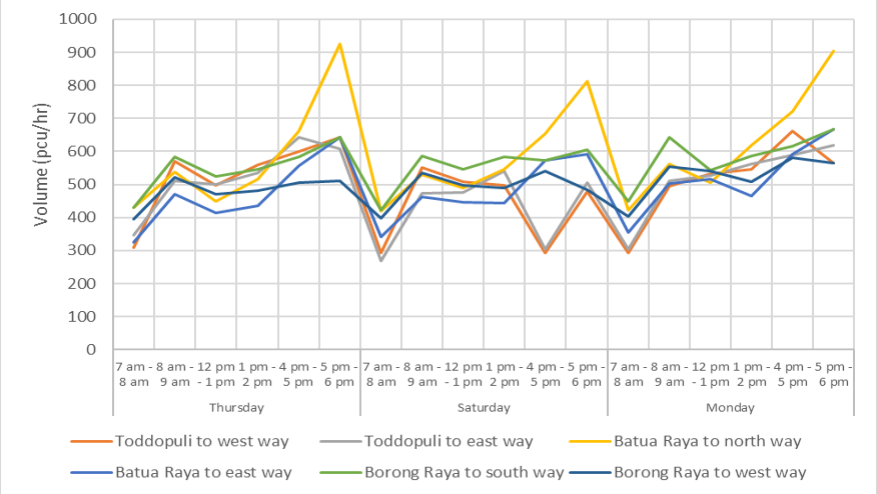

Fig 2. Traffic volume of Batua Raya – Borong Raya – Toddopuli intersection

Fig. 3a. Peak hour conditions Thursday afternoon, **3b.** Saturday morning peak hour conditions, **3c.** Monday afternoon peak hours.

Overall from observation days, delays that occur on weekdays are higher than holidays. For the first day of work and school, Monday morning at peak hours 08.00-09.00 there is an average delay at the intersection of 314.57 seconds, where the Batua Raya approach to the east has the highest delay compared to other approaches, which is 665.1 seconds. In the afternoon at 17.00-18.00 there was a very high intersection delay of an average of 3888.52 seconds, where the biggest delay was on the Batua Raya approach to the east. Peak hours in the afternoon at the Batua Raya – Toddopuli – Borong Raya intersection at 17.00-18.00, because at that time it is time to go home from work and extra-curricular activities from school. The movement from the Batua Raya approach to the east, namely the East Toddopuli approach, is one of the favorite alternative routes for motorists coming from the northern part of Makassar and going to downtown Makassar. Morning peak hours for weekdays (Thursday and Saturday) occur at 08.00-09.00, this time is the time to go to work, whereas in the previous hours, 07-00-08.00 is the time to go to school. On working holidays or Saturdays, the highest delays occur during the afternoon rush hour at 16.00-17.00, with an average delay of 1399.68 seconds, and the Batua Raya approach to the east is the highest contributor to the delay value of 3167.7 seconds. The delay that occurred on Saturday afternoon came from the large number of motorists who chose this time to go to the city center for activities or recreation. The delays that occurred at the Batua Raya-Toddopuli-Borong Raya intersection during peak hours were poor for the intersection performance (level of service F).

Conditions in the field showed that during peak hours in the afternoon there was chaos at the intersection, especially for the movement from Batua Raya towards Toddopuli, which was dominated by motorcycles, where the movement of motorcyclists was easier to maneuver than other types of vehicles. The composition of vehicles during peak hour on Thursday morning was 24.67% light vehicles, 0.748% heavy

vehicles and 74.482% motorcycles. The composition of vehicles during Thursday afternoon's rush hour was 22.171% light vehicles, 0.709% heavy vehicles and 77.109% motorcycles. The composition of vehicles in the afternoon was 16.801% light vehicles, 0.427% heavy vehicles and 82.655% motorcycles. The composition of vehicles on Saturday morning peak hours was 26.436%, heavy vehicles 0.667%, and motorcycles 72.747%. The composition of vehicles on Saturday afternoon peak hours was 24.037% light vehicles, 0.458% heavy vehicles and 69.633% motorcycles. The composition of vehicles on Saturday afternoon peak hours was 17.616% light vehicles, 0.348% heavy vehicles and 81.997% motorcycles. The composition of vehicles on Monday morning peak hours consisted of 29.673% light vehicles, 0.666% heavy vehicles and 69.559% motorcycles. The composition of vehicles on Monday afternoon peak hours consisted of 25.643% light vehicles, 0.345% heavy vehicles and 73.963% motorcycles. The composition of vehicles on Monday afternoon peak hours was 19.626% light vehicles, 0.342% heavy vehicles and 80.162% motorcycles.

Another thing that causes the large value of the delay at the intersection, is that some motorbike riders from Toddopuli at the time of the queue, have taken half of the lane width in the opposite direction. This condition also causes vehicles that are about to enter the East Toddopuli road to experience a slowdown and even have to stop until the movement of vehicles from Toddopuli to Batua Raya is unraveled. The volume of vehicles from Batua Raya to Toddopuli and the volume of vehicles from Toddopuli to Borong Raya is quite large, this triggers conflicts and the delay is quite high, especially the inadequate road width on the Batua Raya and East Toddopuli approaches, so interlocking often occurs at these intersections during peak hour. The delay per approach for each observation time is presented in Figure 4.Delays that occur at intersections can increase emissions from burning vehicle fuel. Some of the emissions resulting from the combustion of fuel are CO_2, CO, HC, and NOx. Vehicle emission loads were analyzed using SIDRA software. The influence of the peak hour factor on the increase in CO_2, CO, HC, and NOx emissions was 2.7%, 2.3%, 2.5%, and 2.7%, respectively. The average CO_2 emission load during the morning peak hour observed Thursday at the Batua Raya-Toddopuli-Borong Raya junction is 361.192 kg/hour, the largest emission load is on the Batua Raya approach heading north and east, respectively 1246.8 kg/ hour and 1088.6 kg/hour. The increase in CO_2 emission load to 526.117 kg/hour occurred during the afternoon rush hour on Thursday's observation day, the Batua Raya approach has the largest emission load value compared to other approaches. Afternoon peak hour increased, the average CO_2 emission load value is 1356.483 kg/hour, where the highest CO_2 emission load is 4217.2 kg/hour on the Batua Raya approach.

On Saturday, the average value of CO_2 load for morning, afternoon and evening rush hours was 315.208 kg/hour, 460 kg/hour, 947.258 kg/hour. An increase in CO_2 emission load also occurred on the observation day Monday, with each value of CO_2 load during the morning, afternoon and evening peak hours of 463.967 kg/hour, 631.633 kg/hour, and 1998.742 kg/hour, which are approx. Batua Raya heading north contributed the largest emission load, namely 6267.4 kg/hour consisting of 10.092% light vehicles, 0.245% heavy vehicles and 89.664% motorcycles. The relationship between traffic delays and CO_2 emissions, which has an effect of 93.64%, every second addition of the delay can increase CO_2 emissions by 87,638 kg/hour. High concentrations of CO_2 can cause a greenhouse effect which triggers climate change. The relationship between delay and CO_2 emissions is presented in Figure 5.

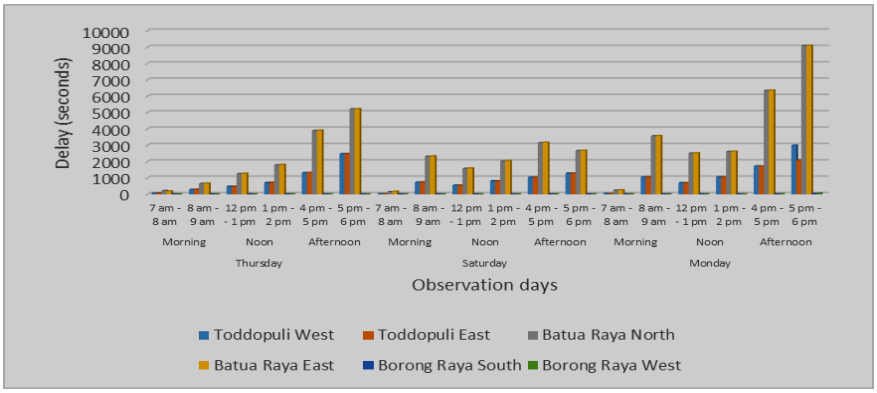

Fig 4. Delays at the Batua Raya-Toddopuli-Borong Raya un-signalized intersection

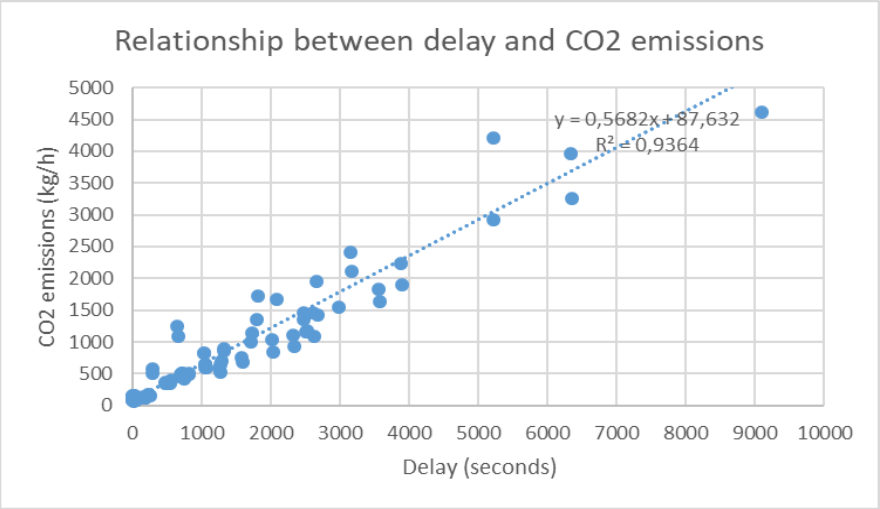

Fig 5. Relationship between delay and load emission CO_2.

The result of incomplete combustion of fuel due to lack of oxygen contains carbon monoxide. If this gas is in high concentrations it can disrupt the process of oxygen absorption in the human body, reduced concentration and ability to think, pain/inflammation in the throat, drowsiness, and worse can cause death. At the Batua Raya-Toddopuli-Batua Raya junction, the average carbon monoxide emission load is 0.225 kg/hour during the morning peak hours observed on Thursday, 0.317 kg/hour during the afternoon peak hours, and 0.8 kg/hour for peak hours. afternoon. The second observation day, namely on a holiday (Saturday), the average value of CO emission load at peak hours in the morning, afternoon and evening was 0.183 kg/hour, 0.267 kg/hour and 0.542 kg/hour respectively. The average CO emission load during peak hours in the morning, afternoon and evening for Monday is 0.267 kg/hour, 0.375 kg/hour and 1.183 kg/hour respectively. The composition of vehicle types on Monday afternoon peak hours was 19.626% light vehicles, 0.342% heavy vehicles and 80.162% motorcycles. The relationship between traffic delays and CO emissions, which has an effect of 95.56%, each second addition of the delay can increase CO emissions by 0.0229 kg/hour.

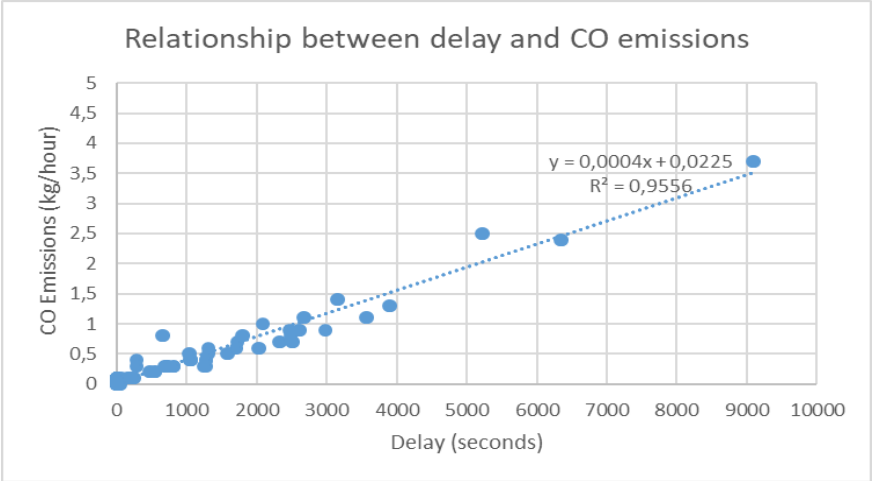

Fig 6. The relationship between un-signalized intersection delay and CO emission

Hydrocarbon gas is produced from burning fuel that comes out of vehicle exhaust, if in large quantities it can cause eye irritation, drowsiness, the appearance of spots on the skin, carcinogenic, and changes in the genetic code. Overall, the Batua Raya approach to the north contributes the largest emission load, ranging from 0.124 kg/hour to 0.763 kg/hour. The composition of vehicle types under conditions of HC emission load of 0.763 kg/hour were 10.092% light vehicles, 0.245% heavy vehicles and 89.664% motorcycles. The average load of hydrocarbon emissions on the observation day Thursday for morning, afternoon and evening rush hours is 0.041 kg/hour, 0.061 kg/hour and 0.162 kg/hour. Emissions of hydrocarbon loads increased on the observation day Saturday, the average values of HC emission load

during morning, afternoon and evening peaks were 0.0346 kg/hour, 0.0525 kg/hour and 0.110 kg/hour. The average total HC emission load on Monday, morning, afternoon and evening rush hours is 0.053 kg/hour, 0.072 kg/hour and 0.241 kg/hour respectively. The relationship between traffic delays and HC emissions, which has an effect of 93.76%, each second addition of the delay increases HC emissions by 0.00595 kg/hour. The relationship between delays and hydro carbon emissions is presented in Figure 7.

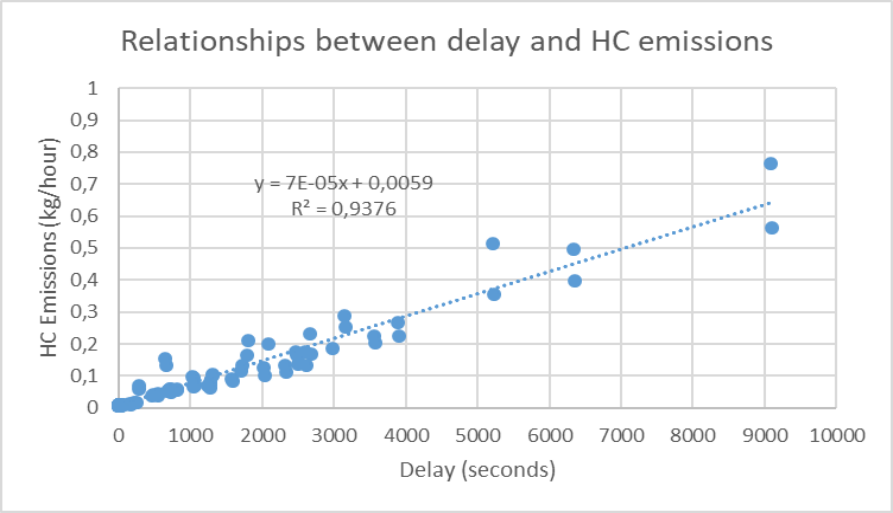

Fig 7. The relationship between un-signalized intersection delay and HC emission

NOx gas in large quantities has the potential to weaken the defense system of living things, irritate the respiratory tract and eyes, and cause headaches. The NOx emission load decreased on the observation day Saturday, but increased on the observation day Thursday and Monday. The Batua Raya approach to the north provides the highest NOx emission values, with a range of 0.137 kg/hour to 0.959 kg/hour. The composition of vehicle types at the highest NOx emission load (0.959 kg/hour) was 10.092% light vehicles, 0.245% heavy vehicles and 89.664% motorcycles. The average values of NOx emission load on the observation day Thursday morning, afternoon and evening peak hours were 0.123 kg/hour, 0.158 kg/hour and 0.272 kg/hour respectively. On the observation day on a holiday (Saturday), the average values of NOx emission load during morning, afternoon and evening peak hours were 0.089 kg/hour, 0.115 kg/hour and 0.171 kg/hour. The average NOx emission load on Monday morning, afternoon and evening peak hours were 0.123 kg/hour, 0.133 kg/hour and 0.346 kg/hour respectively. The relationship between traffic delays and NOx emissions, which has an effect of 84.32%, each second addition of the delay value can increase NOx emissions by 0.0638 kg/hour. The relationship between delay and NOx emission load is presented in Figure 8.

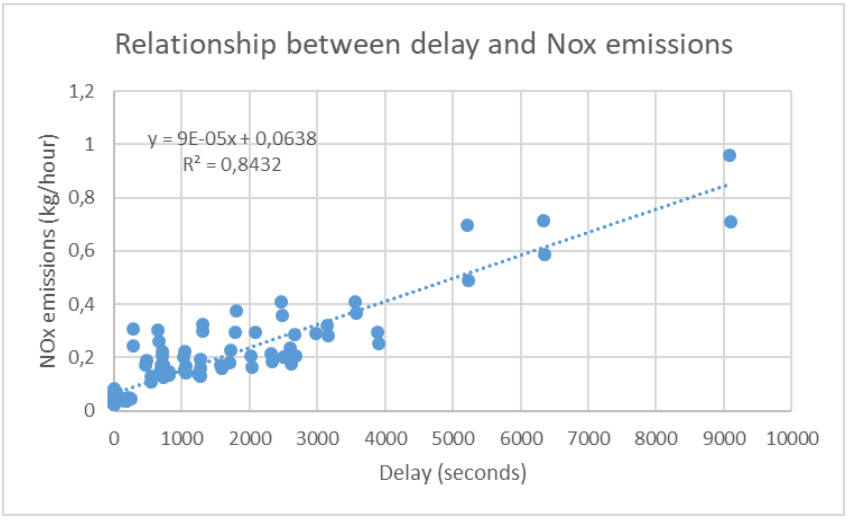

Fig 8. The relationship between un-signalized intersection delay and NOx emission

IV. CONCLUSION

Delays that occur on weekdays are higher than holidays. On weekdays, the average delay at the intersection on Monday afternoon is 3888.52 seconds. On working days off or Saturday afternoon, the average delay at the intersection is 1399.68 seconds. CO2, CO, HC, and NOx emission burden increases if the delay value increases. Each second delay value can increase CO2 emissions by 87,638 kg/hour, CO emissions by 0.0229 kg/hour, HC emissions by 0.00595 kg/hour, and NOx emissions by 0.0638 kg/hour. The addition of delay time at the intersection increases the emission value and reduces the quality of the intersection level of service.

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