Study of traffic noise at elementary school Pondok Cina 1 Depok, West Java

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Abstract. The study aims to analyze the level of traffic noise in the area of Pondok Cina 1 Public Elementary School and analyze the V/C ratio of the main road in front of the school area. The method of measuring noise levels is carried out by the Decree of the Minister of Environment No. 48 of 1996. The data is then processed for the value of each road adjustment factor adjusted to the relevant road conditions by the Indonesian Road Capacity Manual (MKJI). The results showed that the level of traffic noise in the school area ranged from 78.56 to 90.00 dBA. Compared with the results of these measurements, it is evident that the noise level has exceeded the quality standard. Furthermore, based on the calculation of traffic volume and road capacity, the V/C ratios are ranged from 1.23–1.62 which later categorized in the service level F. Road with this level of service has jammed traffic flow, vehicles at low speed, long queues, and large obstacles occur. To avoid having an impact on school activities, it is necessary to control traffic noise in the school area by creating noise barrier.

1. Introduction

Educational buildings adjacent to roadways are very prone to noise and it can affect school activities [1] and has the greatest influence on learning activities and student academic performance [2]. The quality of teaching and learning is greatly influenced by internal factors, such as teacher performance [3] and external factors such as traffic noise [4]. About 95% of teachers reported that they often or sometimes suffer from traffic noise, so they experience a negative impact on learning efficiency and performance [5].

The general effects of chronic noise exposure in children are a continued decrease of visual attention, auditory and speech perception, memory capacity, reading ability, and performance on exams [6]. One of the strongest findings is the relationship between traffic noise in school and children's cognition, especially on the ability to memorize and read [7,8]. Students are empowered to gain knowledge and develop skills needed for life through the learning process [9], so appropriate learning environment is very important for children’s development [10] and requires a calm atmosphere, which is free from distractions including traffic noise [11]. However, traffic noise is unavoidable in modern life [12]. Therefore schools located near roads with heavy traffic need to conduct more action to reduce the level of noise produced by external factors so that the learning process continues to be comfortable even though the location of the school is near the heavy traffic area [13].

Based on several studies previously mentioned, there is a correlation between traffic noise and its disturbance to school. Therefore, this research was conducted at one of the elementary schools located...
2. Research methods

Pondok Cina 1 Public Elementary School is located at Margonda Raya Street, KM 4.5 Depok City with coordinates of 6°22'14.3"S 106°50'01.2"E. Along the street there are shops, campuses, and bus stop. The total population in this school consists of 408 students and 18 teachers. The data required in this study is in the form of primary and secondary data. Primary data consists of vehicle volume and speed measurements, and V/C ratio, while secondary data consists of supporting data obtained from related primary schools.

2.1. Vehicles volume and speed

Traffic flow volume is the number of vehicles that pass a point on the roadway during a certain time interval, which is calculated according to its vehicle wheels, namely 2 wheels (motorcycle), 4 wheels (sedans and minivans), and > 4 wheels (buses and trucks). The calculation of vehicle volume carried out in four-time segments, namely L1 (06.00-09.00) at 07.00, L2 (09.00-11.00) at 10:00, L3 (14.00-17.00) at 15.00, and L4 (17.00-22.00) at 17.00. Vehicle volume of traffic flow is the number or number of vehicles passing a certain point on a road in a unit of time. The calculation of vehicle volume requires the number of motorized vehicles at a certain time. The volume of vehicle traffic flow is expressed by the following equation [14].

\[
V = (MC \times emp_{MC}) + (LV \times emp_{LV}) + (HV \times emp_{HV})
\]  

\[(1)\]

Description:

\(V\) = Volume of vehicles on traffic (smp/hour)

\(MC\) = Number of two-wheeled vehicles on certain period

\(emp_{MC}\) = emp value for motorcycles (two-wheeled vehicles)

\(LV\) = Number of light vehicle (four-wheeled) on certain period

\(emp_{LV}\) = Equivalent value of passenger cars for light vehicles (four-wheeled)

\(HV\) = Number of heavy vehicles (> 4 wheels) on certain period

\(emp_{HV}\) = emp value for heavy vehicles (>4 wheels)

2.2. V/C ratio

Road's performance or level of service is a qualitative measure that explains the operational conditions in traffic flow and its assessment by road users [14]. If the traffic volume is low, then a vehicle has an average speed high space. But if the traffic volume is high, then a vehicle has a low average velocity of space [16]. The data required is the number or volume of vehicles per hour, road width, and shoulder width. The data is then processed for the value of each road adjustment factor adjusted to the road conditions in question. The value of the road capacity is expressed in units of passenger cars. To calculate the volume per capacity of a road, it is necessary to determine the value of a factor referring to the Indonesian Road Capacity Manual (MKJI). Capacity can be calculated using the calculation below [14].

\[
C = Co \times FCw \times FCsp \times FCsf \times FCcs
\]  

\[(2)\]

Description:

\(Co\) = Basic direction capacity

\(FCw\) = Road Width Factor

\(FCsf\) = Side Obstacle Factor
FCsp = Road Separator Factor  
FCcs = City Size Factor 

The rate performance of a road network greatly affects the development of the city. The better the performance of the road, the easier it will be for community activities. In the end, the good performance of the road section has succeeded in increasing the productivity of the community which can then improve the welfare of people's lives [17].

2.3. Traffic noise
One source of traffic noise comes from motorized vehicles, both two-wheeled and four-wheeled, with sources of noise including horns and exhaust sounds [18], the friction of car tires with the road surface, engine noise, vehicle mechanism, as well as airflow (aerodynamic noise) [19]. To calculate traffic noise, the utilized formulation is as follows [20].

\[ L_{eq(i)} = L_{oe} + 10 \log \left( \frac{N \times I \times V}{V_i \times T} \right) + 10 \log \left( \frac{15}{D} \right)^{15} - 13 \]  

Description:
\( L_{eq} \) = Noise intensity (dBA)  
\( L_{oe} \) = Noise emission (dBA)  
\( I \) = Vehicle type  
\( N \) = Number of Vehicle  
\( T \) = Impact length (hour)  
\( V \) = Average Vehicle Speed (km/hour)  
\( D \) = Distance of noise source from receptor (m) = 10 m

3. Results and discussion

3.1. Vehicle volume and speed
Heavy traffic occurs in Depok almost happens on every primary arterial road, however, the highest density occurs on Margonda Raya Street. This road is one of the busiest traffic sections with the highest volume of vehicles in the morning, afternoon, and evening [21]. The daily amount of each type of vehicle for two weeks is illustrated in the graphs in figures 1. Based on the two graphs, we can see that the number of vehicles dominating Margonda Raya Street is 2-wheeled vehicles with a volume of above 1500 vehicles per day. Even for vehicles with > 4 wheels, the amount does not exceed 10 vehicles per day. Meanwhile, the number of 4-wheeled vehicles is average stays above 700 vehicles per day.

![Figure 1. Vehicle number.](image)

3.2. V/C ratio
The Margonda Raya Street is a primary arterial road with a length of approximately 5.3 km and has a special note regarding its notoriously high traffic density [21]. This road has a width of 3.5 m. This road
has no shoulders but is equipped with a sidewalk with an average width of ± 1 m. Based on that, the calculation of road capacity can be done using the following formula:

- **Direction basic capacity (C0)**
  \[ C_0 = \text{Two lanes one way road type} \times 1650 \text{ smp/hour per lane} \]

- **Road width factor (FCw)**
  \[ FCw = \text{Two lanes one way road type (road width 3.5 m)} = 1.00 \]

- **Road separator factor (FCSP)**
  \[ FCSP = \text{Two lanes one way road type d = 1.00} \]

- **Side obstacle factor (FCSF)**
  \[ FCSF = \text{Barrier 1 m, possesses high side activity, located in a commercial area with lanes one-way road type = 0.81} \]

- **City size factor (FCcs)**
  \[ FCcs = \text{Population number of 1 – 3 million = 1.00} \]

With the averagely mentioned data, the capacity of Margona Raya Street is as follows:

\[ C = 1650 \times 1.00 \times 1.00 \times 0.81 \times 1.00 \]
\[ C = 1336.5 \text{ smp/hour} \]

Based on the calculation above, traffic volume ratio (smp/hour) against capacity (smp/hour) hereinafter referred to as V/C ratio is ranged from 1.23–1.62 (Table 1). Minister of Transportation Regulation No. 14 the Year 2005 [22] has divided service level characteristics into six levels. By comparing the results of the V/C ratio calculation above with the characteristics of Margonda Raya Street the service level with a value of > 1, this road is categorized in the service level F.

### Table 1. V/C ratio of Margonda Raya Street.

| Measurement Time | Capacity (smp/hour) | Traffic Flow Volume (smp/hour) | V/C Ratio |
|------------------|---------------------|-----------------------------|-----------|
| Week 1           |                     |                             |           |
| Wednesday        | 1336.5              | 2077                        | 1.55      |
| Thursday         | 1336.5              | 2162                        | 1.62      |
| Friday           | 1336.5              | 2062                        | 1.54      |
| Saturday         | 1336.5              | 1891                        | 1.42      |
| Sunday           | 1336.5              | 1813                        | 1.36      |
| Monday           | 1336.5              | 1870                        | 1.40      |
| Tuesday          | 1336.5              | 1638                        | 1.23      |
| Week 2           |                     |                             |           |
| Wednesday        | 1336.5              | 2133                        | 1.60      |
| Thursday         | 1336.5              | 2088                        | 1.56      |
| Friday           | 1336.5              | 1908                        | 1.43      |
| Saturday         | 1336.5              | 2160                        | 1.62      |
| Sunday           | 1336.5              | 1740                        | 1.30      |
| Monday           | 1336.5              | 2016                        | 1.51      |
| Tuesday          | 1336.5              | 1958                        | 1.47      |

#### 3.3. Traffic noise

In previous studies, it was found that the highest noise level on Margonda Raya Street occurred in the northern segment which was dominated by the education area [19]. In 2012, the level of environmental noise at this school was also examined. The results of his study showed that the attention and concentration of 4th grade students at Pondok Cina Public Elementary School could be significantly affected by noise levels of 53 dBA to 63 dBA. With this finding, noise exposure is proven to affect student learning performance if it exceeds the allowed limitation level [23].

The results of this study as shown in Figure 2, show that the traffic noise level in front of Pondok Cina 1 Public Elementary School for two weeks, ranged from 78.56 dBA to 90 dBA. When compared with the noise level standard in the school environment as regulated by Minister of Environment Decree Number 48 the Year 1996 (55 dBA) [18], the traffic noise level has exceeded the quality standard.
The highest traffic noise level in the week I was measured on Wednesday in the L3 time segment (14.00-17.00) of 90 dBA. This is caused by the measurement time which is at the same time at a busy time where people are coming home from work which resulted in a high number of vehicles passing through the highway at that time. The lowest traffic noise level in the week I was measured on Tuesday in the L2 time segment (09.00-11.00) of 78.56 dBA. This is due to the smaller number of 4-wheeled vehicles compared to other time segments, thus affecting the resulting traffic noise.

In week II, the highest traffic noise level was also measured on Wednesday but in the L2 time segment (09.00-11.00) of 88.01 dBA. This is due to the smaller number of vehicles in the L3 time segment so that the noise is lower than the other time segments. The lowest traffic noise level measured on Sunday in the L4 time segment (17.00-22.00) is 79.79 dBA. This is due to the smaller number of vehicles in the L4 time segment caused by rainy weather conditions so that the number of vehicles passing the highway is less than the other time segments on sunny weather conditions.

![Figure 2. Traffic noise level.](image)

4. **Conclusion**

The results of this study indicate that the level of traffic noise on Margonda Raya Street in the area of Pondok Cina 1 Public Elementary School ranges from 78.56 dBA to 90 dBA. The noise level is much higher than 55 dBA, so it has exceeded the maximum limit of the noise level standard for the school environment. The V/C ratio Margonda Raya Street is ranged from 1.23-1.62 which later categorized in the service level F with jammed traffic flow, vehicles at low speed, long queues, and large obstacles occur.

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