

Modeling Vehicle Emissions Delivery in Tegal City Road

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Abstract

The problem of carbon dioxide in several cities in Indonesia is getting higher and requires more focused handling. The city of Tegal, one of the cities in Indonesia located on the Pantura route, has a significant impact on the distribution of CO₂ emissions. This research was conducted by modeling and mapping the number of emissions on several roads based on the outcomes of transportation efforts in Tegal City. Arc-GIS is used for analysis and modeling, with an approach to calculating emissions based on the number of vehicles, emission factors, and fuel consumption. The results showed that gasoline-fueled cars and other motorized vehicles based on the mapping model became the CO₂ suppliers on every road section. The highest emission distribution was observed on the Tegal City pantura road, which is a national transportation route.

Keywords: *CO₂ Emissions, Fuel, Vehicles, Tegal City*



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INTRODUCTION

A malfunction in one component or network of the transportation system impacts the system since it is interconnected. Transportation problems in Indonesia occur in almost every network or unit to the system's smallest unit. Issues that arise are biased from the unit or due to the influence of the system (Nasution, 2004). Transportation systems and facilities are acknowledged by many parties to have had a significant impact on human life from time to time. However, it cannot be denied that along with its development, transportation brings problems with every movement (Kartika, 2009). The influence of emissions and energy use, which are growing in importance in terms of quantity and quality, on climate change, is one of the problems that has emerged due to Indonesia's transportation growth.

The Government of Indonesia is required to implement and monitor the progress of achieving the Millennium Development Goals (MDGs) indicators at the national level, in particular, to ensure environmental sustainability, with one of the indicators being CO₂ (carbon dioxide) emissions per capita and consumption of ozone-depleting substances. This follows Law No. 6 of 1994 on the Ratification of the United Nations Framework Convention on Climate Change (CFCs). Most of the world's transportation technology relies on petroleum fuels (95%) and produces 6.3 Gton of CO₂ emissions, or about 12% of global emissions, with ground transportation making up 74% of this total. (Ministry of Environment and Forestry, 2009). As a result of this provision, several cities in Indonesia with increasing transportation development must focus more.

LITERATURE REVIEW

Surabaya has researched the contribution of CO₂ emissions, with a total estimated contribution of carbon emission by converting the number of vehicles into passenger car units, 2.2 million tons from transportation activities in the West Surabaya, South Surabaya, and Central Surabaya (Kusuma, 2010). The total average CO₂ emission in Denpasar City in 2012 was 245.08 kg/hour.km, based on 2011 LHR data without vehicle conversion on 14 roads and a 2012 fuel usage study, with motorized vehicle-related Local FE in 2011. Passenger cars and motorcycles are the automobiles that produce the maximum CO₂ emissions (Nurdjanah, 2015).

Transportation as a sector of urban activity has the potential to transform a city's air quality. Transportation-related gas and particulate matter emissions can result in several environmental issues. Increased traffic is expected to reduce air quality as it also leads to increased emissions of air pollutants (Morlok, 1995). Air pollution can damage the environment and cause potential health problems. The carrying capacity of nature is reduced in a degraded environment, which lowers the quality of life for humans and other organisms (Wardhana, 2011). Traffic is a major cause of urban air pollution. Transport activities contribute about 45%, 50%, and 90% of total NO_x, HC, and CO emissions (Karlo, 2012; Apriando, 2014). Although modern technological developments can significantly reduce emissions, the growth in motorized vehicles is relatively high, and the distances traveled are so great that these stops are no longer useful (Carbajo & Faiz, 1994).

The total amount of carbon created by an activity is its carbon emissions. Emissions are often quantified in units of carbon dioxide equivalents and can be either CO or CO₂ gas (considered greenhouse gases) (Expressed in tons of CO₂). Global warming is a term that describes the increase in the Earth's average surface temperature caused by greenhouse gas emissions, particularly CO₂ emissions (SME-ROI, 1996).

Two oxygen atoms are covalently bound to one carbon atom to form the chemical class known as carbon dioxide (CO₂). It is a gas in Earth's atmosphere and has a standard temperature and pressure. When there is enough oxygen for combustion, organic molecules release carbon dioxide. Animals exhale carbon dioxide, which is also produced by various bacteria during fermentation. Plants absorb carbon dioxide during photosynthesis. Therefore, low CO₂ concentrations as a greenhouse gas play a crucial role in the carbon cycle. They are created from plants and animals and as a byproduct of burning fossil fuels (Boedisantoso et al., 2011).

According to estimates, carbon dioxide (CO₂) accounts for 50% of the greenhouse effect in the atmosphere. The amount of CO₂ in the Earth's atmosphere varies by location and time of day, with an average concentration of 387 ppm (Ministry of Environment and Forestry, 2011). All mammals, plants, fungi, and microbes make carbon dioxide during respiration, while plants consume it during photosynthesis. As a result, carbon dioxide plays a significant role in the carbon cycle. The principal gas responsible for the greenhouse effect in the atmosphere is carbon dioxide, which is thought to account for 50% of it. The amount of CO₂ in the Earth's atmosphere varies with location and time of day, with an average concentration of 387 ppm (Kusuma, 2010). Carbon Footprint is an estimate of the individual contribution to global warming in the number of units of time the production of Greenhouse Gases (GHG) by a person and is measured in units equivalent to Carbon Dioxide (CO₂) (Fletcher, 2000). Carbon footprint is divided into 2 parts, direct or primary footprint is a measurement of emissions CO₂ directly from burning fossil fuels including domestic

energy consumption and transportation (such as cars and airplanes) and indirectly or secondary footprint is a measurement of emissions CO₂ indirectly from the overall product lifecycle (Kusuma, 2010).

Tegal city is situated 165 kilometers (km) west of Semarang and 329 kilometers (km) east of Jakarta on the north shore (Pantura) of Central Java. Tegal's position as a link between the Pantura region's trans-border regional economic routes, specifically the west-east (Jakarta-Tegal-Semarang-Surabaya) and the central and southern (Jakarta-Tegal-Purwokerto-Yogyakarta-Surabaya) is very strategic, according to its physical location (Dewantoro & Dewantoro, 2013).

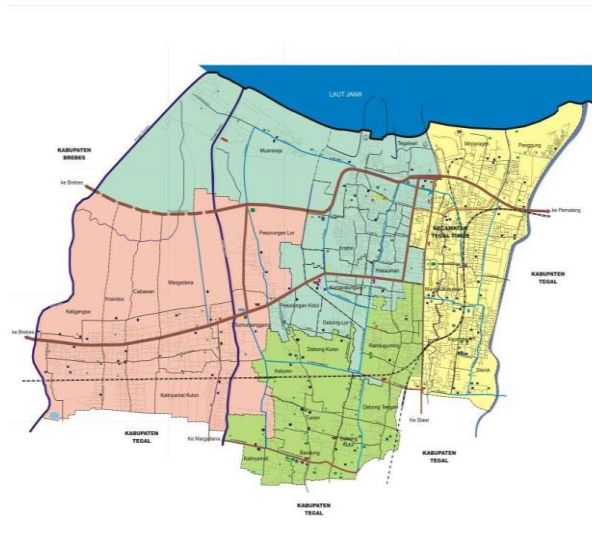


Figure 1. Map of the City of Tegal

The Tegal City economy is primarily composed of the trade and service industries. This city serves as a hub for the final processing and selling various products from Central Java's western region. This can be seen in the construction of trade and tourism facilities such as trade centers and hotels, which are developing rapidly. This has an immediate effect on the transportation industry, whose estuary visibly influences the CO₂ contribution, which is expected to rise sharply. As a result, a map of CO₂ emissions is required to be used as a reference in the future to establish Tegal City's transportation policies. Based on some of the problems above, Emission Mapping Research of CO₂ from the results of transportation activities in the City of Tegal using a quantitative approach. The stages of the research are clearly shown in Figure 2 below.

RESEARCH METHOD

This investigation utilizes a quantitative methodology. The postpositivism paradigm in evolving science is the foundation for the quantitative approach, a research methodology. The quantitative method has several traits, including a reliance on the collecting and interpretation of quantitative (numeric) data, the use of survey and experimental strategies, the performance of measurements and observations, and the use of statistical tests for hypothesis testing. This study's survey involved a field investigation into the distribution of vehicles in Tegal City.

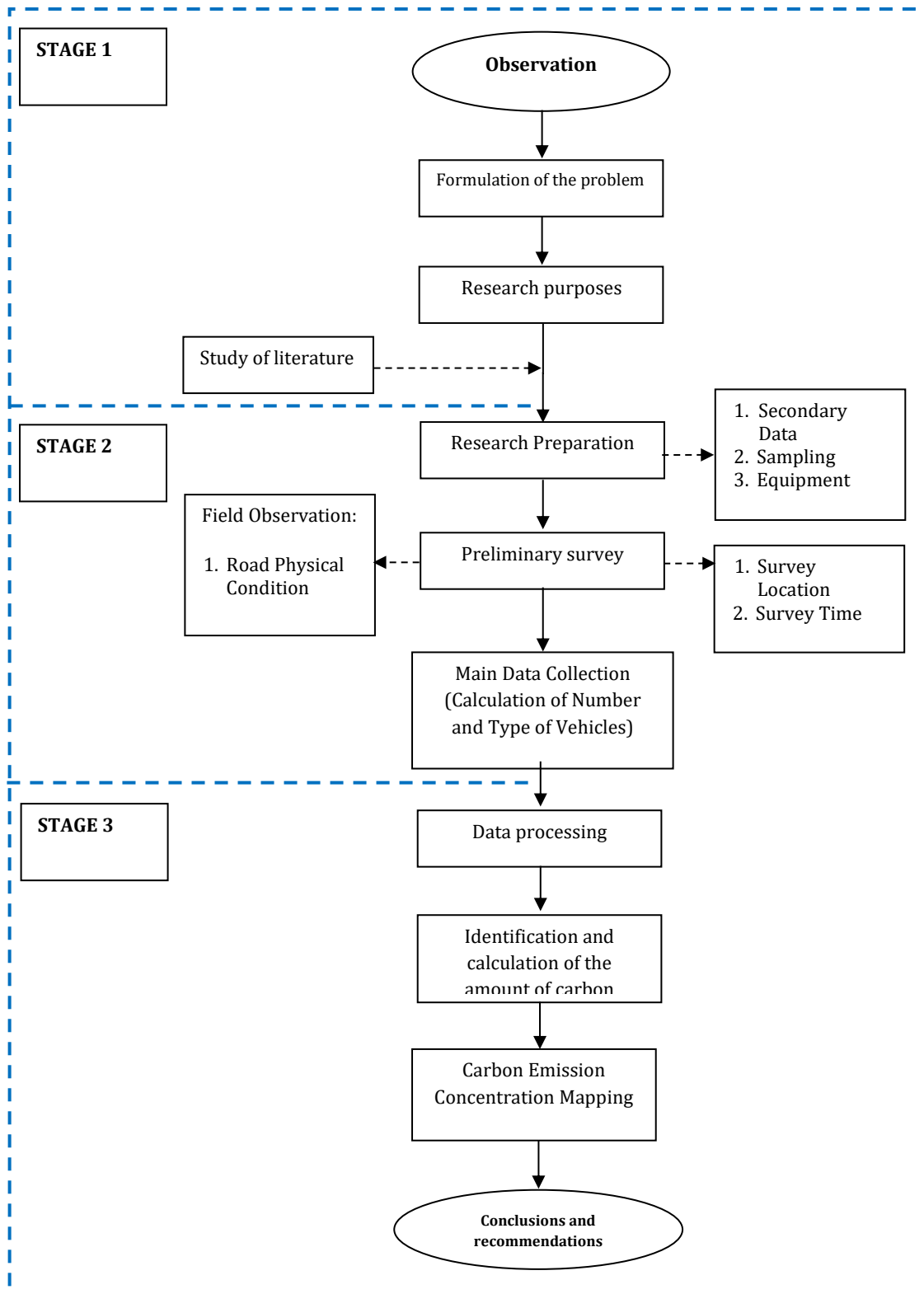


Figure 2. Research stages

In order to collect data for this study, field surveys and research tools in the form of a checklist were used to count the number and kinds of cars that traveled across local, collector, and arterial roads in the Tegal City region. All data obtained were then analyzed and discussed as a result of the research to answer the research objectives previously mentioned. The analysis used in this study consists of two parts, namely the analysis of the preliminary survey, namely by analyzing the results of the survey of the physical condition of the road so that the road category or level is obtained, and the analysis of the main survey, namely in the form of statistical analysis of primary data acquisition from the field carried out. Data analysis was carried out using the help of Arc-GIS and other related software. Using the equation, carbon emissions (CO₂) are calculated: The analysis used in this study consists of two parts, namely the analysis of the preliminary survey, namely analyzing the results of the survey of the physical condition of the road so that the road category or level is obtained and the analysis of the main survey, namely in the form of statistical analysis of primary data acquisition from the field carried out. Data analysis was carried out using the help of Arc-GIS and other related software. Calculating carbon dioxide emissions (CO₂) is carried out using the equation: The analysis used in this study consists of two parts, namely the analysis of the preliminary survey, namely by analyzing the results of the survey of the physical condition of the road so that the road category or level is obtained and the analysis of the main survey, namely in the form of statistical analysis of primary data acquisition from the field carried out. Data analysis was carried out using the help of Arc-GIS and other related software. The equation is used to calculate carbon dioxide emissions.

$$Q = n \times FE \times K \dots\dots\dots (1)$$

Information,

Q = Total emission (g/hour.km)

n = Number of Vehicles (pcu/hour or vehicles/hour)

FE = Emission factor (g/liter)

K = Fuel consumption (liters/100 km)

The value of emission factors by fuel type and vehicle type can be seen in Table 1. As for the fuel consumption that has been adjusted to the type of vehicle, it can be seen in the following table:

Table 1. Specific Energy Consumption of Motor Vehicles

| Transportation type | Specific Energy Consumption (liter/100 km) |
|---------------------|--|
| Passenger car | |
| -Gas | 11.79 |
| -Solar bigBus | 11.36 |
| -Gas | 23.15 |
| -Diesel/Solar | 16.89 |

| | |
|---------------|-------|
| Medium Bus | 13.04 |
| Small Bus | |
| -Gas | 11.35 |
| -Diesel/Solar | 11.83 |
| Bemo, Bajaj | 10.99 |
| Taxi | |
| -Gas | 10.88 |
| -Diesel/Solar | 6.25 |
| Big Truck | 15.82 |
| Medium Truck | 15,15 |
| Small Truck | |
| -Gas | 8.11 |
| -Diesel/Solar | 10.64 |
| Motorcycle | 2.66 |

Source: BPPT in Jinca et al. (2009)

FINDINGS AND DISCUSSION

According to the research findings, the distribution of CO₂ emissions in Tegal City demonstrates that emissions are produced uniformly by different types of cars using Tegal City roadways. This is crucial because it is clear that practically all of the roads that are the focus of the study emit considerable amounts of emissions, with the primary part being the road that runs along Java's north shore, which makes a sizable contribution. According to the study's findings, four roads have a relatively high distribution of emissions: Martoloyo Street, which generated 1,520,271,695 g/hour.km of emissions; Yos Sudarso Street, which produced 1,381,027,365 g/hour.km of emissions; and Cipto Mangunkusumo, which produced 1,381,027,365 g/hour.km of emissions.

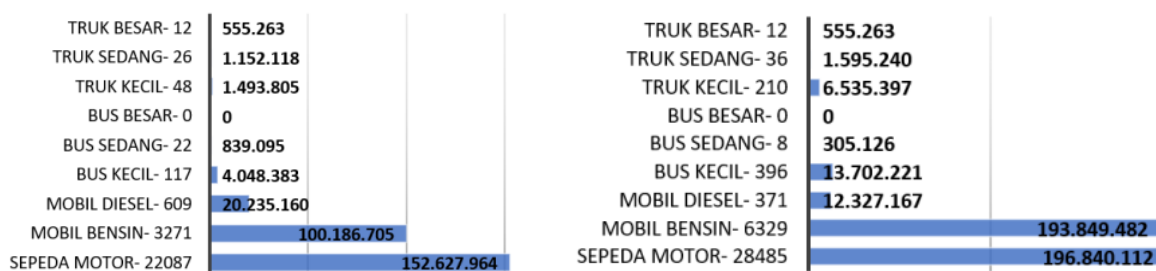


Figure 3. Ahmad Yani CO₂ Diagram

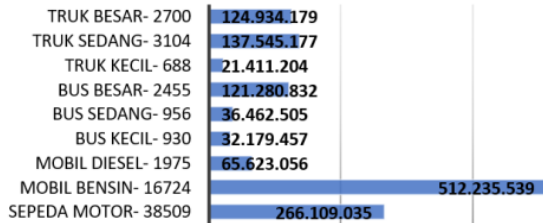


Figure 4. AR Hakim CO₂ Diagram

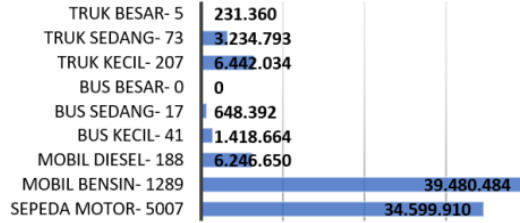


Figure 5. Cipto Mangunkusumo CO₂ Diagram

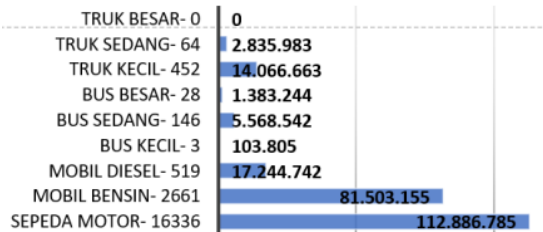


Figure 6. Gatot Subroto CO₂ Diagram

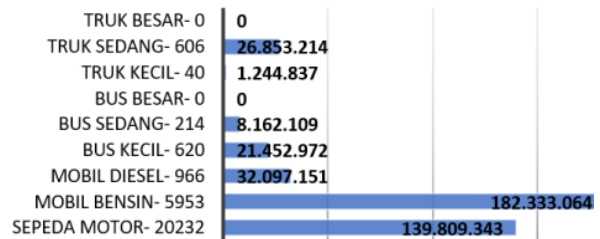


Figure 7. Hanoman CO₂ Diagram

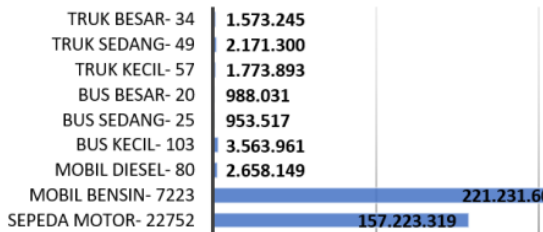


Figure 8. Kapten Ismail CO₂ Diagram

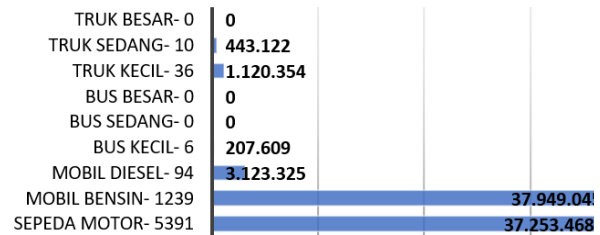


Figure 9. Sudibyo CO₂ Diagram

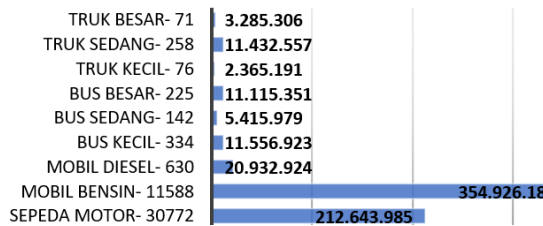


Figure 10. Ki Hajar Dewantoro CO₂ Diagram

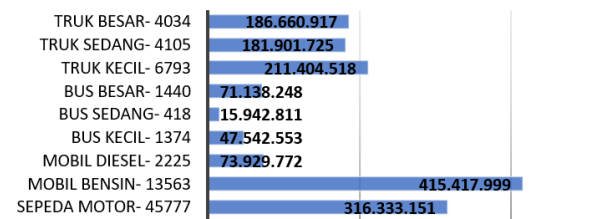


Figure 11. KS Tubun CO₂ Diagram

Figure 12. Martoloyo CO₂ Diagram

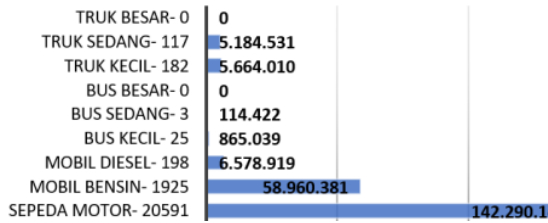


Figure 13. Perintis Kemerdekaan CO₂ Diagram

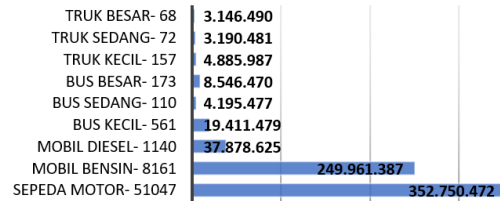


Figure 14. Sultan Agung CO₂ Diagram

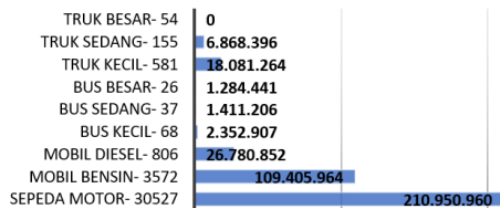


Figure 15. Teuku Umar CO₂ Diagram

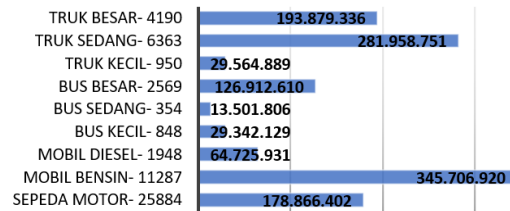


Figure 16. Wahidin Sudirohusodo CO₂ Diagram

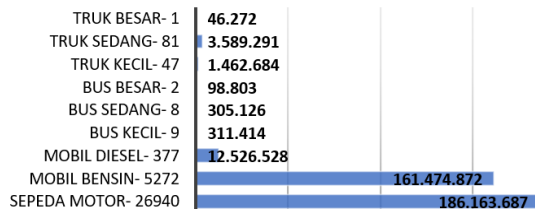


Figure 17. Werkudoro CO₂ Diagram

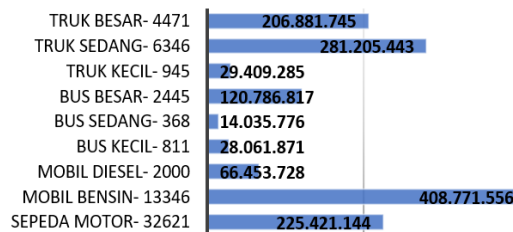


Figure 18. Yos Sudarso CO₂ Diagram

Based on the study's results, it was also found that gasoline-fueled cars and motorized vehicles were almost entirely the suppliers of CO₂ emissions on every road section. In the future, this should become more of a concern for the government in determining policies in the fields of transportation, energy, and the environment, which indirectly must synergize with each other to realize a more comfortable, safe, and prosperous Indonesia.

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