Analysis of Heavy Metal Exposure in the Air and Blood Lead Level Concentration of City Bus Drivers in Surabaya

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Abstract

The increase of motorized vehicles In Indonesia amounted 114,209,360 units throughout the country in 2015 which was a 15% increase from the total number in 2016. Despite showing a good economic growth, it also poses some negative impacts. Road accident is the third leading cause of death in Indonesia. The most number of casualties and losses suffered is mostly caused by road accidents involving buses. The increase of vehicle also caused high pollution such as lead (Pb) especially in metropolitan cities and those who are prone to this are the people working every day on the roads. This research examined lead (Pb) levels in the air on 5 traffic congestion points in Surabaya and in the blood with and 11 Surabaya city bus drivers as the samples. The measurement of lead (Pb) levels in the air and in the blood applied AAS (Atomic Absorption Spectrophotometer) method. The measurement of Pb levels in the air was conducted 3 times for each traffic congestion point. For blood lead level, the measurement was only conducted 1 time in the afternoon after the bus drivers completed their activities. Age and daily smoking frequencies were the measured variables suspected to affect the lead concentration on the blood. The research result showed that the highest Pb concentration in the air was found to be consistent in the afternoon at five traffic congestion points while the data of blood lead level examination revealed that 8 out of 11 city bus drivers had high Pb concentration on their blood which exceeded the allowed threshold point.

Keywords: drivers, lead (Pb), blood, age and smoke

Introduction

The World Health Organization (WHO) notes that, globally, 1 million people decease annually in the highway due to road accidents in which 40% of them are in productive age. The figure on traffic accidents has caused the shift of

illness pattern from infectious diseases to non-infectious diseases[2,13,15,16]. In Indonesia, road accidents cases constantly increase. The causes of accidents include traffic violations, reaching 36.31%; followed by drivers' negligence by 33.34%; and speeding by 30.35%[4]. The data from the Indonesian National Police Department in 2014 showed that there were 95,906 cases of road accidents where 28,297 caused death tolls; 26,840 cases with severe injury and 109,741 cases with minor injury. In 2015, the number increased with 32,872 accident cases with death tolls; 29,910 with severe injury and 107,631 with minor injury [2,4]. Specifically in East Java, the number of road accident cases in 2015 reached 20,530 cases; 3,915 cases with death tolls, 3,825 with severe injury and 10,945 with minor injuries. In 2016 these road accident cases had increased to 23,015 cases, 3,544 cases with death tolls, 3,704 cases with severe injury and 12,312 cases with minor injury[4]. The most number of casualties and losses suffered is mostly caused by road accidents involving buses, resulting social loss of 203-217 trillion Rupiahs in 2015 which increased by 23% in the following year[2].

The high number of accidents are highly related with human population growth. The increase of human population and their mobility coupled with the increase in the number of vehicles/transportation facilities have inevitably triggered the increase of traffic accident cases. The number of global population is now listed as much as 7.3 billion inhabitants. According to data from the UN, this figure will increase up to 9.3 billion people in 2050, and in 2100 there will be 11.2 billion people living on the Earth. Meanwhile in Indonesia, the population projection results show that the number of Indonesian population will continue to increase over the next twenty five years from 238.5 million people in 2010 to 305.6 million in 2035[2.]

This huge casualty and material loss due to traffic accident have become one of the triggers for the Indonesian National Police to target for 50% accident rate decrease within 10 years. The target is also in accordance with the Decade of Action for Road Safety program proclaimed by the United Nations in March 2013[16.] By the end of 2015, The United Nations' program imposes a sustainable development program referred as the Sustainable Development Goals (SDGs) whose third objective on health focuses on the demand to stabilize highways and to globally reduce the mortality rate due to road accident on highways in 2020 and to reduce national figures of road accident in respective member countries. The SDGs Number 11 on transportation for sustainable cities[14.17]. The purposes of SDGs are in line with Article 203 of Law No. 22 in 2009 on road traffic transportation which states that "the Government is responsible on the road traffic insurance and the transportation safety[11]."

In addition to causing death toll increase, the number of motorized vehicles has caused environmental pollution. Since 1972, air pollution has dispersed lead to the atmosphere of around 3 million tons[7,11]. The air pollution emitted from motorized vehicles includes

NO_2, SO_2, CO, Pb, hydrocarbons, and other particulates[9]. Currently, 70% of motorized vehicles in Indonesia have caused air pollution due to bad condition[2,4]. Motorized vehicles emit hazardous substances that can cause negative impacts, both on human health and on the environment safety such as lead (Pb), suspended particulate matters (SPM), nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxides (CO), and oxides of photochemical (O_x)[9,10,11]. Approximately only 25% of lead (Pb) remains in vehicle machines while the other 75% would pollute the air in the form of exhaust fumes[5].

One of the heavy metal air pollutants of lead (Pb) is generated from imperfect combustion in the vehicle engines. In the nature, Pb cannot be degraded or destroyed and thus it is called as non-essential trace element which has the highest concentration level. Therefore, the substance is highly hazardous if accumulated in the body in an abundant level. In 2013, the Publishing Journal of Environmental Research Letters stated that vehicle gas emissions reacting with oxygen has caused the ozone get higher and in the end caused about 470 thousand people die worldwide.

This research was conducted in Surabaya, which is a metropolitan city with the second largest population in Indonesia after the capital city of Jakarta. City bus drivers have great potential of lead poisoning because for adults, Pb intoxication usually occurs in their workplace[3,9].

MATERIAL AND METHODS

The research design employed was cross sectional study towards Surabaya city bus drivers where the research was conducted on Surabaya city bus drivers on one particular observation time by measuring the blood lead level using AAS method (Atomic Absorption Spectrophotometer). The method was also applied to measure lead concentration in the air.

The samplings were conducted 3 times, i.e. at 08.00 in the morning with the assumption of traffic congestion happening due to people's going to school activity or leaving for work; 12.00 AM at noon with the assumption of traffic congestion happening during the period where workers would go out to have lunch while the elementary school students returned home and got picked up with motorized vehicles; and last at 4.00PM, assuming that traffic congestion would take place due to people's coming home from work. The blood sampling was conducted to 11 city bus drivers regularly passing through the traffic congestion points.

FINDINGS

Lead pollution was highly associated with vehicle emissions. The air sampling in this research was conducted in five congestion points in Surabaya which were (1) Margorejo Street heading to Ahmad Yani Street, (2) Rungkut industrial area at Raya Rungkut Industri Street, (3) DTC area on Stasiun Wonokromo Street, (4) Ahmad Yani Street, and last (5) Dupak Street.

Table 1. The Results of Sampling in 5 Traffic Congestion Points in Surabaya in March 2016

The Pb measurement results of five congestion points were then compared to Governor's Decree No. 10/2009 on air quality standard which stated that the maximum limit of Pb in the air was 0.06 μg/Nm^3. From the comparison, it could be seen that the Pb concentration in the air on the traffic congestion points was still below the maximum allowed concentration[21].

Table 2. Lead (Pb) Level on Blood Measurement Results on 11 City Bus Drivers Frequently Passing the 5 Traffic Congestion Points.

No	Blood lead (Pb) level (μg/dl)	Respondents
1	Not Normal (>25 μg/dl)	8
2	Normal (≤ 25 μg/dl)	3

Under the WHO stipulations, the blood lead level in human not exposed to Pb should be approximately 10-25 g/100 ml[13,14]. From the research results, 8 out of 11 respondents had their blood lead level exceed the permitted quality standard. There were several factors that caused a significant influence on the high blood lead level of these city bus drivers such as age, working period, daily duration of Pb exposure and smoking habit.

Table 2 showed that 50% of respondents were 29-38 years old, 40% were 42-48 years old, and 20% were over 50 years old. In terms of working experience, 54.5% had worked under 10 years and 55.5% had worked as drivers for over 10 years. The habit of smoking was very high among drivers day and night

No	Locations	at 8.00AM	at 12.00AM	at 4.00PM
1.	Margorejo St. heading to Ahmad Yani	0.05 μg/Nm^3	0.011 μg/Nm^3	0.045 μg/Nm^3
2.	Rungkut Industrial Area	0.002 μg/Nm^3	0.015 μg/Nm^3	0.058 μg/Nm^3
3.	DTC on Stasiun Wono-kromo St.	0.045 μg/Nm3	0.033 μg/Nm^3	0.053 μg/Nm^3
4.	A.Yani St.	0.025 μg/Nm^3	0.020 μg/Nm^3	0.033 μg/Nm^3
5.	Dupak St.	0.011 μg/Nm^3	0.015 μg/Nm^3	0.017 μg/Nm^3

intensity of smoking every day each as much as 36.36% is a heavy smoker for about 3 packs a day or 54 cigarettes/day. Moderate smokers with daily smoking intensity smoked as much as 36 sticks/day.

Table 3. Respondents' Characteristics

No	Names *	Age (yr)	Working experience (yr)	Period of Pb Expo-sure (hour/ day)	Smoking /day (1 pack = 18 sticks)
1	Kk	29	5	10	3 pcks/ 54 sticks
2	Fs	33	8	16	2 pcks/ 36 sticks
3	Sd	55	12	16	1 pck/18 sticks
4	Ab	42	11	10	3 pcks/ 54 sticks
5	Kc	38	9	16	2 pcks/ 36 sticks
6	Ut	47	15	10	1 pck/18 sticks

7	Cm	51	17	16	½ pcks/ 9 sticks
8	Jb	36	9	20	3 pcks/ 54 sticks
9	Hm	42	10	16	2 pcks/ 36 sticks
10	Tg	48	13	10	2 pcks/ 36 sticks
11	An	37	7	16	3 pcks/ 54 sticks

** Names are classified due to confidentiality*

Lead (Pb) exposure might come from food, beverage, air, general environment, and Pb-contaminated working environment. Pb enters the human body through the respiratory tract which is the largest exposure path and also through the gastrointestinal tract. The absorption of Pb of the air in the respiratory tract amounted approximately 40% while in the digestive tract it amounted approximately 5-10%. Then, Pb is distributed into blood where around 95% is tied to the red blood cells and the rest is bound to the blood plasma.

The Pb measurement results on the five traffic congestion points in Surabaya were found to increase despite still below the threshold point. However, the concentration increased on the third investigation period which was at 4.00PM. This was because the traffic routes experienced traffic congestion on the period as people were coming home from work. In addition, it was the time when pollution from morning until afternoon was accumulated, either from vehicle fumes or from the industries along the roads.

From the analysis of the Chi-Square statistic test it could be seen that there was a correlation between smoking as the most influential variables towards high blood lead level. The smoking habit of the respondents marked p=0.027, while age variable marked p=0.04. According to Lee (2005), smokers' are 4.5 times more prone to have higher blood lead levels than those who do not smoke for in every 20 cigarettes, a smoker would inhale 1.5 gr of lead[10]. This research of Zhang & Batterman (2013) applied incremental analysis to estimate the pollution impact and the health risk characteristics caused by traffic congestions. The result found that traffic congestions could increase the health risks of individuals driving on the roads, pedestrians walking by and individuals living or working near the highways [20]. Zota et al. (2013) indicated that blood lead level was correlated with high blood pressure in adult males, resulting high allostatic load [18]. According to Zota (2015), other environmental contaminants such as cadmium should be taken into account in future studies since it often interacts with Pb [19].

The research of Kim, Ahn, Lee, Park, & Kim (2017) found that teenage boys had high lead and mercury exposure to their blood. There would be an increase in blood cadmium as they age, but lead in the blood would decrease with ageing. In addition, the concentration of lead, cadmium, and mercury in adolescences' blood was positively related to the levels of lead, cadmium, and mercury in their parents[8]. The result of the research on Surabaya city bus drivers showed that this intoxication occurred as their daily smoking frequencies could reach 54 cigarettes/day. This was triggered by the suggestion that smoking prevented them from being sleepy when driving.

CONCLUSION

Age and daily smoking frequencies cause a significant influence towards the increase of blood lead level the city bus drivers in Surabaya. The highest Pb

exposure at five traffic congestion points occurred in the afternoon.

CONFLICT OF INTEREST

None.

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ETHICAL CLEARANCE

The study was approved by the institutional Ethical Board of the Public Health, Airlangga University.All subjects were fully informed about the procedures and objectives of this study and each subject prior to the study signed an informed consent form.

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