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The Factors Affecting Velocity Waste Transport By Dump Truck (Case Study At Malang City, Indonesia)

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ABSTRACT
The high operating costs are the problems that often arise in handling the municipal solid waste which are continuously growing in quantity. The transport operation costs up to 85% of the total expenditure of the waste management. In the calculation of vehicle operating costs, vehicle speed is very influential so that high operational costs are also influenced by the speed of the vehicle during transport. Therefore, it is crucial to be able to identify what factors leading to the speed of vehicles. In this study, the primary data in the form of geometric data road, distance and time of transport, as well as the volume of waste was obtained by surveying Dump Truck vehicle movement patterns. The secondary data such as the age of the driver and vehicle age was obtained from the results of previous studies. Data analysis was performed to determine the factors that affect the speed. Based on the analysis, waste transportation speed is influenced by two factors: external factors and internal factors. External factors include the degree of saturation and the geometric slope, while internal factors include the volume of waste and the age of the driver. Both of these factors strongly affected the speed of the vehicle with a correlation coefficient (R) of 0.749 for external factors and 0.732 for internal factors.

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INTRODUCTION

Transporting waste is influenced by accessibility (travel time), patterns of transport, modes of transport, the transport frequency, and level of transport services (Maryono, 2007). The accessibility, patterns of transport and modes of transport also affect the speed of vehicles in the process of waste transporting activities (Maryono, 2007). These three aspects are also influenced by builder aspects that indirectly associated with the speediness of the vehicles (Maryono, 2007).

The high operating costs are the problems that often arise in handling municipal solid waste which are continuously growing in quantity (Aries Dwi, 2010). Its expense reaches up to 85% from the total expenditure of the waste management (Apaydin, 2007). Vehicle speed has contributing factor to the calculation of vehicle operating costs (Sugiyanto, 2011). Therefore, this problematic cost is also influenced by the speed of the vehicle in transport waste activities.

The cost per person or the cost per unit weight of the item underlies the allocation for transport of goods or people, regardless traffic conditions (Salim, Abbas, 2006). Indeed, traffic conditions are not put into consideration. PT. Satya Ragam (www.satyaragam.blogspot.com) suggests that considerable factors in determining the amount of freight cost accord with (1) distance in tonne-kilometers, (2) transport capacity utilization rate in the measurement of time, and (3) the special nature of cargo (Salim, Abbas, 2006). These apparent examples show that traffic factors are not taken into account. Nevertheless, traffic elements play a major role in regard with the vehicle speed which certainly associate with vehicle operating costs.

Performance of the transport of goods and services in urban areas is affected by two things: internal and external factors. Internal factors are factors inherent in apparatus transporter, while the external factors are the influence of environmental factors (Purnomo, 2005). On internal factors include the transport of such heavy goods transported, the driver (driver age), and used vehicles (vehicle age), while external factors include the condition of roads and road geometric conditions. In this study, the calculation of waste transport speed on those

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two factors into account. So that it can be seen to the influence of both factors on the speed of transporting waste.

Stationery Container System (SCS):

Transporting waste by using the Dump Truck is a transport with stationery container system (SCS). Stationery container system is the waste collection system where waste storage container is left at the point of decision. The workings of the container system remains as Figure 1.

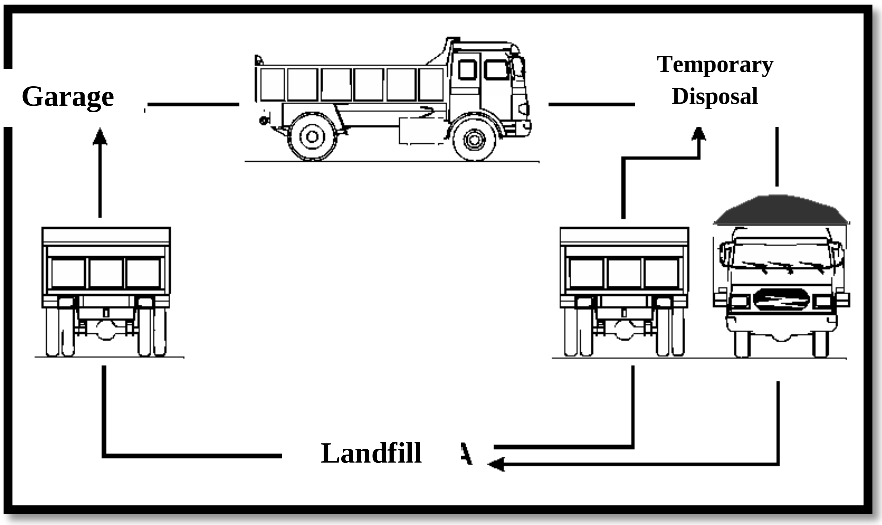

Fig. 1: SCS Waste Transportation Systems

SCS transport sequence is performed as follows; 1) move containers from the garage to the point of decision, 2) Put garbage in the existing TPS down garbage trucks manually or assisted by the existing mechanical equipment in the truck, and then transported to the landfill, 3) after disposing them in a landfill, the trucks return to the polls if required, 4) if the transport waste activities are completed, the truck goes back to the pool.

Speed:

Speed is the movement of vehicles within per unit time (Nugroho, 2010). Traffic speed is the value of the movement of a vehicle in the distance per unit of time, expressed in units of km / hour, including instantaneous speed, movement speed and travel speed (Arifin, 2007). In the movement of traffic, each vehicle has a different speed, so it is not known the characteristics of single speed but more as a distribution of a single vehicle speed. The calculation of the average speed can be divided into two, that is *Time Mean Speed* (TMS), which is defined as the average speed of all vehicles passing a point on road for an indefinite period. *Space Mean Speed* (SMS) means the average speed of all vehicles that occupy a fragment of road over a period of time (Nugroho, 2010).

Federal Highway Administrtion (US Department of Transportation) reveals that the types of roads are also instrumental in the vehicle's speed and reliability. Road characteristics that affect the vehicle performance include the number and width of lanes, presence or absence of the shoulder, in the form of merging local interchanges, and street alignment such as values and curves. Considering the road characteristics to calculate the speediness of vehicles is thus important.

Analyzing the vehicle speed when congestion occurs and normal conditions (free flow) uses the following equation: (MKJI, 1997)

1. Vehicle Speed :

$$V = L/TT \tag{1}$$

Where :
V = Speed (km/hour)
L = the Long road (km)
TT = Travel time (hour)

2. Free flow speed is determined by using the following formula : (MKJI, 1997)

$$FV = (FVo + FVw) \times FFVsf \times FFVes \tag{2}$$

Where :
FV = Free flow speed of light vehicles (km/hour)
FVo = Free flow speed basic light vehicle (km/hour)
FVw = Traffic lane width adjustment factor effectively (km/hour)
FFVsf = Side friction condition adjustment factor
FFVcs = City size adjustment factor

For free flow speed, the road base and value factors for each adjustments are tailored to the conditions of the roads themselves. The urban waste transport system generally uses urban lines. According to the Minister of Transportation Regulation KM 14 of 2006, the speed of urban track is 30-50 km / h.

Waste Volume:

Domestic waste production can be calculated by the following formula: (Dwi Susanto, 2009)

$$Q_{wasteD} = q_{waste} \times \sum P \quad (3)$$

Where:
Q_{WasteD} = volume / production of domestic waste a city (m^3/day)
q_{Waste} = the rate of landfill waste (m^3/day)
$\sum P$ = underserved population in the service area (people)

Production of non-domestic waste can be calculated by the following formula:

$$Q_{wasteND} = q_{waste} \times C \quad (4)$$

Where:
$Q_{WasteND}$ = volume / production of non-domestic waste a city (m^3/day)
Q_{Waste} = the rate of landfill waste (m^3/day)
C = Correlation coefficient (0.25-0.40)

So that the calculation of the volume / total waste production of a city is as follows:

$$Q_{wasteT} = Q_{wasteD} + Q_{wasteND} \quad (5)$$

Traffic Conditions:

Urban freight transport is subject to local, regional and national policies in different policy areas, such as transportation planning, environmental planning and planning (Visser J, 1999). While research conducted at University of South Florida reveals that the selection method of transporting goods needs to carefully consider the things that are typically worrying, as well as congestion and road safety. Therefore, the urban freight transport needs to consider the level of road service of each service area. The level of road service is the value of services provided by the road for the vehicle movement. Service level itself is affected by the capacity, volume, and density.

There are two definitions of the level of road services: (Tamin, 2000: 46). They are:

1. Level of service (depending on the flow). This aspect relates to the speed of operation or road facilities which rely on the comparison between the (vehicle) flow and road capacity. Therefore, the level of services in a way depends on the traffic flow. This definition is used by Highway Capacity Manual, illustrated by Figure 2 which has six (6) pieces of the level of service below:

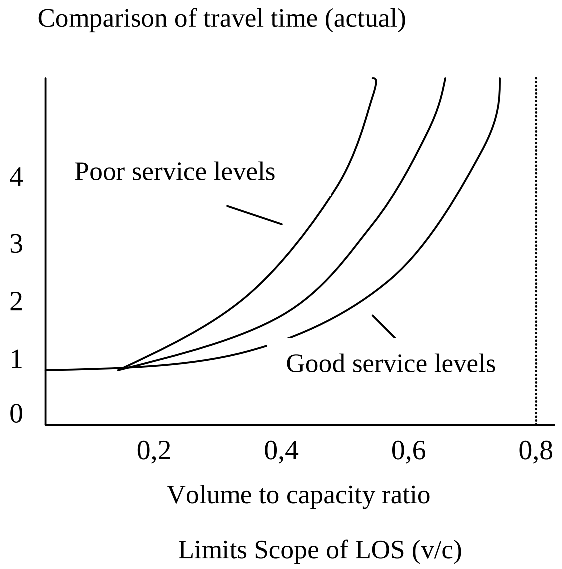

Fig. 2: Level Of Service

2. Level of service (depending on the facilities). This aspect really depends on the type of service facilities instead of the (vehicle) flow. The freeway has a high level of service. In contrast, the narrow road has a low level of service. This is illustrated in Figure 3.

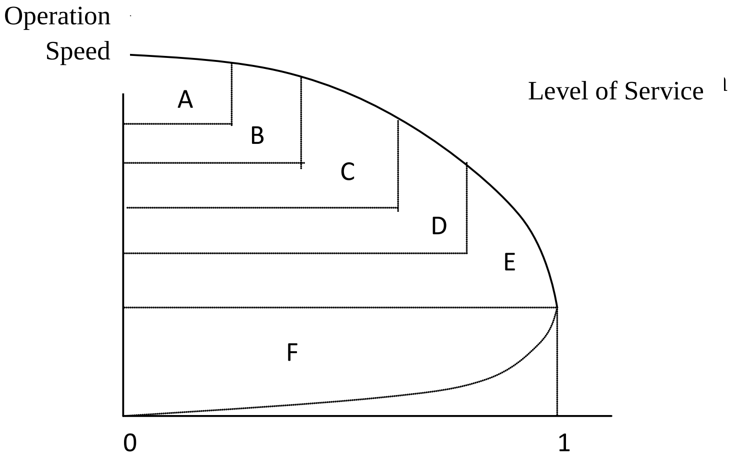

Fig. 3: Level Of Service (LOS)

There are three main variables of the traffic flow used to identify the traffic characteristics (Nugroho, 2010). They are:

a. Volume (flow) : the number of vehicles that pass a certain point on a road per unit of time. The unit is a vehicle / hour, vehicles / day.

b. Speed : the distance vehicle can take up on the road section per unit time. The unit is km / hour or km / sec

c. Density : the number of vehicles per unit length of a particular path. The unit is a vehicle / kilometers

Relationship between volume, velocity, and density can be depicted graphically by using mathematical equation. The following picture shows how the three variables mentioned relate to each others:

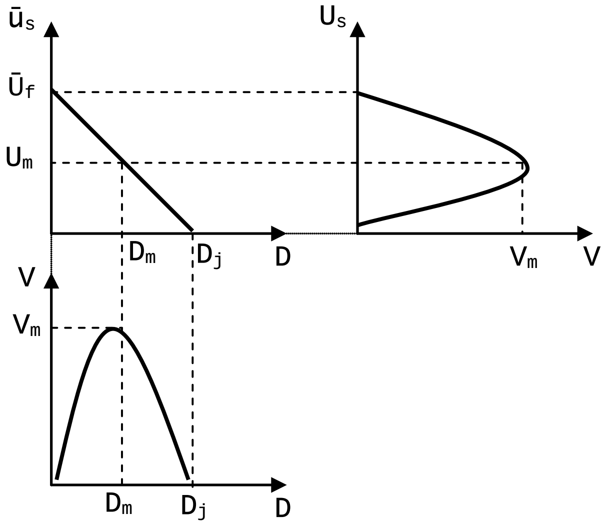

Fig. 4: The relationship between volume, speed and density

Caption 4:
Um = Velocity at maximum speed
Uf = Average speed of the current state of free
Vm = Maximum volume
Dm = Density at maximum volume
V = Volume
D = Density
Us = The average velocity space
Dj = Hours density (density at standstill)

The three basic variable relationship is then expressed in the following mathematical relationship:

$$V = D\ \bar{u}s \quad (6)$$

where :
V = volume (vehicle/hour)
ūs = space mean speed (km/hour)
D = density (vehicle/hour)

Two important things (Djumari, 2003) that can be used as a description of the circumstances that are common in the traffic flow are:

a. The average speed of density approaching zero price (traffic flow is very quiet) is average to to the average speed at free flow conditions, and the current closes to zero.

b. When the magnitude of the density nears the highest price (maximum), then it is called saturated density (density hour). The travel speed thus approaches the zero price and traffic flow will return to near zero.

The Indonesian Highway Capacity Manual (MKJI) defines “capacity” as the maximum flow through a point on the road that can be sustained per unit at a certain condition. For the two-lane road two-way, the capacity is determined for the two-way flow (a combination of two-way). For the road with many lanes, the current, however, is separated per direction and the capacity is broken up per lane.

The following formula indicates the basic equation for determining the capacity:

$$C = CO \times FCW \times FCSP \times FCSF \times FCCS \quad (7)$$

where:
C = Capacity (smp/hour)
CO = Basic Capacity (smp/hour)
FCW = Road width adjustment factor
FCSP = Adjustment factor separation direction (only for undivided roads)
FCSF = Adjustment side factor and the shoulder of the road
FCCS = factor correction city size

If the actual conditions are in line with the ideal conditions previously specified, then all adjustment factors become 1.0 and the capacity is equal to the basic capacity.

Degree of saturation (DS) is defined as the ratio of flow to capacity, is used as the primary factor in determining the level of performance of intersections and road segments. DS value indicates whether the road segment has a capacity problem or not.

$$DS = Q/C \tag{8}$$

Degree of saturation is calculated by using the flow and capacity expressed in pcu / hour. DS is used for the analysis of traffic behavior in the form of speed.

Geometric Condition of the Road:

In the geometric design, the vertical alignment should ideally be made as flat as possible, but kept adjusting to the topography so that flatness lengthwise is unavoidable. Vertical alignment should be approximated to the surface of the ground which technically serves as a based ground in order to reduce the earthwork (balance between cut and fill). For the safety and comfort reasons, the unstable ramps at a long-short distance and an extreme climb/drop should be avoided.

The extreme ramp drop should be followed with the climb in order to minimize the speed of the truck which is often too high. The movement of vehicles is affected by several external factors. These factors include air resistance (Fa), prisoners play (Fr), frictional resistance (Fs), and detainees due to road gradient (Fg), and of course the influence of the strength of the machine (Fp).

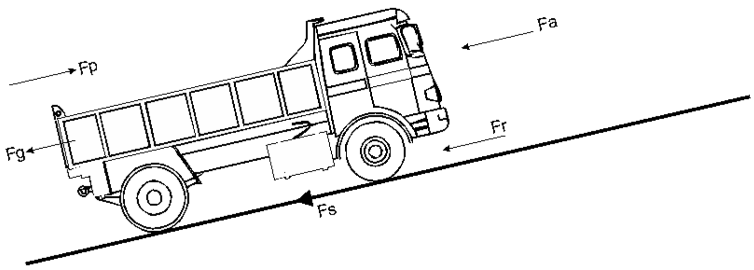

Fig. 5: External factors that affect the movement of vehicles

The age of the driver and vehicle:

According to the Directorate General of Civil Engineering in the book of Traffic plan, age factors have a role to play in relation to driver’s reaction indicating that the elderly drivers show a slow reaction and have deteriorated views. Consequently, they drive slowly. Research conducted in England demonstrates that male drivers under 25 years old have more potential traffic accidents 2.5 times compared to male drivers over 25 years old. Therefore, it can be argued that age factors influence the speed of the vehicles (Abubakar I, 1999). Fitzpatrick argues that the determination of the driver's speed investigated based on geometric, roadside, and traffic control device variables might have an effect on the driver’s performance.

Moreover, the vehicle age should be taken into consideration. The capability of transport vehicle production declines in line with the age of the vehicles that are getting old. This circumstance reduces the day-to-day frequencies of operational activities in each month. One of the foreseen consequences from the age factors fill the vehicles is that the operating cost components also increase unless the tires, wages and depreciation costs (Handayani, 2003)

Methods:

The research was conducted on the traffic conditions through which the transport vehicle segment waste, geometric segment conditions, vehicle speed, distance, time and volume transport of waste transported. The study was conducted on the entire fleet of garbage trucks dump trucks that serve the city of Malang. Primary data includes geometric state roads, distance and transport time and the volume of waste. Secondary data included age of the driver and vehicle. Primary data were collected by surveying motion patterns Dump Truck vehicle types, while the secondary data obtained from the results of previous studies.

The research on the vehicle movement patterns conducted to the entire Dump Truck providing services in Malang city by following them while operating during a month. Moreover, the survey on road geometrics such as the traffic conditions, the width of the road and the slope of the road, was done. The data pertaining to the drivers and vehicles was gathered from sanitation department of Malang city and depth interviews.

The SPSS 20 software was used to analyze the correlating factors to the Dump Truck speed. Those factors encompass the volume of the waste, the age of drivers and vehicles, the degree of saturation and the slope of the geometric path (Figure 6).

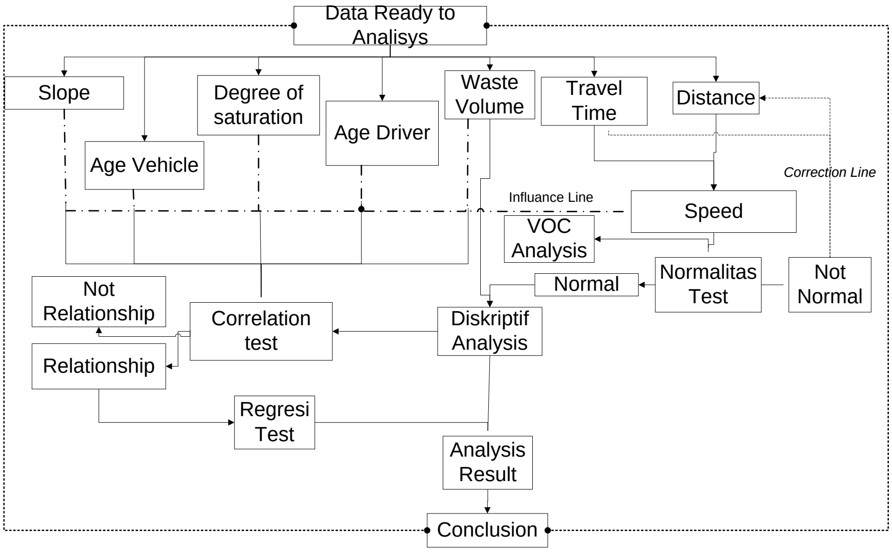

Fig. 6: Flow chart of the data analysis process

RESULT AND DISCUSSION

Data analysis was carried out two factors that affect the speed of the vehicle Dump truck, the external factors and internal factors.

Eksternal Factors:

Table 1: Speed, degree of saturation and value slope on each road segment

Roads	Code Road	Vr (km/h)	Degree of Saturattion (DS)	Slope (m)
Jaksa agung	A	29,31	0,27	-9,932
Hasym ashari	B	19,33	0,39	-2,667
Brigjen Katamso	C	21,04	0,55	-4,437
Jupri	D	19,05	1,17	5,884
Bend. Sutami	E	19,48	0,98	-0,751
Raya Langsep	F	31,95	0,26	-8,387
Ijen	G	21,95	0,36	5,913
Wilis	H	23,57	0,31	6,000
Tugu	I	21,08	0,46	3,158
Irian Jaya	J	27,73	0,49	2,397
S.Supriadi	K	14,86	0,75	6,147
Soekarno-Hatta	L	17,17	0,91	-0,713

Analysis:
Correlation:

Table 2: Segment velocity correlation with the degree of saturation and slope

		Velocity (km/jam)	Degree of Saturation (DS)	Slope (m)
Velocity every segment (km/hour)	Pearson Correlation	1	-0,659*	-0,569
	Sig. (2-tailed)		0,020	0,054
	N	12	12	12
*. Correlation is significant at the 0.05 level (2-tailed).				

Analysis:

- There was a fairly strong correlation between the DS and tilt speed. This is evidenced by the Pearson correlation values above 0.5 (SD = 0.659; slope = 0.569).
- The relationship between the velocity correlation with the DS and the slope indicates the opposite direction (indicated by a negative sign (-)).
- In the second part of the output Sig. (2-tailed) obtained a series of probabilities. Shows the relationship between the speed with DS = 0.020 <0.05. While the relationship between the speed with slope = 0.054> 0.05.

Regression:

Table 3: Variables entered / removed in relationship pace with DS and Slope

Model	Variables Entered	Variables Removed	Method
1	Slope, DS[b]	.	Enter
a. Dependent Variable: Velocity (Km/hour)			
b. All requested variables entered.			

Table 4: Model Summary in relationship velocity with DS and Slope

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,749[a]	,561	,463	3,73300
a. Predictors: (Constant), Slope (m), DS				
b. Dependent Variable: Velocity (km/hour)				

Table 5: ANOVA analysis of speed relationship with DS and Slope

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	160,032	2	80,016	5,742	,025[b]
	Residual	125,418	9	13,935		
	Total	285,450	11			
a. Dependent Variable:Velocity (Km/hour)						
b. Predictors: (Constant), Slope (m), DS						

Table 6: Coefficient of velocity relationship with DS and Slope

Model		Un standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	27,295	2,501		10,914	,000
	DS	-8,713	3,953	-,522	-2,204	,055
	Slope	-,341	,212	-,380	-1,606	,143
a. Dependent Variable: Velocity (Km/hour)						

Analysis:

- Table Variables Entered indicates that no variable is removed (removed), or in other words the two independent variables included in the regression calculation.
- Figures show .561 R square. Mean 56.1% rate can be explained by variable degrees of saturation (DS) and the slope of the road. While the remaining 43.9% is explained by other causes.
- Standard error of estimate is 3,733 or 3,73 km/hour
- Functions :

Y = 27,285 – 8,713 X1 – 0,341X2

Where :

Y = Velocity (Km/hour)

X1 = Degree of Saturation (DS)

X2 = Slope (m)

➢ Constant at 27.285 states that if there is no DS and no slope, the speed was 27.285 km / h

➢ Regression X1 coefficient of -8.713 state that occurs every DS reduction by 1, then the velocity increase of 8.713 km / h

➢ Regression X1coefficient of -0.341 stated that any reduction in the slope occurs at 1, then the velocity increase of 0.341 km / h

T test to test the significance of the constant and variable dependent.

H0 ➔ no relationship

H1 ➔ relationship

Value R = 0,749

t estimate = 3,574

t table = 2,281 (➔n-2=12-2=10)

t estimate > t table ➔ 3,574 > 2,281, H_0 rejected

Sig. 0,025 < 0,05, H_0 rejected

Internal Factors:

Table 7: Data speed, volume of waste, age of the driver and vehicle age

TPS	V TPSA (km/hour)	Waste Volume (m3)	Age Driver (Year)	Age Vehicle (Year)
Asahan 1	25,85	8,46	30	21
Sumbersari	26,63	8,26	36	21
Cianjur	23,05	8,65	45	21
Stadion Blimbing	21,06	9,88	48	21
Rampal Cilaket	19,48	11,15	36	21
Manyar	21,23	11,81	30	21
Asahan 2	21,13	11,17	45	11
Tawangmangu	17,91	10,64	30	11
Benthoel	24,51	10,89	48	11
Oro-oro Dowo	22,43	11,15	48	11
Kartini	17,75	12,18	50	7
Langsep	23,27	7,92	33	6
Sulfat	17,19	11,15	48	7
Borobudur	23,59	8,45	30	7
Muharto	27,65	9,21	30	6
Seram	20,41	10,90	56	6

Analysis:

Correlation:

Table 8: Correlation with the volume transport speed, driver age and vehicle age

		Velocity (Km/Hour)	Age Driver (Year)	Waste Volume (m3)	Age Vehicle (Year)
Velocity (Km/Hour)	Pearson Correlation	1	-0,534*	-0,698**	0,173
	Sig. (2-tailed)		0,033	0,003	0,523
	N	16	16	16	16
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Analysis:

- There was a fairly strong correlation between the speed with driver age and the volume of waste. This is evidenced by the Pearson correlation values above 0.5 (U.S. = 0.534; VS = 0.698).
- The correlation between the speed of the vehicle's age is weak.
- The relationship between the velocity correlation with the age of the driver and the volume of waste showed the opposite direction (indicated by a negative sign (-).
- In the second part of the output Sig. (2-tailed) obtained a series of probabilities. Shows the relationship between the speed of the U.S. = 0.033 <0.05. While the relationship between the speed with VS = 0.003 <0.05.

Regression:

Table 9: Variables entered/removed in relationship speed with waste volume and age driver

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	Age Driver (year), Waste volume (m3)[b]	.	Enter
a. Dependent Variable: Velocity (Km/hour)			
b. All requested variables entered.			

Table 10: Summary of velocity modeling relationships with waste volume and age driver

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,732[a]	,536	,464	2,30559
a. Predictors: (Constant), Age driver (year), Waste Volume (m3)				
b. Dependent Variable: Velocity (Km/hour)				

Table 11: ANOVA analysis of speed relationship with waste volume and age driver

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	79,763	2	39,881	7,502	,007[b]
	Residual	69,105	13	5,316		
	Total	148,868	15			
a. Dependent Variable: Velocity (Km/hour)						
b. Predictors: (Constant), Age Driver (year), waste volume (m3)						

Table 12: Relation coefficient with waste volume and age driver

Model		Un standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	38,586	4,360		8,851	,000
	Waste Volume (m3)	-1,283	,484	-,573	-2,648	,020
	Age Driver (Year)	-,088	,075	-,254	-1,174	,261
a. Dependent Variable: Velocity (Km/hour)						

Analysis:

- Table Variables Entered showed that no variable is removed (removed), or in other words the two independent variables included in the regression calculation.
- Figures 0.536 R square shows. Mean 53.6% can be explained by the variable speed of the volume of waste and the age of the driver. While the remaining 46.4% is explained by other causes.
- Standard error of estimate is 2,31 or 2,31 km/hour
- Function :

Y = 38,586 – 1,283 X1 – 0,088 X2

Where :

Y = Velocity (km/hour)

X1 = Waste Volume (m3)

X2 = Age Driver (year)

➢ Constant at 38.586 states that if there is no waste volume and no age driver, then the speed is 38.586 km / h

➢ Regression X1 coefficient of -1.283 states that every happened waste volume reduction by 1, then the velocity increase of 1.283 km / h

➢ Regression X1 coefficient of -0.088 states that every happened age driver reduction by 1, then the speed increases by 0.088 km / h

T test to test the significance of the constants and the dependent variable.

H0 ➔ no relationship

H1 ➔ relationship

Value R = 0,732

t estimate = 4,020

t table = 2,1448 (➔ n-2=16-2=14)

t estimate > t table ➔ 4,020 > 2,1448, H_0 rejected

Sig. 0,007 < 0,05, H_0 rejected

Based on the analysis of the two factors above can be seen that the external and internal factors strongly affected the speed of the vehicle with a correlation coefficient (R) of 0.749 to 0.732 for the external factors and internal factors.

Equation on external factors is Y = 27.285-8.713 X1 - 0.341 X2, where X1 are the degree of saturation and X2 of the slope, while the internal factors of the equation is Y = 38.586-1.283 X1 - 0.088 X2, where X1 are the volume of waste and X2 is age driver.

Conclusion:

Waste transport speed is influenced by two factors: external factors and internal factors. External factors include the degree of saturation and the geometric slope, while internal factors include the volume of waste and the age of the driver. Both of these factors strongly affected the speed of the vehicle with a correlation coefficient (R) of 0.749 for external factors and 0.732 for internal factors.

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