KnE Life Sciences

The 3rd IMOPH & the 1st YSSOPH
The 3rd International Meeting of Public Health and
The 1st Young Scholar Symposium on Public Health
Volume 2019

Knowledge E
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Conference Paper

Urinary 1-Hydroxypyrene (1-OHP) Analysis Related to Diesel Exhaust on Vehicle Testing Mechanics at Cilincing, North Jakarta, Indonesia

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Abstract

Diesel engine exhaust is categorized as carcinogenic to human (group 1) by International Agency for Research on Cancer (IARC) in 2012. Transportation is the biggest contributor of diesel exhaust pollutant. Polycyclic Aromatic Hydrocarbons (PAHs) are the major compound of diesel exhaust that can be found on gas and particle phases. 1-Hydroxypyrene (1-OHP), a metabolite of pyrene, has been used extensively as a biological monitoring of exposure to PAHs. This study aimed to analyze the concentration of urinary 1-OHP related to diesel engine exhaust among vehicle testing mechanics at Vehicle Testing Center Cilincing, North Jakarta. Non-occupational factors such as exposure to cigarette smoke, consumption to grilled food, exposure to open fire, and the presence of pollutant near respondent's residence are also analyzed. Diesel exhaust exposure was measured by its particle phase, which is personal concentration of $PM_{2.5}$, PM_1, $PM_{0.5}$, and $PM_{0.25}$. The subject was 19 vehicle testing mechanics and 18 non-mechanics as the control group. Personal concentration of particulate matter collected using Leland Legacy pump and Sioutas Cascade Impactor and analyzed using gravimetric method. Urinary 1-OHP analyzed using High-Performance Liquid Chromatography with fluorescence detector. Personal concentration of $PM_{2.5}$, PM_1, $PM_{0.5}$, and $PM_{0.25}$ are 232.23 µg/m^3, 190.58 µg/m^3, 164.73 µg/m^3, and 140.10 µg/m^3. Concentration of urinary 1-OHP ranging from 11.72 to 61.88 µg/or creatinine. The result showed that mean concentration of 1-Hydroxypyrene of mechanic group is significantly higher than non-mechanic group (p=0.001). There is a positive correlation between particulate matter concentration in all size and urinary 1-OHP concentration. There's no significant correlation between non-occupational factors and urinary 1-OHP concentration. Particulate matter related to diesel engine exhaust is the main contributor of the increase of urinary 1-OHP concentration among vehicle testing mechanics.

Keywords: 1-Hydroxypyrene, diesel exhaust, particulate matter, vehicle testing

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Received: 21 December 2018
Accepted: 23 January 2019
Published: 28 February 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the 3rd IMOPH & the 1st YSSOPH Conference Committee.

1. Introduction

There's a significant increase in number of motor vehicle in Indonesia, which reportedly increased by 96.14 million from 1987 to 2013 [1]. Diesel exhaust (DE) is kind of vehicle emission that is harmful and known as carcinogenic to human [2]. Short-term effects of exposure to diesel exhaust can cause headache, acute irritation of the eyes, throat and bronchial, neurophysiological symptoms such as lightheadedness and nausea, and respiratory symptoms such as cough and phlegm [3, 4]. In addition, diesel exhaust has been shown to increase immunological response, which leads to allergic responses in some allergens and asthma-like symptoms [4]. Long-term exposure to DPM may lead to an increase in cardiovascular disease, cardiopulmonary, respiratory disease, and lung cancer [3].

DE consists of hundred compounds in either a gas and particle form. Exposure to DE may occur occupationally, in United States over a million workers are estimated exposed DE in their workplace [5]. Occupations with potential exposure to DE include miners, construction workers, heavy equipment operators, bridge and tunnel workers, railroad workers, oil and gas workers, loading dock workers, truck drivers, material handling operators, farm workers, long-shoring workers, and auto, truck and bus maintenance garage workers [3]. Polycyclic Aromatic Hydrocarbons (PAHs) are the major compound of DE that can be found on gas and particle form. Although the concentrations of PAH are much greater in gas-phase DE than those of particulate-phase DE. Due to its abundant concentration in DE, metabolite of PAH can be an alternative biomarker of exposure to DE. Urinary metabolite of PAH that has been used intensively as biomarker of exposure of PAHs is 1-Hydroxypyrene (1-OHP) [6]. The half-life of 1-OHP is 6-35 hours, in which 1-OHP concentration can describe exposure to PAHs during the last 24 hours [7].

Previous studies have shown that there's an increase in urinary 1-OHP concentration due to exposure to DE [8 -10].. While in another study shown that non-occupational factor such as grilled food consumption, exposure to cigarette smoke and exposure to open fire have a greater impact to increase 1-OHP concentration than exposure to DE in the workplace [11]. We analyze urinary concentration of 1-OHP related to DE exposure among vehicle testing mechanics at Cilincing vehicle testing center, North Jakarta, Indonesia. This vehicle testing center only for heavy duty vehicle and the number of vehicle tested ranging from 300-500 units per day. Previous study in Pulogadung vehicle testing center, has shown that mean concentration of personal $PM_{2.5}$ among vehicle testing mechanics were 149.01 µg/$m^3$and 103.28 µg/m^3 among administration officer [12]. That previous study shown that vehicle testing mechanics has a higher risk to exposed $PM_{2.5}$ related to diesel exhaust than administration officer. DE are measured by personal concentration of $PM_{2.5}$, PM_1, $PM_{0.5}$, and $PM_{0.25}$. Non-occupational factors are also analyzed, includes exposure to cigarette smoke, grilled food consumption, exposure to open fire, and the presence of pollutant near their residence. Individual characteristics such as age, sex, and body mass index (BMI) are also analyzed.

2. Methods

This study is analytical study. The subject was 19 vehicle testing mechanics and 18 non-mechanics as the control group. Subject that has kidney disorders or under treatment to kidney disease are excluded. The creatinine concentrations are excluded based on standard by American Conference of Governmental Industrial Hygienist (ACGIH) 2015, which is lower than 0.3 g/L or higher than 3 g/L. Urine samples are not performed for female respondents who are menstruating.

2.1. Particulate matter analysis

Particulate matter was collected by personal breathing zone sampling on 19 vehicle testing mechanics to collect concentration of $PM_{2.5}$, PM_{1}, $PM_{0,25}$, and $PM_{0,25}$ inhaled by each mechanic. Sampling methodology refers to IP-10A SKC.Inc. Sample was collected using Leland legacy pump and sioutas cascade impactor with 25 mm Polytetrafluoroethylene filter (PTFE) and 37 mm quartz fiber filter. PTFE filter was installed on impaction stage A to D while Fiber Quartz Filter was installed on after-filter stage. Sampling was conducted for 8 hours or during the service time of vehicle testing station. Then, sample is analyzed using gravimetric analytical method where filter is weighed before and after sampling to determine the dust mass and to calculate the concentration of particulate matter. Filter weighing for gravimetric method conducted in National Nuclear Institution in Bandung, West Java, Indonesia using Micro Mettler Toledo balance scales.

2.2. Urine sampling and analysis

Urine samples are collected in the end of work week, which is every Friday afternoon. The amount of urine samples was 50-100 ml. Before analyzed, urine samples are stored at -20˚C. Analysis urinary 1-OHP and creatinine concentration is conducted by Laboratory of chemical and doping analysis in Health Laboratory of Jakarta, Indonesia using High-Performance Liquid Chromatography (HPLC) with fluorescence detector. Analysis of urinary 1-OHP conducted based on method in previous study [13]. Urine creatinine was analyzed using *Jaffe's* method.

2.3. Another variables

BMI was analyzed using weight and height ratio. Other variables are collected using questionnaire and observation.

2.4. Statistical analysis

Univariate analysis was conducted to see distribution and frequency of the variables studied. In bivariate analysis, it was used independent T-test and Pearson correlation test.

3. Results

According to the distribution number of vehicle during research period, average motor vehicle tested in Cilincing Vehicle Testing Center was 399 vehicles per day. The smallest number of vehicles is 343 vehicles and the most are 550 vehicles (Figure 1).

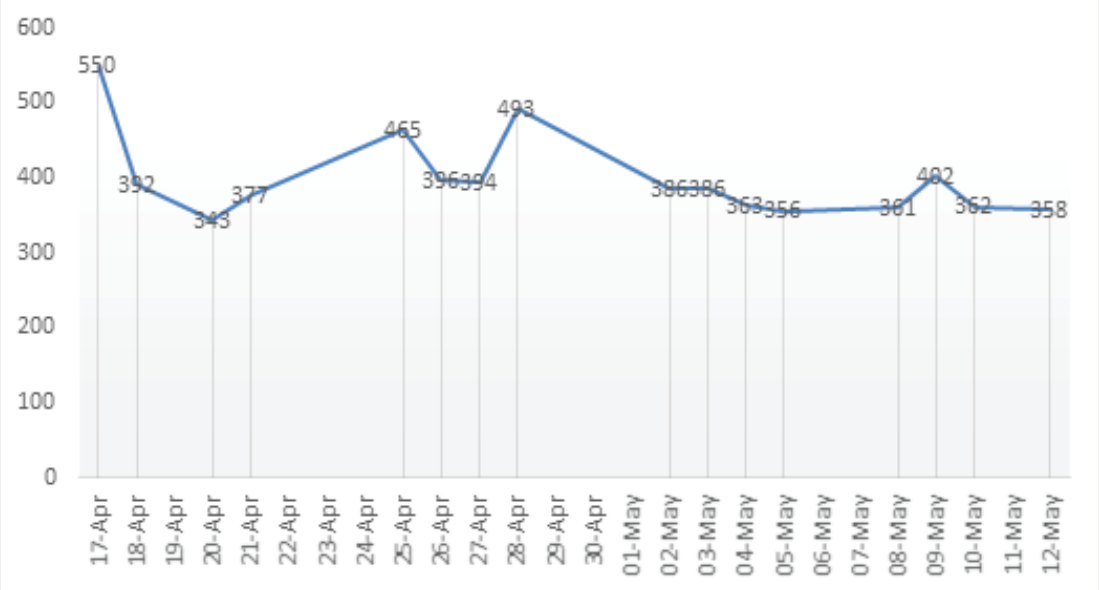

Figure 1: Distribution number of vehicle during research period.

The results of urinary creatinine concentration measurements in 22 vehicle testing mechanics and 23 comparison subject showed that urine creatinine concentrations in mechanical test workers ranged from 32.6 to 429.6 mg/dL while in comparison group, urine creatinine concentration distribution ranged from 68.9-465.8 mg/dL. There were 3 vehicle testing mechanics and 5 respondents from the comparison group who had an abnormal urine creatinine concentration. The distribution of urinary 1-OHP concentration among vehicle testing mechanics was 11.72-61.88 µg/or creatinine. The mean urinary 1-OHP concentration was significantly higher among vehicle testing mechanics than the comparison group.

The average concentration of $PM_{2.5}$, PM_{1}, $PM_{0.5}$, and $PM_{0.25}$ among vehicle testing mechanics were 232.23 µg/m^3, 190.58 µg/m^3, 164.73 µg/m^3, and 140.10 µg/m^3. While the average concentration among administration officers were 168.87 µg/m^3, 149.18 µg/m^3, 128.02 µg/m^3, and 110.42 µg/m^3. Average particulate matter concentration in all sizes are higher among vehicle testing mechanics than administration officers (Table 1).

In this study, there are two scenarios. First scenario aims to see the correlation between 1-OHP and weekly concentration of particulate matter. Second scenario aims to see the correlation between 1-OHP and concentration of particulate matter in the end of workweek. There are positive and strong correlation between urinary 1-OHP and weekly concentration of particulate matter in all sizes (r=0.701 – 0.739). There are positive and strong correlation between urinary 1-OHP and concentration of particulate matter in the end of workweek (r=0.496-0.573).

Table 1: Distribution of Personal Concentration Particulate Matter.

Size	Mean (μg/m^3)	Median (μg/m^3)	Minimum (μg/m^3)	Maksimum (μg/m^3)	Std Dev (μg/m^3)
Vehicle testing mechanics					
$PM_{2.5}$	232.23	202.01	113.05	520.77	107.45
PM_{1}	190.58	163.02	84.76	484.20	97.56
$PM_{0.5}$	164.73	138.59	68.41	458.39	91.41
$PM_{0.25}$	140.10	117.67	37.90	403.59	83.95
Administration officers					
$PM_{2.5}$	168.87	171.36	105.97	226.77	65.17
PM_{1}	149.18	149.72	87.46	209.82	64.53
$PM_{0.5}$	128.02	129.42	73.65	179.57	57.70
$PM_{0.25}$	110.42	109.71	61.36	160.88	56.00

There is no significant difference between mean urinary 1-OHP concentration in all non-occupational factor (smoking habit, number of cigarette consumption per day, the presence of smoker co-workers, grilled food consumption, and presence of pollutant near residence (Table 2).

Table 2: Mean comparison of 1-OHP concentration in non-occupational factor

Variables	N	Mean 1-OHP (μg/gr creatinine)	Std Dev (μg/gr creatinine)
Smoking Habit			
- Yes	21	18.974	12.683
- No	16	15.558	13.403
Number of cigarette consumption			
- ≤ 5 per day	11	17.129	10.636
- > 5 per day	10	21.004	14.934
Presence of smoker co-worker			
- Yes	20	19.705	16534.84
- No	17	14.899	6179.73
Grilled food consumption			
- Yes	31	18.757	13.731
- No	6	10.987	3.417
Pollutant near residence			
- Yes	10	21.499	17926
- No	27	16.015	10578.62

4. Discussion

Results showed that the average urinary concentration of 1-OHP among vehicle testing mechanics was greater than the comparison group. Statistical result also showed that there was a significant difference between mean urinary 1-OHP and vehicle testing mechanics than the comparison group. This results are consistent with previous studies [14M-15]. It is known that the average concentration of 1-OHP in the exposed group was 22 times greater than the average 1-OHP concentration among toll gate officer exposed to vehicle emissions [14].. It is shown that the higher concentration of 1-OHP among vehicle testing mechanics because the higher exposure to diesel exhaust emission.

The results indicated that the average personal concentration $PM_{2.5}$ was 1.5 times greater than the average personal concentration $PM_{2.5}$ in the previous study in Pulogadung Vehicle Testing Center [12] due to the differences of the types of vehicle tested between Cilincing and Pulogadung Vehicle Testing Center. The majority types of vehicle in Cilincing was heavy-duty vehicle while in Pulogadung, it was light-duty vehicle, supporting previous research conducted in Sao Paulo, Brazil showing that heavy-duty vehicle contributed to emission $PM_{2.5}$ was six times higher that light-duty vehicle [16].

Cigarette smoke is one of the potential sources of PAH exposure. It is known that the average urinary 1-OHP concentration is higher among smoker than non-smoker respondents. The presence of co-workers who smoke also can be source of PAH exposure. The result shows that the average concentration of urinary 1-OHP among respondents who have smoker co-workers are higher compared with respondents who do not have smoker co-workers. This result are in line with previous studies showing that the average urinary 1-OHP concentration is higher among respondent exposed to cigarette smoke [14, 17, 18] but there's no significant differences based on statistical test between mean 1-OHP concentration among respondent exposed to cigarette smoke and unexposed to cigarette smoke.

The number of the cigarette concentration average of urinary 1-OHP is higher among respondents who consume more than 5 cigarettes per day which is in line with previous study showing that there was significant differences in the median of 1-OHP between heavy smoker and light smoker group [19]. In addition, every 1 cigarette consumption per day may increase 0.023 µmol/mol creatinine [15]. Based on statistical test, there's no significant differences between mean 1-OHP concentration among respondent who consumed more than 5 and less than 5 cigarettes per day.

Grilled food is one of the source of PAH through oral route caused by an incomplete combustion process in the grilled food processing. Based on weekly consumption of grilled food it is known that the average concentration of urinary 1-OHP is higher among respondent who consumed grilled food. This result supports previous studies [11, 20]. Grilled food is not a major variable contributes to urinary 1-OHP concentration in this study, because there was no statistically significant between concentration urinary 1-OHP and grilled food consumption.

It is known that factories and crowded highway is the source of air pollution. Therefore, the presence of factories and crowded highway near respondent's residence is the

sources of PAH and particulate exposure and might effect to urinary 1-OHP concentration. Previous research conducted in Shanghai, China shows that average personal concentration of $PM_{2.5}$ on respondents who live within 50 meters by road is 111 µg/m^3 [20]. This study showed that respondent who live near highway or factories have a higher average urinary 1-OHP concentration. There was no significant correlation between concentration urinary 1-OHP and the presence of highway and factories near respondent's residence.

5. Conclusion

Particulate matter resulting from diesel engine emission are the major contributor to the elevation of urinary 1-OHP concentration among vehicle testing mechanics in Cilincing Testing Center, North Jakarta, Indonesia.

Acknowledgement

This work was supported by an internal grant of University of Indonesia.

Conflict of Interest

The authors have no conflicts of interest associated with the material presented in this paper

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