

An Analysis of Heterogeneous Traffic Dominated by Motorcycles at Signalized Intersections in Pekanbaru

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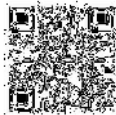
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ABSTRACT

Kota Pekanbaru, salah satu kawasan metropolitan yang sedang berkembang di Indonesia, menghadapi tantangan lalu lintas yang signifikan, terutama karena meningkatnya jumlah sepeda motor. Seiring dengan pesatnya pertumbuhan penduduk, volume kendaraan bermotor meningkat, yang menyebabkan kemacetan lalu lintas yang sering terjadi—terutama pada jam-jam sibuk. Studi ini menganalisis kinerja lalu lintas di persimpangan bersinyal di Pekanbaru, dengan fokus pada masalah kemacetan yang diakibatkan oleh dominasi sepeda motor. Penelitian ini meneliti volume kendaraan, panjang antrean, dan keterlambatan di persimpangan tertentu. Temuan penelitian mengungkapkan bahwa persimpangan Gramedia (Nangka) dan Kantor Gubernur mengalami kepadatan lalu lintas yang tinggi, yang meningkatkan risiko kecelakaan. Studi ini menawarkan rekomendasi praktis untuk mendukung keputusan manajemen lalu lintas dan memandu pengembangan sistem transportasi perkotaan yang lebih efisien.

Pekanbaru City, one of Indonesia's growing metropolitan areas, faces significant traffic challenges, particularly due to the increasing number of motorcycles. As the population rapidly expands, the volume of motorized vehicles rises, leading to frequent congestion—especially during peak hours. This study analyzes traffic performance at signalized intersections in Pekanbaru, focusing on congestion problems resulting from motorcycle dominance. The research examines vehicle volume, queue lengths, and delays at selected intersections. Findings reveal that the Gramedia (Nangka) and Governor's Office intersections experience high traffic density, which elevates the risk of accidents. This study offers practical recommendations to support traffic management decisions and guide the development of a more efficient urban transportation system.



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INTRODUCTION

Traffic is vital in urban life, particularly in Pekanbaru, one of Indonesia's major metropolitan areas. As the population grows rapidly, the number of motorized vehicles in Pekanbaru continues to rise yearly. Among these vehicles, motorcycles dominate the city's roads. This trend is evident in the high volume of motorcycles passing through signalized intersections across the city. Consequently, Pekanbaru frequently experiences traffic congestion, especially along major roads such as Sudirman Street, Sukarno-Hatta Street, Pekan Raya Street, and Riau Street. Traffic jams often occur during peak hours, including mornings, office hours, afternoons, and evenings. The daily flow of vehicles contributes significantly to this congestion.

Data from the Statistics Agency and Police Headquarters of Riau Province show a steady increase in private vehicles. Pekanbaru recorded 559,461 motorcycles, 150,035 cars, 2,201 buses, and 69,139 trucks in 2019. By 2024, these numbers had surged: motorcycles reached 901,784 units (37%), cars rose to 184,396 units (18%), buses grew to 3,162 units (30%), and trucks climbed to 84,611 units

(18%). This sharp growth in vehicle numbers, especially motorcycles, highlights the urgent need to address traffic congestion in the city.

Pekanbaru's busiest intersections are the Gramedia intersection (commonly known as the Nangka intersection) and the Governor's Office intersection. These intersections experience heavy traffic primarily because they are located on Sudirman Street, one of the city's main arterial roads. In addition, the proximity of the Government Office of Pekanbaru contributes to the traffic intensity in the area.

Made Kariyana (2022), in a study titled "*A Motorcycle Equivalence Analysis Using the Speed-Based Linear Regression Method in North Kuta During Public Activity Restrictions*," aimed to determine the motorcycle equivalence value during the public activity restrictions period. The study used a linear regression method to calculate vehicle equivalence. Based on the analysis, results show that on the road segment of Kerobokan Street, the ESM (equivalency of standard motorcycle) values are 1.00 for motorcycles, 8.36 for light vehicles, and 16.22 for heavy vehicles. On the Cangu Highway segment, the ESM values are 1.00 for motorcycles, 7.15 for light vehicles, and 15.28 for heavy vehicles. Meanwhile, on the Padang Luwih Highway segment, the ESM values are 1.00 for motorcycles, 3.98 for light vehicles, and 14.53 for heavy vehicles. The traffic flow in motorcycle equivalent units (MEUs) on Cangu Highway was recorded at 9,059 MEUs/hour, with a degree of saturation (DS) of 3.46. On Kerobokan Highway, the DS was 2.56, with a traffic flow of 6,925 MEUs/hour. Meanwhile, on Padang Luwih Highway, the traffic flow reached 9,008 MEUs/hour, with a DS of 2.93. Based on the analysis of the increasing growth of motorcycle users, it is currently relevant to consider motorcycles as the standard conversion unit when summing motorized vehicles using motorcycle equivalent units (MEUs). For further research, it is also necessary to consider the volume-to-capacity (v/c) ratio to determine the degree of saturation (DS) based on MEUs since currently, the Indonesian Highway Capacity Manual (Indonesian: *Manual Kapasitas Jalan Indonesia* (MKJI)) determines DS only based on passenger car units (PCUs).

Traffic Characteristics

Traffic flow is never identical, even under similar conditions, as the flow on any given road section always varies. However, specific parameters are essential for indicating the condition of a road segment. These parameters include volume, speed, density, level of service, and degree of saturation.

Vehicle Characteristics

Vehicle characteristics are distinguished based on physical attributes such as dimensions, weight, and performance. Vehicle dimensions affect several aspects, including the width of traffic lanes, the width of paved road shoulders, and the length and width of parking spaces. Key vehicle dimensions include width, height, turning radius, and carrying capacity.

METHODS

The empirical measurement of performance (EMP) value is obtained by recording the time headway between consecutive vehicles as they pass a predetermined point.

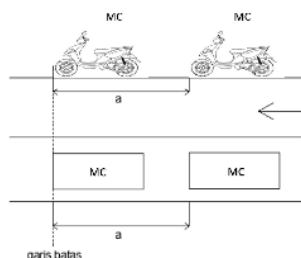


Figure 1. Example of MC-MC time headway

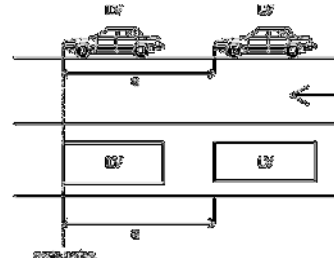


Figure 2. Example of LV-LV time headway

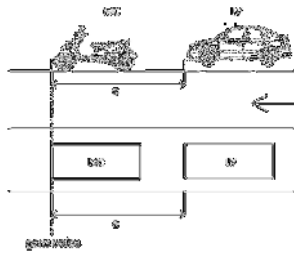


Figure 3. Example of MC-LV time headway

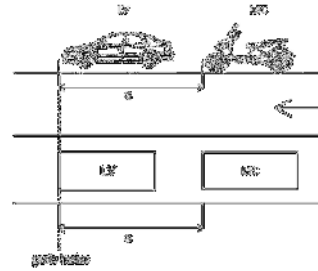


Figure 4. Example of LV-MC time headway

The required headway ratios include four types of vehicle combinations, as follows.

1. Motorcycle (MC) followed by motorcycle (MC),
2. Motorcycle (MC) followed by light vehicle (LV),
3. Light vehicle (LV) followed by light vehicle (LV), and
4. Light vehicle (LV) followed by motorcycle (MC).

The EMP time headway value is calculated by dividing the average time headway of a motorcycle followed by another motorcycle by the average time headway of a motorcycle followed by a light vehicle. This result is valid only if the light vehicle's time does not depend on the vehicle that precedes or follows it. This condition holds when the average time headway of a light vehicle followed by a motorcycle equals the average time headway of a light vehicle followed by another. This relationship can be expressed with the following equations.

$$ta + tb = tc + td \quad (1)$$

$$\left[ta - \frac{k}{na}\right] + \left[tb - \frac{k}{nb}\right] = \left[ta - \frac{k}{nc}\right] + \left[tb - \frac{k}{nd}\right] \quad (2)$$

$$K = \frac{na \cdot nb \cdot nc \cdot nd \cdot [ta + tb - tc \cdot td]}{nb \cdot nc \cdot nd + na \cdot nc \cdot nd + na \cdot nb \cdot nd + na \cdot nb \cdot nc} \quad (3)$$

$$ta_k = ta - \frac{k}{na} \quad (4)$$

$$tb_k = tb - \frac{k}{nb} \quad (5)$$

$$tc_k = tc + \frac{k}{nc} \quad (6)$$

$$td_k = td + \frac{k}{nd} \quad (7)$$

Using the corrected average time headway values, we obtain the following.

$$ta_k + tb_k = tc_k + td_k \quad (8)$$

$$\text{EMP Heavy Vehicle (HV)} = \frac{tb_k}{ta_k} \quad (9)$$

RESULTS AND DISCUSSION

The analysis shows that the Gramedia (Nangka) intersection experiences heavy traffic flow due to high vehicle volumes and the increasing number of vehicles in Pekanbaru. The EMP values obtained for the Gramedia intersection are 0.095 on Monday, 0.263 on Wednesday, 0.180 on Friday, and 0.135 on Sunday. Meanwhile, the EMP values for the Governor's Office intersection are 0.175 on Monday, 0.2 on Wednesday, 0.188 on Friday, and 0.141 on Sunday.

According to previous studies, motorcycles dominate roadways in Indonesia because they are the most commonly owned type of vehicle. As motorcycle ownership increases annually, motorcycles dominate on main roads and at signalized intersections.

The high number of motorized vehicles and a lack of public education on proper driving behavior have led to frequent traffic violations. Many drivers obey traffic rules only when they see police officers

on the road. This disregard for traffic safety—stemming from limited awareness and discipline—often results in drivers being ticketed by law enforcement.

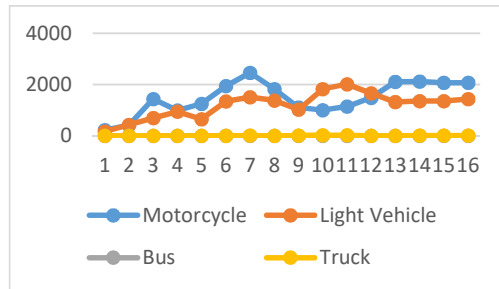


Figure 5. Graph of Vehicle Volume on Monday at the Gramedia Intersection

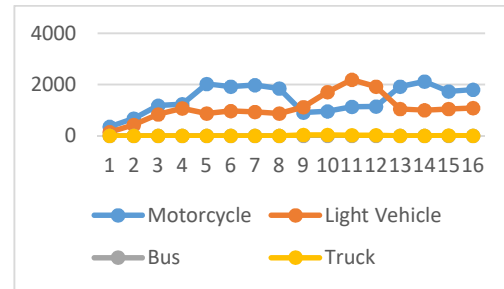


Figure 6. Graph of Vehicle Volume on Wednesday at the Gramedia Intersection

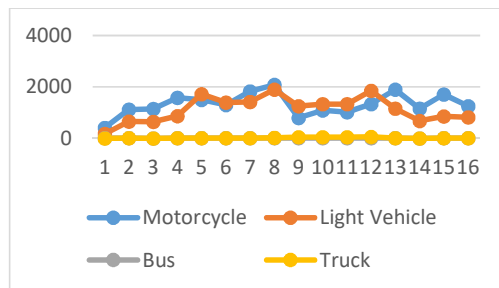


Figure 7. Graph of Vehicle Volume on Friday at the Gramedia Intersection

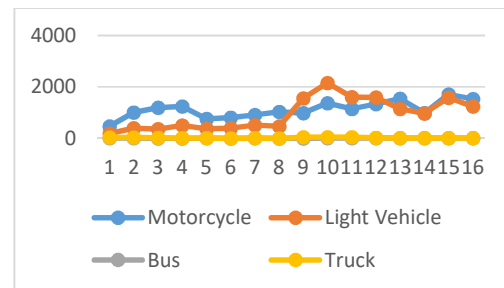


Figure 8. Graph of Vehicle Volume on Sunday at the Gramedia Intersection

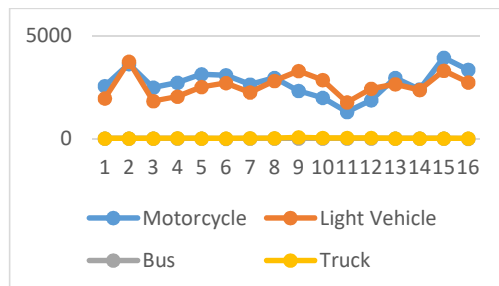


Figure 9. Graph of Vehicle Volume on Monday at the Governor's Office Intersection

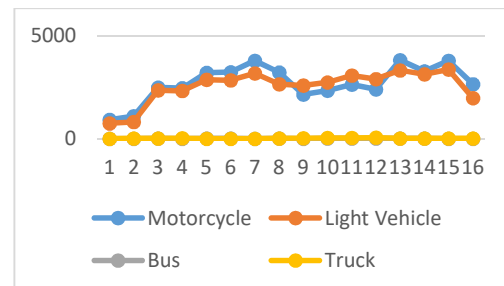


Figure 10. Graph of Vehicle Volume on Wednesday at the Governor's Office Intersection

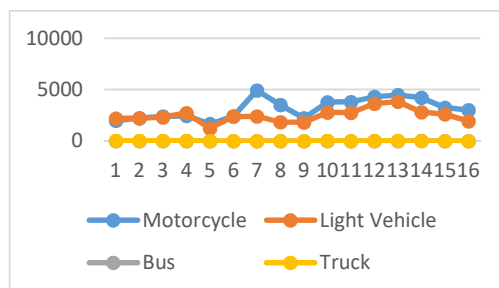


Figure 11. Graph of Vehicle Volume on Friday at the Governor's Office Intersection

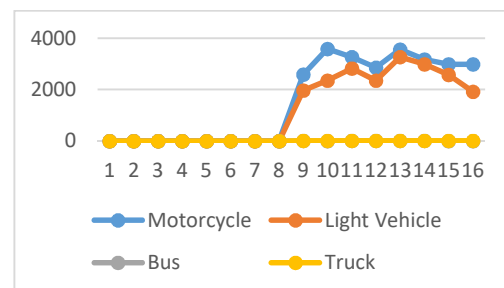


Figure 12. Graph of Vehicle Volume on Sunday at the Governor's Office Intersection

CONSLUSIONS

This study aimed to analyze the traffic conditions at key intersections in Pekanbaru, particularly the Gramedia and Governor's Office intersections. The findings revealed that the high traffic volume, especially the dominance of motorcycles, significantly contributes to congestion at these locations. The increasing number of motorized vehicles and a lack of awareness of safe driving practices exacerbate traffic issues. The calculated EMP values at both intersections support the conclusion that motorcycles play a critical role in traffic flow analysis and should be considered a standard conversion unit when evaluating road capacity and traffic management. These insights align with the study's objectives and provide a foundation for improving intersection planning and traffic regulation strategies in urban areas.

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