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Environmentally Sustainable Transport: Dust Particles (PM10) on Provincial Roads in South Sulawesi, Indonesia

Murniati[1], Natsir Abduh[2]

[1]Department of Agrotechnology, Faculty of Agriculture, Universitas Bosowa, Makassar, Indonesia
[2]Department of Civil Engineering, Faculty of Engineering, Universitas Bosowa, Makassar, Indonesia

murnihutss@gmail.com

Abstract. The research objective was to determine and analyze the concentration of dust particles (PM10) and the relationship between traffic flow and dust particles (PM10). Quantitative research by measuring two parameters, namely the volume of traffic flow and the concentration of dust particles (PM10). Traffic volume data were obtained using a manual count following the Indonesian road capacity manual. Dust particles (PM10) were measured using the BAM1020 instrument and data analysis using SPSS version 16.20 with multiple linear regression (MLR). The concentration of dust particles (PM10) produced at 3 points in Maros City, respectively 155.85 µg / m3, 157.22 µg / m^3, 151.77 µg / m^3 and 1 point in Pangkep City is 150.25 µg / m^3. There is a significant positive relationship between the traffic flow and the concentration of dust particles (PM10) shown from the calculation of PM10, $r = 0.693$; $P < 0.001$.

1. Preliminary

The development of a city in the world is in line with the problems that occur so that this problem will always follow the development of a city [1]. This development can be seen from the existence of the transportation sector that supports the movement of goods and people, so that the need for transportation increases. Sector transportation is very important in people's lives, and it can be said that transportation is one of the backbones of a country's economy.

Rapid economic growth has logical consequences on urban transportation systems and patterns and has an impact on the environment. Naturally, the city turns into a city that is quite dense in traffic even though it occurs at certain times accompanied by an increase in environmental pollution [2].

In several developed countries such as Japan, France, Sweden, England, and Germany, environmental issues receive priority attention in the development of sustainable urban transportation[3]. Sustainability in the environmental aspect can be interpreted as reducing emissions and waste so as not to exceed the absorption of the earth, transportation that does not endanger public health [4]. The thing that will be studied further regarding the sustainability of transportation is dust particle pollution (PM10).

Dust particles (PM10) are particulate material with a diameter of 10 micrometers or less than 10 micrometers (Department of Agriculture. Water and Environment, in the form of dust, dirt, soot, or smoke, which comes from exhaust pipes, road dust resuspension, dust storms that can cause environmental impacts [5].

In Indonesia, the growth in the number of motorized vehicles ranges from 8-12 percent per year, which is the largest automotive market in Southeast Asia with 17 million cars in 2018. Cars, trucks, and

buses produce dust particles (PM10) which are particulate matter in the form of soot seen in vehicle exhausts (Report & Multimedia/Explaner, 2018).
South Sulawesi in supporting its development requires adequate transportation facilities. Trade activity is quite high and infrastructure development is very fast, especially in Maros City and Pangkep City.

The purpose of this study was to determine and analyze the concentration of dust particles (PM10) and the correlation between traffic flow and dust particles (PM10) in the study area of Maros City-Pangkep, South Sulawesi Province.

2. Research Method

2.1 Research Desaign

The research was conducted in Maros City - Pangkep, South Sulawesi Province. The research location was chosen because it is one of the provincial roads in South Sulawesi which is very congested and is passed by heavy vehicles.

Research in Maros City 4 sample points, namely point 1 Sultan Hasanuddin Airport Roundabout, point 2 Maros City Gate, point 3 Grand Mall Batangase, and point 4 Traffic light Maros-Bantimurung. In Pangkep City, namely point 5 Bambu Runcing Pangkep, point 6 BRI Pangkep Office and point 7 Pangkep-Tonasa Traffic Light 1. Location and research points are shown in Figure 1.

Figure 1. Location Study Maros Regency – Pangkep Regency

3. Results and Discussion

3.1 Traffic Flow and Dust Particles (PMI10)

a. Flow of Vehicle Traffic

Vehicles using the Kota Maros-Pangkep road 17% are heavy vehicles, including buses and trucks or vehicles with more than four wheels; 36% of light vehicles include passenger cars such as buses or minibuses, taxis, pick-ups, boxes and small trucks, and 47% motorbikes.

High tonnage vehicles are a means of transportation between provinces, namely; Southeast Sulawesi, Central Sulawesi and North Sulawesi. Most of the transportation of building materials serves the needs of Makassar, Maros and Pangkep cities. Light buses as public transportation serve inter-regency transportation in South Sulawesi and inter-province transportation. The traffic volume can be shown in figure 2.

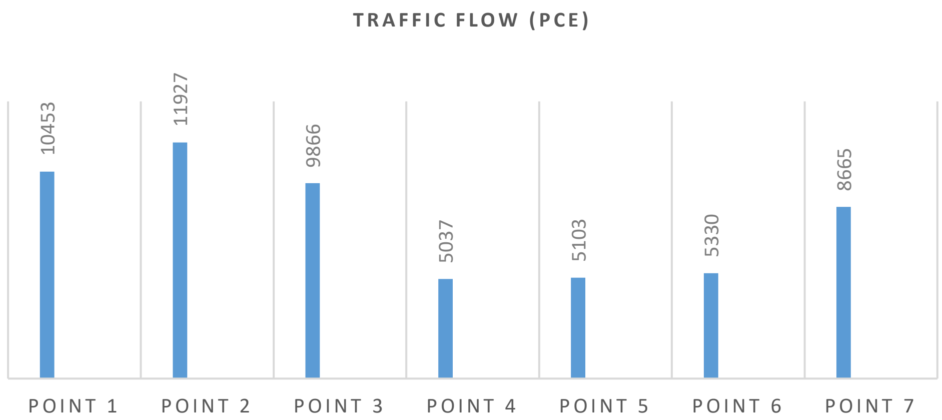

Figure 2. Traffic Flow of Maros-Pangkep City Road

The results of the research in Figure 2 show that the highest average traffic flow in Maros City is at point 2 (gate of Maros city) as many as 11,927 PCE (Passenger Car Equivalent) and in Pangkep City the highest average is at point 7 (Pangkep-Tonasa 1 traffic light) 8,665 PCE. If you look closely, there is the largest traffic flow in Maros City at the entrance to Maros City which is caused by road narrowing so that the road capacity is insufficient to accommodate the traffic flow from Sultan Hasanuddin Airport, from Makassar which passes the main city road and from Makassar which passes the Sutami Toll road . The use of road shoulders as parking spaces is often encountered because there are shops with inadequate parking infrastructure.

The study, entitled Safety Effects of Narrow Lanes and Shoulder-Use Lanes to Increase Capacity of Urban Freeways, said that congestion on urban roads is often a necessity to increase the capacity of freeways by adding additional lanes. Turning shoulders into roads is a practical solution [6].

Research in the book The Diplomat (Asean Beat Southeast Asia), says that in general, traffic congestion in Indonesia is caused by the growth in the number of vehicles that exceed the capacity of roads. The number of vehicles in Indonesia has increased rapidly, from around 30 million vehicles in 2004 to nearly 125 million vehicles in 2016. It is estimated that it is growing at around 6 million units per year, 10 to 15 percent of which are cars. Cars and motorbikes parked casually on the side of the road, resulting in narrower roads which resulted in severe congestion.

Another study, entitled Managing traffic congestion in the Accra Central Market in Ghana, recommended public education, strict enforcement of road traffic regulations, and provision of adequate parking spaces to help manage traffic congestion in the Accra Central market, Gana [7].

b. Dust Particles (PM10)

PM10 fine dust comes from the exhaust of passing vehicles and the wind blowing on the roads. Many dust particles are generated in places where congestion occurs. The results of the study on dust particles (PM10) are shown in Figure 3.

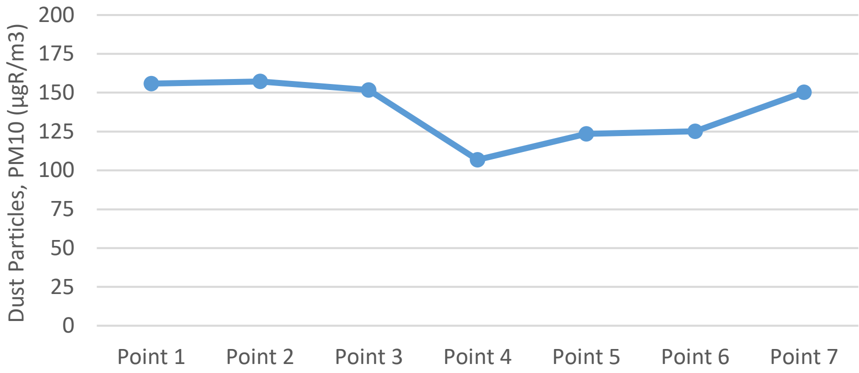

Figure 3. Dust Particles (PM10) of Maros-Pangkep City Road

In Figure 3, the results of the research on PM10 dust particles are on average in point 1 of 155.85 µg / m3, point 2 of 157.22 µg / m^3. , point 3 of 151.77, point 4 of 108.83 µg / m^3. , point 5 is 123.50 µg / m^3. , point 6 is 125.10 µg / m3 and point 7 is 150.25 µg / m3. At 7 research points, the highest PM10 dust particles were at point 2 (the city gate of Maros) at 157.22 µg / m3, followed by point 1 (roundabout Sultan Hasanuddin Airport) at 155.85 µg / m^3. The two sample points are not far apart, it's just that the causes and duration of congestion are different. The highest PM10 dust particles at the City Gate of Maros are caused by congestion due to traffic of light vehicles and high tonnage heavy vehicles so that the volume of vehicles increases at the study point. Besides that, at the study point the road conditions began to break down and wind gusts often occurred at this research point, especially in the afternoon.

The dust particles (PM10) produced at 3 points in Maros City, respectively 155.85 µg / m^3, 157.22 µg / m3, 151.77 µg / m^3. and 1 point in Pangkep City of 150.25 µg / m^3. have exceeded the permitted threshold. US EPA compliant, through the National Ambient Air Quality Standards (NAAQS), provides threshold values for PM10 150 µg / m^3.

The study, entitled the health impact of air pollution due to transport, states that dust particle (PM) emissions from road traffic come from exhaust pipes, tire wear, brake linings and road dust resuspension. Road dust resuspension depends on several factors, such as road surface, humidity, traffic intensity and wind speed. The resulting turbulence thus the amount of resuspension increases with the speed and weight of the vehicle.

Another study, said that the highest concentration of dust particles (PM) occurs in heavy traffic and the concentrations of PM10, PM2.5, and PM1 were measured from April to September 2010 in Iraq. The data obtained the average value for PM10 respectively of 5,337.6 µg / m^3.; PM2.5 is 910.9 µg / m^3 and PM1 is 495 µg / m^3. The presence of blowing west winds is the main source of dust in this area which occurs for 72 days or 711 hours. High concentrations yield AQI values of up to 500 to an estimated total mortality and morbidity of 1,131 and 8,157 cases.

The results of the same study say that dust particles are a complex and mixed material consisting of carbon-based particles, dust and acid aerosols. Dust particles can irritate the lungs. In the city of Birmingham with a population of one million people a day average particle concentration per day is between 25-50 µgr / m^3 (average 24 hours) there is an increasing number of patients hospitalized for respiratory problems [5].

The potential health effects cause shortness of breath, recurrent asthma (exacerbations), respiratory infections, chronic bronchitis, and chronic obstructive pulmonary disease (COPD), and chronic COPD. Autonomous disorders can cause death mainly due to cardiovascular disease [8].

City air quality monitoring in Italy is measured using the European Air Quality Directive 50/2008 threshold, the air quality parameters studied are the same [9] there are six parameters: NO2 and NOx, O3, SO 2, C6H6, CO, and PM10. Results in winter, pollutant concentrations are higher due to contributions from vehicle traffic and additional emissions from heating use [10]. There is no single metropolitan area that is capable of creating a safe and comfortable transportation system and supporting regulations / policies related to sustainable transportation.

3.2 Relationship of Traffic Flow with Dust Particles (PM10)

The result of the highest average traffic calculation in Figure 2 is in Maros City of 11,927 PCE, significantly higher than in Pangkep City, namely 8,665 PCE. The highest concentration of PM10 dust particles on average in Maros City was 143.42 µg/m3, significantly higher than in Pangkep City, namely 132.95 µg/m^3. There is no difference in calculated in the two study areas. The traffic flow count results showed a significant correlation between traffic flow and dust particles (PM10), r=0.693; P <0.001. There is a significant positive relationship between traffic volume and the number of PM10 dust particles. The higher the traffic volume, the higher the number of PM10 dust particles.

The results of the study, entitled Relationshir Between Vehicle Counts and Particulate Air Pollution in Amman, in their findings indicate that TSP and PM10 are still significantly correlated with TSP traffic calculations, r = 0.726, P <0.001; PM10, r = 0.719, P <0.001 [11].

4. Conclusion

The concentration of dust particles (PM10) produced at 3 points in Maros City, respectively 155.85 µg / m^3, 157.22 µg / m^3, 151.77 µg / m^3 and 1 point in Pangkep City of 150.25 µg / m^3 have exceeded the permissible threshold that is 150 µg / m^3. There is a significant positive relationship between traffic flow and dust particle concentration (PM10) which shows a significant positive correlation from the PM10 calculation, r = 0.693; P <0.001.

Controlling the sustainability of environmental management requires government support through policies in implementing emission tests related to vehicle eligibility, periodic air quality tests, use of public transportation and green road infrastructure.

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