VALUATION OF TRANSPORTATION POLICY IN MAKASSAR CITY BASED ON VEHICLE EMISSION POLLUTION FOR SUSTAINABLE ZONE PLANNING

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Abstract

City expansion, vehicle growing number, fossil fuel consumption as non-renewable energy, and highest carbon emission has increased green house effect with potentially expanding global warming. Global warming has negative impacts on citizen quality of life as well as economic growth. Makassar City as one of the metropolitan in Indonesia with the high number of vehicle has a potential to endure global warming. This is excarbated by the decreasing environmental carrying capacity caused by household and industrial pollution and greater vehicle emission. This study aims to (1) identify the vehicle emission gas using descriptive analysis, (2) evaluate ambient air quality in several locations within Makassar City based on field measurement, and (3) formulate the zone plan with potential vehicle-sourced high pollution using AHP. It can be concluded from this study that 99% of Makassar City's pollution is caused by vehicle emissions with specifically refers to vehicle ages, car engine types, and low maintenance. It is found that high pollution level occurs in the suburbs, while medium pollution level happens in the transition zone and low level of pollution in city center. Urban infrastructure improvement is carried out by Makassar City Development Agency (Bappeda) with consistency ratio between 0.05 and 0.06.

Keywords: Ambient Air Quality, Vehicle Emission, Zone Planning

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INTRODUCTION

Transportation problems and challenges are multi-dimensional in the transportation system and urban system. These include in the planning, management and operational aspects as a policy framework and based on the dimensions of economic, social and environmental aspects. Makassar City as one of the metropolitan cities with a high number of vehicles has the potential to experience conditions like the one above. In addition, the reduced carrying capacity of the environment caused by pollution from industry and households as well as from vehicle emissions which are far greater than other sources of pollution. This is in line with the basic concept of sustainable development (Fauzi, 2004), where the sustainable transportation needs is the embodiment of safe, comfortable and affordable transportation. Bus services include timely and accurate information to ease users to plan their journey and providing comfortable bus stops (Min, 2022). While Chavarria (2002) used AHP for modelling the management of the transportation system.

The spatial planning of urban areas based on the level of vehicle pollution emissions originating from non-bus passenger public transport is still very limited in Indonesia, but if it is carried out it will be very useful in spatial planning, especially aspects of transportation-based area planning. Air pollution has become a serious threat to public health due to the rapid economic development globally, and urban air pollution is thought to cause 1.3 million deaths annually (Sahrir, 2022a). This is due to the increasing expansion of pollution-prone areas which are characterized by high lead levels of up to 60 micrograms per deciliter found in children in seven sub-districts in Makassar City. Several previous studies have described the development of models of air pollution from motorized vehicles (Santosa, 2005). Therefore, this paper is important due to the lack of integration of policies in the management of non-bus passenger public transport with urban spatial planning policies.

This paper aims to (i) identify the level of vehicle exhaust emissions (non-bus passenger public transport), (ii) assess the ambient air quality in several urban areas, and (iii) formulate policies for structuring areas that are potentially prone to pollution from vehicles.

LITERATURE REVIEW
Sustainable Urban Transport System Approach

The approach to a sustainable urban transportation system based on the user's perspective is intended to obtain an in-depth view of the technical parameters and conditions of official regulations to suit the expected goals and cannot be separated from sustainable urban development (Miyamoto et al.,1996). The problem formulation of the urban transportation system can be viewed from environmental, social, and economic parameters. These are represented by

several indicators, namely identification of land use and environmentally friendly alternative vehicles, equity of access and health, as well as the capability and affordability of public transportation (Deakin, 2001). These problems are closely related to the time horizon, environmental influences, and their nature and are based on rational and gradual logic of thinking (Sujarto, 2001).

Spatial planning and transport interaction modeling
Transportation and spatial interaction modeling or land use and transportation integration model is a model that allocates each land use based on its interaction and uses accessibility variables (facilities and infrastructure factors) as a link between the two. The integration model can be divided into predictive models and optimization models that consider factors: accessibility, land attractiveness, and city government policies (Najid et al., 2001).

A predictive model is a model that will explain changes in land use to transportation and vice versa or is a dynamic model based on demand behavior. While the optimization model is a mapping of land use patterns to optimize the utility of travelers or optimize city efficiency which is determined by travel and development costs (Tamin, 1997).

Environment as a Function of the Transportation Environment
The new paradigm in development that aims to improve human welfare also considers ecosystem aspects (Zubair, 2000). For this study, several transportation and environmental factors that need to be considered are unlimited emissions and waste in the form of air, land, and water pollution (natural environment), vehicle innovation from renewable energy sources (sunlight), not using natural resources for recycling, and the design of a transportation system that minimizes land use. Some of the main environmental and transportation issues are air quality, greenhouse gas emissions, noise, impact on biodiversity and land use. The main components of transportation emissions include CO_2, CO, HCs, VOCs, NO_x, SO_2, PM, and other products that are harmful to living things (Hensher et al., 2003).

Although important, little is known about how the general public views the risk of air pollution it implies that the authority might provide a significant contribution by creating strategies to lessen the effects of air pollution on people, particularly in cities where air pollution is a problem (Sahrir, 2022b).

City ambient air quality and vehicle exhaust emission levels mutually influence each other, where high vehicle emission levels are due to age, engines, and lack of vehicle maintenance in large quantities and for a long time and have an effect on decreasing city ambient air quality.

Analytical Hierarchy Process in Transportation Management

Analytical Hierarchy Process (AHP) is a flexible model and decision-making by combining considerations and personal values logically (Saaty, 1993). The Principle of AHP is an effort to simplify a complex problem that is unstructured, but strategic, and dynamic into parts and arranges them in a hierarchy. The level of importance of each variable is assigned a numerical value subjectively representing its urgency when compared to other variables. Synthesis was done based on various consideration to set up the highest priority and role to influence the system (Marimin, 2004).

A strategic decision in the management of sustainable transportation is carried out based on actors, namely users, entrepreneurs, and the government in order to achieve various alternatives (Chavarria, 2002).

RESEARCH METHODOLOGY

This study performs qualitative research, where the analysis of data in the form of documents, based on objectives. For data analysis, several methods including descriptive analysis was described in this article using frequency. Emission data and ambient air quality based on primary and secondary data using units of ug/Nm3 and percentages for each measurement parameter using Excel for Windows. Furthermore, the policy for structuring pollution-prone areas with AHP with an overall inconsistency (consistency index value) of 0.05-0.06 means that the paired weighting value of each matrix is consistent, or in other words the respondents' answers are carried out consistently (See Figure 1 Land Use Map of Makassar City)
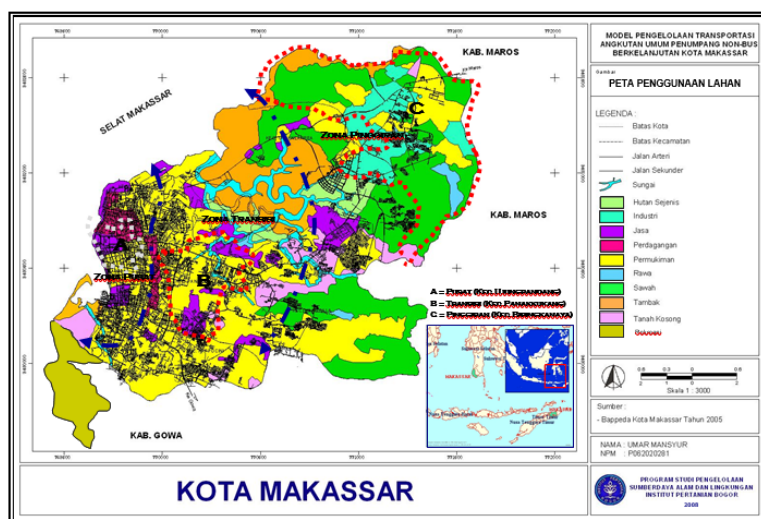

Figure 1: Land Use Map of Makassar City

It was analyzed with the help of Expert Choice 2000 with seven respondents (stakeholders) who are involved in or directly related to the objectives of policy formulation, namely:

1) representatives of the regulators (City Development Planning Agency, Public Works Service, Environment and Sanitation Service, Transportation Service, and City Police Agency),
2) operator representatives (transportation entrepreneurs), and
3) user representatives (transport users).

ANALYSIS AND DISCUSSION

From a macro perspective, the ambient air quality for Makassar City was measured over a period of 5 to 6 years (2001-2005) at several locations as samples representing each land use, namely (1) downtown in Karebosi Field and in front of the Mattoangin Stadium, (2) residential zone in Panakkukang, (3) services and education zone on Jalan Urip Sumohardjo, (4) trading zone in Central Market and Pannampu Market, and (5) industry area in front of PT. Berdikari and Makassar Industrial Zone (KIMA).

The results of these measurements concluded that the air condition based on pollutant parameters and indications of their sources (Environmental Impact Control Agency of Makassar City, 2001-2005) is as follows:

- The parameter of Carbon Monoxide (CO) with 24-hour quality standard = 150 ug/Nm3 is the highest although it has not exceeded the quality standard at Pannampu Market and Jalan Urip Sumohardjo; and the lowest was in Karebosi Field which was caused by heavy traffic or came from vehicles and dense settlements.
- Nitrogen Dioxide (NO2) with a 24-hour quality standard = 150 ug/Nm3 is the highest, although it has not exceeded the quality standard at PT. Berdikari, Panakkukang, KIMA, and Central Market; and the lowest was at the Mattoangin Stadium caused by industry, settlements and heavy traffic.
- Oxidant (O3) with a quality standard of 1 hour = 235 ug/Nm3 is the highest although it has not exceeded the quality standard in the Central Market, and Panakkukang; and the lowest in the Market Pannampu which is caused by heavy traffic or comes from vehicles and settlements.
- Sulfur Dioxide (SO2) with a 24-hour quality standard = 365 ug/Nm3 is the highest although it has not exceeded the quality standard at Jalan Urip Sumohardjo and Karebosi Field; and the lowest in Panakkukang caused by heavy traffic or from vehicles.

- Dust (TSP) with a 24-hourquality standard = 230 ug/Nm3 is the highest and has exceeded the quality standard on Jalan Urip Sumohardjo and Karebosi Field; and the lowest at KIMA caused by heavy traffic or coming from vehicles.
- Lead (Pb) with a 24-hour quality standard = 2 ug/Nm3 is the highest and has exceeded the quality standard in Pannampu Market and Jalan Urip Sumohardjo and the lowest in Karebosi Field which is indicated due to high concentrations of Lead by heavy traffic or from vehicles.

Based on the monitoring results over the 5-year period above, it can be concluded that the source of air pollution or pollution in Makassar City is emissions from vehicles. Because based on observation locations with the highest pollutant levels are locations with heavy traffic and densely populated settlements. Air quality in other locations that are not heavily trafficked has not yet exceeded environmental quality standards.

The emission level of vehicles using gasoline or premium (gasoline) fuel in Makassar City is based on secondary data from testing with the AVL Emission Tester Series 4000 which was carried out for 3 days of observation at the research location, namely Makassar City Hall Jalan Ahmad Yani (Ujungpandang District), Center Regional Ministry of Environment Sumapapua Perintis Kemerdekaan Street (Biringkanaya District), and Ruko Yanti Jalan Sultan Alauddin (Panak-kukang District) (see Table 1).

Table 1: Vehicle Emission Test Result in Makassar City in 2006

No	Testing point	Vehicle number	Emission Test Result and Vehicle System						Ket.
			System	CO (%)	CO_2 (%)	O_2 (%)	HC (ppm)	Lambda (λ)	
1	City Hall Ahmad Yani Street (Ujungpandang)	**161** Private=85 Agencies=66 Public=9 Taxi=1	Carburator **90 vehicles**	Total 506.8	Total 1855.02	Total 314.46	Total 110.722	Total 61.431	Public 5.6 %
			Injection **71 vehicles**	Average 3.15 (unideal)	Average 11.52 (unideal)	Average 1.95 (ideal)	Average 688 (unideal)	Average 0.38 (unideal)	
2	Pusreg KLH Sumapapua Office, Perintis Kemerdekaan Street (Biringkanaya)	**52** Private =29 Agencies =14 Public =9 Taxi =0	Carburator **41 vehicles**	Total 183.6	Total 574.69	Total 98.54	Total 20.070	Total 9.641	Public 17.3 %
			Injection **11 vehicles**	Average 3.53 (unideal)	Average 11.05 (unideal)	Average 1.895 (ideal)	Average 720 (unideal)	Average 0.367 (unideal)	
3	In front of Ruko Yanti, S.Alauddin Street (Panakkukang)	**143** Private=89 Agencies=9 Public=42 Taxi=3	Carburator **107 vehicles**	Total 673.02	Total 1395.32	Total 512.73	Total 121.998	Total 103.319	Public 25.2 %
			Injection **36 vehicles**	Average 4.71 (unideal)	Average 9.76 (unideal)	Average 3.59 (unideal)	Average 835 (unideal)	Average 0.725 (unideal)	
	Total / Average	356 / 119	238 (K) 118 (I)	11.39 / 3.79	32.33/ 10.78	7.435 / 2.48	2 243 / 748	1.472 / 0.49	48.1/ 16

Remarks: ideal emission values CO $\leq$ 2,0%; $CO_2 \geq$ 12,0%; 0,5% $\leq O_2 \leq$ 2,0%; HC $\leq$ 200 ppm; and Lambda 0,950 $\leq \lambda \leq$ 1,050; C = carburator dan I = injection

Based on the results of the three-day test at the three locations above, it can be concluded that of the number of vehicles tested, 356 vehicles and an average of 119 vehicles per test day with a vehicle system using carburetors, 238

vehicles and 118 vehicles injection. The vehicle exhaust emission levels tested on average per type of pollutant source and their parameters are as follows: (i) Carbon monoxide in unideal level around 3,79%; (ii) Carbon dioxide in unideal level around 10,78%; (iii) Oxygen in unideal level around 2,48%; (iv) Hidro carbon in unideal level around 748 ppm; dan (v) Lambda in unideal level around 0,49.

These results indicate that the vehicle carburator system in large quantities compared to injection and is more prone to causing gas emissions that are not ideal and is evidenced by the average test results for each pollutant parameter, all of which are in non-ideal conditions. Based on various types of vehicle use, namely private vehicles by 57 percent, service 25 percent, city transportation 17 percent, and taxis 0.8 percent, it has been indicated that the level of vehicle emissions in general is not fully influenced by this type of use but is highly dependent on the level of vehicle maintenance. In addition, the results of vehicle emission tests based on the type and year of manufacture were on average with 1500 CC type engines and were produced in 1998.

In general, these conditions have the potential to generate emissions and produce conditions that are not ideal for each pollutant parameter. The results of emission tests on non-bus passenger public transport vehicles, amounting to 48.1% of all tested vehicles, indicate vehicles with a very high potential to generate emissions.

The detailed results of emission tests indicate that 99% of city transportation was in critical condition. It occured because all emission test parameters were not ideal either due to the age of the vehicle, type of engine, or due to lack of vehicle and engine maintenance. Vehicle emissions and ambient air quality in Makassar City directly influence each other, because the higher the level of vehicle emissions in cumulative amounts on the highway will affect overall air quality.

Based on the conditions mentioned above, it can be concluded that at the research location the average emission level of vehicles in the city center zone (Ujungpandang District) was identified as low, while in the urban transition zone (Panakkukang District) is moderate, and finally in the periphery zone (District Biringkanaya) is high. In addition, the quality of ambient air at the study site is strongly influenced by the level of activity of the population and the pattern of land use in the area and the level of vehicle traffic density.

This condition explains that although there is a relationship between increased vehicle emissions and decreased city ambient air quality, this situation is more due to the condition of the types of vehicles and the volume of vehicles in each of these zones. Vehicle condition is related to type, age, and maintenance factors, while vehicle volume is related to traffic density and low vehicle speed

on a road section in an area. City ambient air quality in the long term will continue to decline in line with increasing vehicle emission levels.

Based on these calculations, it can be concluded that the amount of carbon monoxide (CO) emissions based on the type of vehicle at the study site was dominated by sedans/jeeps, deer and pick-ups by 38%, buses by 36%, mini buses and city transportation by 34.2 %, and mini trucks 20%.

Analysis of the description of emission levels at the study sites can be concluded based on the average vehicle emission levels in the 2006 test. Fuel consumption based on the average volume of vehicles at each study location as shown in Table 2.

Table 2. Total Vehicle Emission in Study Location

No	Vehicle type	Vehicle emission testing point			Emission Factor CO (%/volume)	Fuel consumption (Volume)	Total Emission (%)
		Ahmad Yani	Perintis Kemerdekaan	Sultan Alauddin			
1	Sedan/Jeep	5188	3973	2460	3.8	10	38
2	Kijang	11243	9195	6220	3.8	10	38
3	Mini Bus	105	262	248	3.8	9	34.2
4	Bus	1811	99	194	4.0	9	36
5	Pick-up	568	220	1652	3.8	10	38
6	Truk mini	135	872	1191	4.0	5	20
7	Publictransport (Angkot/pete2)	16202	4391	4796	3.8	9	34.2
	Total	35252	20997	16761	27	62	238.4
	Vehicle	5036	2999	2394	3.8	8.8	34.06

Remarks: diesel engine type vehicle and motorcycle has not analyzed

In general, the research location has the potential to be an area prone to pollution from four-wheeled vehicles that use gasoline with one type of parameter, namely carbon monoxide, which is an average of 116% and for a total average of 389,871%. For more details, the condition of the vehicle emission test results at the research location can be seen in Figure 2.
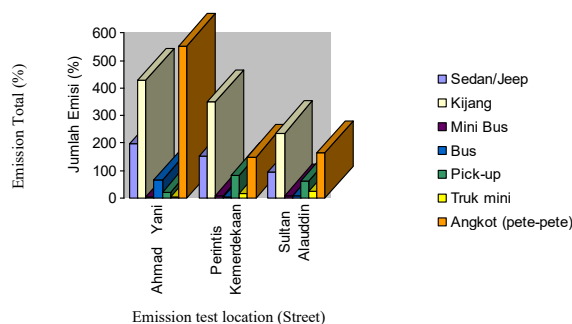
Figure 2: Vehicle Emission in Study Location

Identification of ambient air quality and vehicle emission levels as part of planning pollution-prone areas is part of the environmental parameters in the management of sustainable non-bus passenger public transport. The level of vehicle emissions, especially those caused by large numbers of public transportation passengers (angkot) or pete-pete, has caused the quality of city ambient air to improve in the medium and long term. Differences in the ambient air quality at the study sites are influenced by differences in land use and the area of open space as well as geographical and weather conditions such as wind speed at each location.

The results of the third study are the weighting values of the tabulations and questionnaire analysis of experts or actors related to the field of transportation and the environment (see Figure 3), while based on the hierarchical structure has alternative strategies based on priority from the first is environmental facility improvement with 0.323. The objectives of spatial planning in pollution-prone areas based on priority is location arrangement with a weight of 0.289. Prioritized actors from first is Bappeda with a weight of 0.219. The priority factors or criteria in the arrangement are city spatial plans with a weight of 0.241.

Spatial planning of áreas in prone to pollution due to vehicle emissions with alternative priorities for improving environmental facilities as part of the location planning objectives to be carried out by Bappeda actors and based on factors or criteria for urban spatial plans with a valid ratio consistency value between 0.05-0.06.
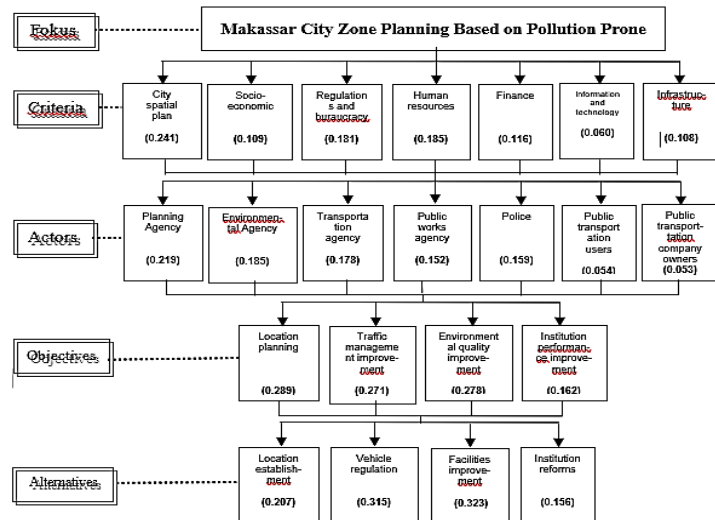

Figure 3: Hierarchy Structure of Zone Planning in Pollution Prone Area

CONCLUSION

This study seeks to formulate policies for structuring areas prone to pollution due to vehicle emissions that are in line with the concept of energy-efficient urban development. It can be concluded that minimizing the type, length, and frequency of trips can change driving behaviour and thus modify urban development patterns. Therefore, this policy that is very concerned with the concept of transportation demand management. Efforts to organize the area as part of the environmental parameters are expected to synergize with other programs and be sustainable, especially for future generations in Makassar City. In addition, policies to structure the area have a sustainable dimension with various alternative approaches, with environmental aspects: limiting vehicle emissions, implementing environmentally friendly vehicles, and improving quality of life and health. While economic aspects consist of: providing access justice for residents, having funding, and operational and economic. As for the social aspect is minimizing land use.

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