

## **Carbon Footprint Analysis of Motor Vehicles at the Military Academy**

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### **Abstract**

*The Military Academy, abbreviated as Akmil is the Central Implementing Agency at the Mabesad level in the field of education which is domiciled directly under the Kasad. Based on the organizational structure and duties (Orgas) Akmil consists of Leadership Elements, Leadership Assistant Elements, Service Elements, and Implementing Elements. Currently, Akmil personnel number 2,408 people with details of Officers 685, Non-Commissioned Officers 597, Tamtama 571, and Civil Servants 555 people. To facilitate access in service, Akmil provides official house facilities to each member in the Panca Arga Magelang Housing Complex. The majority of personnel who go to work in Akmil use motorized vehicles, both two-wheeled and four-wheeled. Round-trip activities from the Panca Arga Housing Complex to Akmil using motorized vehicles, of course, are inseparable from the so-called carbon footprint. The research method used is a review literature of several scientific articles related to exhaust emissions. The exhaust emissions in two-wheeled vehicles were 15,686.5 Kg/L, while four-wheeled vehicles were 9,155.8 Kg/L. It is necessary to calculate the emission of CO<sub>2</sub> waste gases assuming the fuel used is pertalite and pertamax.*

**Keywords:** CO<sub>2</sub>, Exhaust Emissions, Military Academy, Motor Vehicles

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## **INTRODUCTION**

The Military Academy, abbreviated as Akmil, is the Central Implementing Body at the Headquarters level in the field of education which is located directly under the Army Chief of Staff. The Military Academy's main task is to organize the first education for volunteer TNI AD officers at Academy level. Candidates for Indonesian Army officers are expected to have the capacity and quality standards to be able to carry out their duties well to meet the demands of their duties as professional officers who are loved by the people. Apart from carrying out the main function in the field of education, the Military Academy also carries out organic military functions, namely carrying out activities in the fields of intelligence, operations, training, personnel, logistics, territory, planning and internal control.

Based on the organizational structure and tasks (Orgas), the Military Academy consists of Leadership Elements, Assistant Leadership Elements, Service Elements, and Implementing Elements. Currently there are 2,408 Akmil personnel with details of 685 officers, 597 non-commissioned officers, 571 enlisted personnel and 555 civil servants. To facilitate access to service, the Military Academy provides official housing facilities to each member at the Panca Arga Magelang Housing Complex. The majority of personnel who go to work at the Military Academy use motorized vehicles, both two-wheeled and four-wheeled. With a large number of personnel, of course this will have an impact on the number of motorized vehicles owned.

Commuting activities from the Panca Arga Housing Complex to the Military Academy using motorized vehicles, of course, cannot be separated from the carbon footprint. A carbon footprint is a measure of the total amount of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases emitted by a community, population, work system or person, which includes analysis of pollutant sources, spatial and temporal savings in populations and activities, and calculated as carbon dioxide equivalent using GWP 100 or 100 years Global Warming Potential [1]. To minimize the

carbon footprint at Akmil, mitigation must be carried out by Akmil to reduce air pollution caused by motor vehicle emissions.

The government is very serious about realizing its net zero emission (NZE) commitment by 2060. In fact, if possible it will be faster than that. Therefore, the government is currently preparing a roadmap to implement NZE to face various challenges and risks of climate change in the future. Net zero emissions or zero carbon emissions is a condition where the amount of carbon emissions released into the atmosphere does not exceed the amount of emissions that the earth can absorb. To achieve this requires a transition from the energy system currently used to a clean energy system in order to achieve a state of balance between human activities and natural balance. One of the things that needs to be considered in doing so is reducing the amount of carbon or gas emissions produced from various human activities over a certain period of time, or more commonly known as the carbon footprint. The carbon footprint that we produce will have a negative impact on our life on earth, such as drought and reduced sources of clean water, extreme weather and natural disasters, changes in food chain production, and various other natural damage.

The NZE program became a popular term after the Paris Climate Agreement was held in 2015. The program aims to reduce environmental pollution which has the potential to result in global warming. So, to reduce the carbon footprint and achieve net zero emissions, the government applies five main principles, namely: Increasing the use of new renewable energy (EBT); reduction of fossil energy; use of electric vehicles in the transportation sector; increasing electricity use in households and industry; and finally the use of Carbon Capture and Storage (CCS). Therefore, researchers wrote research entitled Analysis of the Carbon Footprint of Motorized Vehicles at Military Academies.

## **RESEARCH METHODS**

### **Research Methods**

The research method used is a review literature of several scientific articles related to exhaust emissions. The purpose of the study is to obtain the results to be achieved by the researcher with the intentions that have been planned and also adjusted to the level of the research itself (Maghfuri et al., 2022).

## **RESULT AND DISCUSSION**

### **Exhaust Emissions**

Habibi (2016) said, "Exhaust emissions are the residual results of fuel combustion in internal combustion engines and external combustion engines, which are released through the engine exhaust system" (Sunaryanto et al., 2020).

### **Carbon dioxide (CO<sub>2</sub>).**

Carbon dioxide or charcoal acid is a kind of chemical compound consisting of two oxygen atoms that are covalently bound to a carbon atom. Carbon dioxide is gaseous at standard temperature and pressure states and is present in the earth's diatmospheric (Sunaryanto et al., 2020).

### **Carbonmonoxide (CO).**

Srikandi (1992:94). Carbon Monoxide is a colorless, odorless and tasteless component found in

gaseous form at temperatures above 192 °C. In the air when given fire will burn by emitting blue smoke and become CO<sub>2</sub> (carbon dioxide). Derived from motor vehicles 93%, power generators 7%, especially where the source is in vehicles at the time of idling (Sunaryanto et al., 2020).

Based on Sunaryanto's research (2020), it is stated that the recapitulation of the comparison of exhaust emissions between premium, pertalite and pertamax on the Honda Revo EFI can be shown in the following Table 1.

**Table 1.** Exhaust Emissions Comparison Between Premium, Peralite and Pertamax on the Honda Revo EFI

Exhaust Emissions	Fuel Type		
	Premium	Pertalite	Pertamax
CO (%)	2,77	2,62	2,53
HC (ppm)	1233	837	749

Source : Sunaryanto et al. (2020)

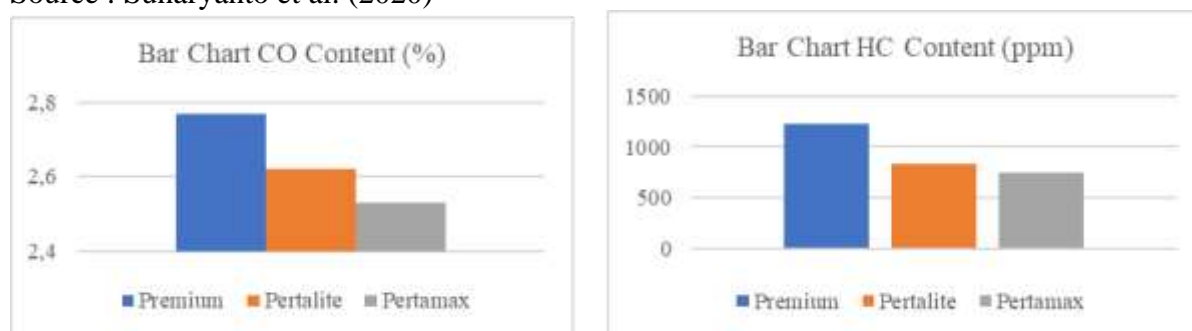


Figure 1. Exhaust Emissions Comparison Between Premium, Peralite and Pertamax on the Honda Revo EFI

Source: Sunaryanto et al. (2020)

M. Luthfi (2017), stated that the recapitulation of the ratio of exhaust emissions between premium and pertalite in Toyota Avanza vehicles can be shown in the following Table 2.

**Table 2.** Exhaust Emissions Comparison Between Premium and Peralite on Toyota Avanza Vehicles

Exhaust Emissions	Fuel Type	
	Premium	Pertalite
CO (%)	0,64	0,09
CO <sub>2</sub> (%)	12,0	13,1
HC (ppm)	218	94

Source : Luthfi et al. (2018)

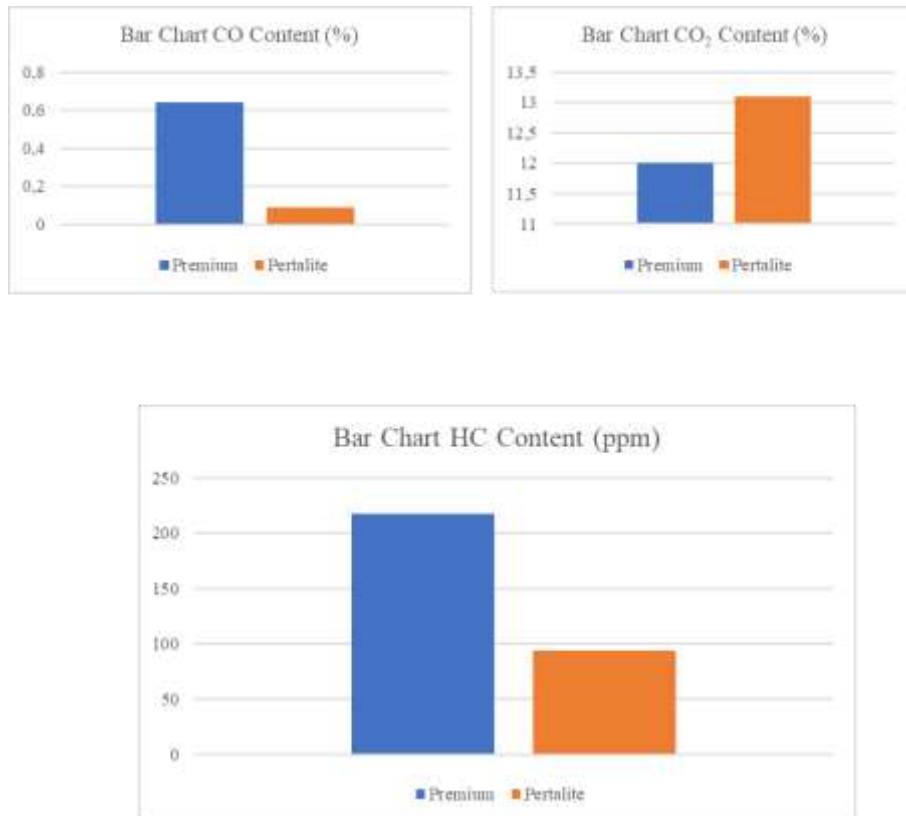


Figure 2. Exhaust Emissions Comparison Between Premium and Peralite on Toyota Avanza Vehicles  
Source: Luthfi et al. (2018)

### Location Map of Akmil

Akmil is located at coordinates 7°29'58.0"S 110°12'36.8"E in the city of Magelang, The distance of the Panca Arga Housing complex to Akmil is approximately 2 Km. Sampling location map can be seen in Figure 3 below.

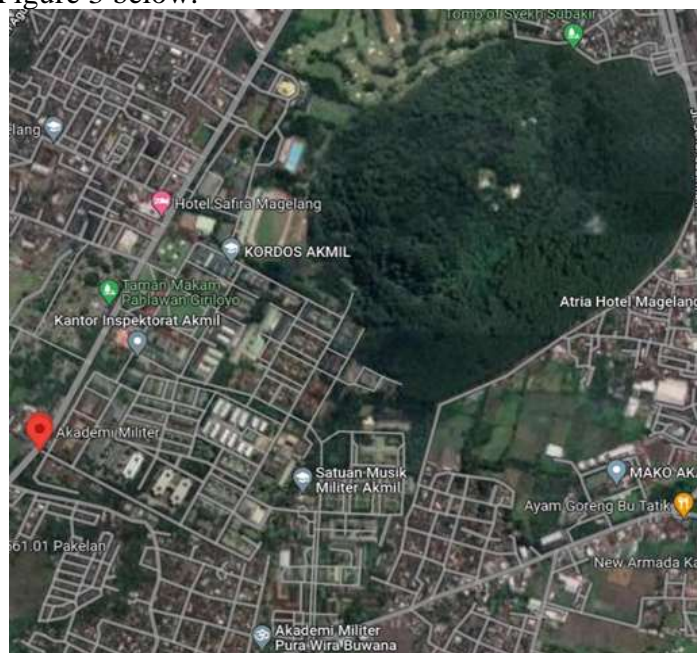


Figure 3. Military Academy Location Map  
Source: Google Map (2022)

The assumptions of users of two-wheeled motor vehicles and four-wheeled Akmil personnel can be shown in Table 3 below.

**Table 3.** Comparison of The Assumption of The Number of Samples of Two-Wheeled Vehicles and Akmil Personnel Four Wheels

Personnel	Sum	Vehicle Samples	
		Two Wheels	Four Wheels
Officer	685	202	415
Non-commissioned officers	597	330	180
Tamtama	571	400	
PNS	555	350	150
<b>Total</b>	<b>2.408</b>	<b>1282</b>	<b>745</b>

Source : Military Academy Organization and Task Book (2019)

To calculate the amount of CO<sub>2</sub> emissions produced from the type of vehicle passing through the road section of the Panca Arga Housing complex to Akmil, you can use Equation 3 (Roshinta and Sarwoko, 2016) (Erusani et al., 2022).

$$Q = Ni \times Fei \times Ki \times L$$

**Where**

- Q** : the amount of emissions in g/h,
- Ni** : number of motorized vehicles type i (vehicles / hour),
- Fi** : Fco2 emission actors of two-wheeled vehicles (motorbikes) are 3,180 g/kg of fuel and the type of four-wheeled vehicles (cars) is 3,178 g/kg of fuel (PERMENLH, 2010).
- Ki** : Type-i specific energy consumption (liters/100 km) based on vehicle type for petrol-fueled passenger cars of 11.79 L/100 km while motorcycles of 2.66 L/100 km.
- L** : Proad event (km)

**Discussion**

Based on the data table above, it can be explained that the use of pertamax fuel in two-wheeled vehicles has a lower exhaust emission value than pertalite and premium, where the CO value is 2.53% and HC is 749 ppm. Meanwhile, in four-wheeled vehicles, the use of pertalite fuel has a value of CO 0.09%, CO<sub>2</sub> 13.1%, and HC 94 ppm. There is a difference between exhaust emissions produced by four-wheeled and four-wheeled vehicles, including the technology used in these vehicles. Four-wheeled vehicles already have catalytic converter technology to reduce exhaust emissions so that the emission results are lower than two-wheeled vehicles.

Determining the CO<sub>2</sub> value in two-wheeled and four-wheeled vehicles of Akmil personnel with an assumption time of 1 hour. CO<sub>2</sub> emissions generated from motor vehicles in the Panca Arga Housing complex to Akmil are calculated using Equation 3. The CO<sub>2</sub> emission factor used is 3,180 g/kg of fuel for two-wheeled vehicles (motorbikes) and 3.178 g/kg (PERMENLH, 2010), the emission load unit in g/kg is converted into g/L, so that the density of gasoline is needed to produce an emission factor with units of g/L. According to Roshintha and Sarwoko, 2016, the density of gasoline (premium) is 0.724 kg/L. So that the CO<sub>2</sub> emission factor for cars is 2,300.87 g/L and the motor is 2,302.32 g/L (Erusani et al., 2022).

### Calculating CO<sub>2</sub> in Two-Wheeled Motor Vehicles

$$Q = Ni \times Fei \times Ki \times L$$
$$Q = 1282 \times 2.3 \text{ Kg/L} \times 2.66 \times 2$$
$$Q = 15,686.5 \text{ kg/l}$$

### Calculating CO<sub>2</sub> in Four-Wheeled Motor Vehicles

$$Q = Ni \times Fei \times Ki \times L$$
$$Q = 745 \times 2.3 \text{ Kg/L} \times 2.66 \times 2$$
$$Q = 9.155.8 \text{ kg/l}$$

**Table 4.** Comparison of CO<sub>2</sub> in Two-Wheeled and Four-Wheeled Vehicles

	Vehicle Samples	
	Two Wheels	Four Wheels
<b>Military and civil servants</b>	<b>1282</b>	<b>745</b>
<b>Up to CO<sub>2</sub></b>	<b>15.686.5 kg/l</b>	<b>9.155.8 kg/l</b>

Based on Table 4 above, it can be shown that the value of CO<sub>2</sub> exhaust emissions in two-wheeled motor vehicles is 15,686.5 Kg / L and in four-wheeled vehicles it is 9,155.8 Kg / L.

## CONCLUSION

Based on the research data mentioned above, it can be concluded that the use of two-wheeled vehicles within the Military Academy is the largest source of exhaust emissions, namely 15,686.5 Kg/L, while four-wheeled vehicles produce exhaust emissions of 9,155.8 Kg/L. The calculation is assumed that the vehicle under study uses a premium type of fuel. Of course, the results of the exhaust emissions produced will be different if the use of fuel in the form of pertalite or pertamax.

To reduce exhaust emissions in motorized vehicles on the path of the Panca Arga Housing complex to Akmil , several things are recommended as follows:

- 1) It is necessary to calculate CO<sub>2</sub> waste gas emissions assuming the fuel used is pertalite and pertamax
- 2) There needs to be a policy to pick up and drop off personnel serving in Akmil using the Bus

There needs to be a policy from the institution to recommend the use of electric vehicles bagi personnel militer class Officers and civil servants class IV.

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