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Exposure to Air Pollutants and Its Relation on Lung Function of Kuala Lumpur Central Ktmb Depot's Worker

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A B S T R A C T

Air pollution is defined as the presence of any air pollutants in the air that have the potential to cause health effect or cause harm to the environment. This study was conducted to investigate the exposure levels to air pollutants among workers in a depot, and the relationship between the exposure levels and the respiratory level of the workers in the depot. The methods used in this study included measuring the concentration of air pollutants namely CO, CO_2, total volatile organic compounds (TVOCs), PM_{10} and two types of heavy metals namely lead (PB) and arsenic (As). Lung function test was also done for workers who were exposed. Three sampling points were chosen to measure the concentrations of air pollutants, namely Loco, power generating car (PGC) and coach lines. Kuala Lumpur Central Office Depot was selected as the control station. Low volume sampler and sampling devices were used to measure the concentration of the air pollutants. This study found that there were three air pollutants with concentrations exceeding the standard limits of suspended particles PM_{10}, lead, and arsenic. The highest concentrations of PM_{10} and Pb recorded were in the PGC line with 0.49 ± 0.03 mg/m^3 and 160 ± 5.13 µg/m^3, respectively. The highest concentration of As recorded was in coach line with 36.00 ± 15.50 µg/m^3. Statistical test results showed that only the concentration of As had a significant difference between the sampling stations. For the lung function test, the values of forced vital capacity (FVC) and forced expiratory volume in the first second (FEV_1) for the exposed group were below normal. These findings showed that the depot workers had a lower respiratory level compared to the workers at the depot office. Statistical analysis showed a significant difference between spirometry diagnosis of employees who had served more than ten years and spirometry diagnosis of employees who had served for ten years and less. In conclusion, the depot workers who had long exposure to air pollutants had low respiratory levels.

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INTRODUCTION

Air pollution as indicated by the United States Environmental Protection Agencies (US EPA) is the presence of any pollutants in the air. Air pollution can cause health problems and bring harm to the environment [1]. Indoor air is defined as air in the building, including the air in the room and the air removed from the room by mechanical methods [2]. Indoor air quality is the quality of air in a building. A good indoor air quality could lead to the comfort and health of the occupants in the building [3]. According to the US EPA, at present, most people spend almost 90% of their time in the house or in the building. Scientific evidence shows that the air inside a home or building can be more polluted than the air outside. Thus, for most people, the effects of indoor pollution on health are even more dangerous than outdoor pollution because of longer exposure to indoor air pollution than outdoor air pollution (www.epa.gov/iaq/pubs/insidesroty.html).

Air pollutants are any substances that can cause harm to humans, animals, and plants. Various air pollutants have been reported, and each of these air pollutants varies in chemical composition, response, emission, persistent in the environment, and impact on human and animal health [4]. For example, carbon monoxide (CO) is a colourless, odourless, and toxic gas (http://www.epa.gov/iaq/co.html). It is a gas that is

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resulted from incomplete combustion of materials containing carbon. Apart from the incomplete combustion, carbon monoxide is also present in the environment as a result of the introduction of outdoor air into the building, smoke on the vehicle in the garage, tobacco smoke, and the use of gasoline-powered electricity generator during a power failure [5].

Carbon dioxide (CO_2) is a colourless gas and is odourless. Carbon dioxide is present in the environment as a result from metabolic processes in humans and animals [5]. Carbon dioxide emission to the environment is also caused by the combustion of carbon-containing fossil fuels such as oil, natural gas, and coal [3].

Total volatile organic compounds (TVOCs) are any chemical compounds that have at least one carbon and hydrogen in their molecular structure. The main source of TVOCs is from natural and anthropogenic activities [5]. TVOCs can also come from human activities, building product emissions, and air entering from outside into a building [6].

Particulate matter (PM) is a generic term used for type of air pollutants that consist of a mixture of suspended particles. This mixture differs in size and composition as a result of natural and antropogenic activities [4]. The main sources of PM are from diesel engine exhaust, food preparation activities, and dust from wood combustion [7].

Lead (Pb) has long been recognised as a harmful environmental pollutant. Humans can be exposed to lead in many ways such as through air, drinks, foods, contaminated soil, and dust. Airborne lead enters the body when a person breathes or swallows lead particles or dust. Fuel from motor vehicles and industrial sources is a major contributor to the emission of lead (http://www.epa.gov/schoolair/pollutants.html#Arsen).

Arsenic and arsenic compounds are carcinogenic to humans. Arsenic is a heavy metal that is always found in low concentrations in the environment. Exposure to arsenic occurs via oral route (ingestion), inhalation, and contact with skin. Exposure during working hours is often associated with exposure through inhalation [1].

This study was conducted specifically to measure the concentration of air pollutants in the Kuala Lumpur Central KTMB Depot. Measurement of the concentration of these contaminants can help in the assessment of the level of exposure to the employees at the work area and in determining the health effects of exposure to workers. Evaluation of pollutant exposure levels was to find out which employees would be exposed to pollutants higher than others under certain circumstances. Other than that, the determination of the effects of exposure was conducted to determine the level of exposure that could affect the health of the people in a location.

MATERIALS AND METHODS

This study was divided into two parts namely sampling of air pollutants and health impact assessment. Sampling of air pollutants was to measure concentrations of selected air pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), total volatile organic compounds (TVOCs), particulate matter (PM_{10}), and heavy metals of lead and arsenic. The health impact assessment was to assess lung function in workers exposed to air pollutants during working hours using spirometry test.

Air sampling

Sampling location

The sampling stations chosen were Loco line, power generating car (PGC) line, and Coach line in Kuala Lumpur Central Depot. The Kuala Lumpur Central Office Depot was selected as the control station.

Parameters of air pollutants

The sampling of air pollutants involved six parameters namely carbon monoxide (CO), carbon dioxide (CO_2), total volatile organic compounds (TVOCs), particulate matter (PM_{10}), lead, and arsenic.

Air pollutant sampling methods

The first sampling method was by using devices that took readings directly or *in situ*. This method was applied to pollutants CO, CO_2 and TVOCs. CO was sampled using Tetra 3 Portable Gas Detector, CO_2 was sampled using Aeroqual Series 500, and TVOC was sampled using Photo Ionisation Detector (PID). Sensor of each device was placed at the level of 75 cm to 125 cm from the floor. Direct readings were taken every 10 min intervals for a period of 30 min.

The second method was by using a low volume air sampling device (LVS) for sampling PM_{10}. This tool's flow rate was adjusted to 6 L/min at a pressure of 7 psi for 6 h.

Laboratory Procedure

Laboratory analysis in this study focused on acid digestion method. The analysis was done on a sample parameter PM_{10}. The method was carried out to extract lead, Pb and arsenic, As from PM_{10} sample according to NIOSH Method 7300 with some modifications when appropriate.

Small sample of filter paper were cut and mixed together for homogeneity in a 50 mL beaker. 10 mL of 1:1 nitric acid was added to the beaker and refluxed for 10–15 min. The beaker was covered during the reflux. Then, the sample was cooled to room temperature, and then 5 mL concentrated nitric acid was added. The sample were then refluxed for another 2 h, and the beaker was closed again. After 2 h, the sample were

cooled to room temperature. Then, the beaker was added with 2 mL of distilled water and 3 mL of hydrogen. The sample were refluxed until the foam subsided. The sample were refluxed again for 2 h or until the end sample volume was 5 mL. The sample were allowed to cool to room temperature. The process continued with filtration using Whatman filter paper No. 41 in the conical flask. The sample was then diluted with 100 mL distilled water. The samples were placed in a cold room before analysis using Induced Coupled Plasma Mass Spectometry (ICP-MS).

Lung function test

Lung function test is one of the most important methods for the assessment of the effect of air pollution on human health. This test is a fundamental procedure to diagnose, assess, and monitor respiratory diseases and is often done using spirometry. In this study, the spirometry test was based on NIOSH method (NIOSH. 2003. NIOSH Spirometry Training Guide. United States: National Institute for Occupational Safety and Health.). Before starting the test, the subjects were asked to complete a survey form to get their demographic data.

First, the subjects were asked to sit or stand. If sitting, the subjects were asked to sit up straight. The subjects were then asked to loosen tight clothing as it could restrict breathing. Then, the subjects were instructed to elevate their chin and extend their neck. Nose clip was used when appropriate. Forced expiratory manoeuvre was then started. The subjects held the tube spirometry at shoulder level. Then, they were asked to inhale as deep as possible. Next, they were asked to put spirometry funnel into their mouth and exhale as hard and as long as possible until instructed to stop. The forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and ratio of FEV_1 to FVC (FEV_1/FVC) were recorded and analysed.

Statistical analysis

The data collected were analysed using the Statistical Package for Social Sciences (SPSS) version 18.0. The analysis tests used were descriptive analysis and inferential analysis.

RESULTS AND DISCUSSION

Air sampling

Table 1 shows the average concentration of each pollutant at each sampling station.

The highest average concentration of CO recorded was at PGC with a reading of 1.00 ± 0.39 ppm. From the one-way ANOVA, there was no significant difference between the average concentrations of CO at each sampling station. PGC line is the line for the maintenance and repair of Power Generating Car (PGC), which is one of the components in a train. High concentrations of CO in indoor air can be attributed to the emission into the building with smoke ventilation systems and from parked vehicles and engines turned on [8]. However, the average concentration of CO at each sampling station was below the standard of 10 ppm set by the Department of Safety and Health (COP. 2010. Industrial Code of Practice On Indoor Air Quality. Malaysia: Department of Safety and Health, Ministry of Human Resource).

The highest concentration of CO_2 recorded was in Kuala Lumpur Central Depot office with an average of 977.33 ± 6.93 ppm. One-way ANOVA showed no significant difference in the average CO_2 concentrations at each sampling station. high concentrations in the depot office are due to the limited area of the office and the number of employees occupying the space in it. Next, Loco, PGC, and Coach lines had a lower average reading of CO_2 compared to the depot office. This was because the area of the depot was greater than other areas despite the many employees.

The CO_2 concentration in the indoor air depends on the number of occupants in the building and the level of metabolic activity carried out in that space [3]. The Department of Occupational Safety and Health (DOSH) has set the limit of acceptable indoor air CO_2, which is 1,000 ppm. Thus, the CO_2 concentrations at each sampling station in this study were still under the standard limit.

The highest average concentration of TVOCs recorded at Loco line was 0.13 ± 0.09 ppm. One-way ANOVA showed no significant difference between the average TVOCs concentrations at each sampling station. According to Kampa and Castanas [4], fuel combustion especially the combustion processes for energy production and road transport is an important source of TVOCs [6]. In addition, the TVOCs can also come from paint, paint stripper, cleaning materials, pesticides, building materials, and office equipment (www.epa.gov/iaq/pubs/insidesroty.html). TVOCs present in Kuala Lumpur Central Depot resulted from the combustion of the fuel used to ignite the train. As for the office depot, the presence of TVOCs was from furniture, wall paint, and office equipment such as printers, photocopiers, and stationery tools. The standard limit allowed by DOSH in Indoor Air Quality Industry Code of Practice is at a concentration of 3 ppm. Thus, the TVOCs concentrations at each sampling station were below the standard.

TABLE 1. The average concentration of air pollutants at each sampling station

Sampling Stations	Average concentration ± Standard deviation					
	CO(ppm)	**CO_2(ppm)**	**TVOC (ppm)**	**PM_{10} (mg/m^3)**	**Pb($\mu g/m^3$)**	**As($\mu g/m^3$)**
Loco	0.78 ± 0.45	895.67 ± 52.49	**0.13 ± 0.09**	0.40 ± 0.06	75.33 ± 29.00	10.67 ± 1.33
PGC	**1.00 ± 0.39**	702.67 ± 100.77	0.00 ± 0.00	**0.49 ± 0.03**	**160.00 ± 5.13**	35.33 ± 3.76
Coach	0.44 ± 0.29	888.00 ± 80.60	0.10 ± 0.00	0.41 ± 0.03	91.67 ± 44.39	**36.00 ± 15.50**
KL Central Depot Office	0.00 ± 0.00	**977.33 ± 6.93**	0.07 ± 0.03	0.31 ± 0.08	35.67 ± 28.69	27.33 ± 2.85
Acceptable Limits	10	1000	3	0.15	50	10

* significant value at $p < 0.05$

Notes: Bold values indicate the highest concentration value for each parameter at each station

The highest average concentration of PM_{10} recorded was 0.49 ± 0.03 mg/m^3 in PGC line. The lowest PM_{10} reading recorded was 0.31 ± 0.08 mg/m^3 at the office depot in Kuala Lumpur Central. The Kruskal-Wallis statistical test showed no significant difference between the average PM_{10} concentrations at each sampling station. The standard limit set by DOSH as in the Indoor Air Quality Industry Code of Practice is 12:15 mg/m^3. Thus, the average PM_{10} concentrations at all sampling stations namely Loco, PGC, and coach lines and Kuala Lumpur Central Office Depot exceeded the standard.The average concentrations of PM_{10} were high and exceeded the standard. This was likely a result from the activity done inside the depot. PM_{10} detected in PGC line was due to smoke produced when the PGC as on. Besides being a place to repair the PGC, this line was also used as a parking area for trains for heating up the engine before starting the journey. Apart from the PGC, among other resources that could be associated with the high PM_{10} concentrations were from the dust brought in by trains entering the depot, smoke, and other external sources [2]. For the depot office, the presence of PM_{10} was caused by the entry of dust particles from construction sites located near the depot office. The presence of PM_{10} could also be caused by the depot workers who were exposed to high concentrations of PM_{10} and walked into the office depot thus affecting air quality interior. According to Yau et al. [3], the ventilation system that is not properly maintained will increase the concentration of pollutants in indoor air [3]. Overall, the concentration of PM_{10} in each sampling point was higher than the allowable standard limits, and this high concentration of PM_{10} can affect the workers who were exposed in long periods of time.

The average concentration of lead (Pb) was the highest at PGC line with 160 ± 5.13 mg/m^3, while the lowest average concentration was recorded at the Kuala Lumpur Central depot office with 35.67 ± 28.69 mg/m^3. There was no significant difference between the average concentrations of Pb in each sampling station. The average concentrations of Pb in Loco, PGC, and coach line exceeded the standard set at 50 mg/m^3. The average concentration of Pb at the PGC was high due to the production of smoke and soot emissions. Pb is usually found in smoke produced by motor vehicles. Apart from the PGC, loco parked with the engine turned on was also a source of Pb. Turning on the engine before starting on a long journey or for the purpose of inspection and maintenance of loco can also produce smoke and soot [14].

The highest arsenic average concentration was recorded in coach line with 36.00 ± 15.50 mg/m^3. The lowest average concentration of As of 1.33 ± 10.67 mg/m^3 was recorded at Loco line. All the sampling stations had an average concentration of As exceeding the standard limit set in USECHH 2000 of 10 mg/m^3 for an 8-hour Time Weighted Average (TWA). However, from the Games-Howell Post Hoc test, there were significant differences among the average concentrations of As at the Loco and PGC lines and at the Kuala Lumpur Central Office Depot. The highest concentration of As in coach line was from the smoke emitted by the train under maintainence. In addition, this sampling station was far from sources of outside air. Inadequate ventilation and air circulation slowly caused accumulation of pollutants at this station. Based on the results, the concentration of As in each sampling point was higher than the standard limit allowed. According to Awang et al. [2], As is usually found in the suspended particulates, environmental tobacco smoke, and construction activities [2]. During sampling at the depot, some employees were smoking near the work area. A similar situation was observed at the office depot. Some employees were smoking at the emergency stairs in the office. Smoking activity causes the release of environmental tobacco smoke, thus increasing the concentration of As in the environment.

Lung Function (Spirometry)

In lung function test, a total of 38 subjects were involved. Of the total number of subjects, 28 of them represented the exposed group, and the remaining 10 represented the control group. The exposed group was for those who worked at the Kuala Lumpur Central Depot that was directly exposed to air pollutants, while the control group was for those employees who worked

at the Kuala Lumpur Central Depot office. All the subjects were men and had no history of respiratory disease.

From the results, the average FVC and FEV_1 readings for depot workers were below the normal limit of 80% set. However, one sample *t*-test showed a significant difference between the readings of FEV_1/FVC in both groups of subjects with normal limits. The FEV_1/FVC readings for exposed group and control group were above the normal limits. According to Al-Ashkar et al. [15], readings of FEV_1/FVC that are normal and FVC readings that are lower than normal levels show restrictive pattern of lung function tests [15]. In comparison, FVC and FEV_1 readings for the exposed group were lower than the control group. This was because the depot workers were directly exposed to air pollutants. FVC and FEV_1 decline in reading was due to the presence of PM_{10}.

After getting the readings of FVC, FEV_1, and FEV_1/FVC, the subjects were categorised into three groups namely normal, restriction, and obstruction. Overall, of the 28 subjects from the exposed group, 36% of them were normal, 18, 36% of them had mild restriction, 28% of them had moderate restriction, and 18% of them had severe restriction. For the control group, 70% of the 10 subjects were diagnosed normal, and the rest 30% were diagnosed with mild restriction. From chi-square Fisher Exact test, there were significant differences among the spirometry diagnoses of the exposed group and the control group.

To test the correlation between sociodemographic data and the workers' breathing status, two factors were chosen, namely length of service and smoking habit. Table 2 shows the relationship between both factors based on the spirometry diagnosis.

Based on the results, the length of service (>10 years) and smoking habit contributed to abnormalities of lung function, with 89% and 59%, respectively. Several studies show that smoking causes the decline in FVC and FEV_1 of a smoker [7]. Smoking not only causes reduction in FEV_1 reading of a smoker, but also causes chronic obstructive lung disease (COLD). From the chi-square Fisher Exact test, there were no significant differences in the diagnoses between the employees who smoked and did not smoke.

However, this test showed that there were significant differences in the diagnosis among the employees who had worked for more than ten years and employees who had served for 10 years and less. Exposure to air pollutants present at low concentrations in a long period of time can affect the breathing of a person [5]. Therefore, employees who had served more than 10 years were at greater risk to have low levels of respiration than those who had served for 10 years and lesser.

CONCLUSION

Overall, the PGC line was the most polluted area in Kuala Lumpur Central Depot because there were three parameters of air pollutants with the highest concentrations, namely carbon monoxide (CO), particulate matter (PM_{10}), and lead (Pb). For the measured pollutants, particulate matter (PM_{10}), metal lead (Pb), and arsenic (As) had higher average concentrations at each sampling station compared to the standard given by DOSH. Therefore, it is mandatory for the administration of KTMB to ensure every employee who works at the depot and is directly exposed to air pollutants to always wear appropriate personal protective equipment such as face mask. Moreover, it is desirable to strengthen the directive prohibited smoking in the depot and to allow smoking at the provided area only.

For the lung function tests, the FVC and FEV_1 readings for the workers at the Depot Kuala Lumpur Central were beyond the normal limits prescribed, and 68% of the employees were diagnosed of having abnormal spirometry. This finding showed that the level of the workers' breathing in Kuala Lumpur Central Depot was lower compared to workers at the Kuala Lumpur Central Depot office. The abnormality of the diagnosis was also contributed by the length of service.

TABLE 2. Spirometry test diagnosis results for exposed group according to their length of service and smoking habit

Sociodemography	Kuala Lumpur Central Depot Worker		P value
	Normal Diagnosis n (%)	**Abnormal Diagosis n (%)**	
Length of service			
≤10 years	6 (60%)	2 (11%)	0.011*
>10 years	4 (40%)	16 (89%)	
Smoking habits			
Smoking	3 (30%)	10 (56%)	0.254
Not smoking	7 (70%)	8 (44%)	
*** significant value at p < 0.05**			

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Persian Abstract

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چکیده

آلودگی هوا عبارت است از حضور هر نوع آلاینده جوی در هوا که توانایی اثر سوء بر سلامتی یا امکان صدمه به محیط زیست را دارا می‌باشد. این تحقیق جهت بررسی مراتب در معرض قرار گرفتن آلاینده‌های هوا با کارگران انبار و رابطه بین میزان در معرض قرارگیری و سطوح تنفسی آن‌ها، انجام شده است. روش استفاده شده در این روش شامل اندازه‌گیری غلظت آلاینده‌ها یعنی CO و CO_2، میزان کل ترکیبات آلی فرار (TVOCs)، PM_{10} و دو نمونه از فلزات سنگین به نام سرب و آرسنیک می‌شود. تست عملکرد ریه برای کارگرانی که در معرض این آلاینده‌ها قرار داشتند نیز انجام گرفت. برای اندازه‌گیری غلظت آلاینده‌های هوا سه نقطه نمونه‌گیری یعنی Loco، ماشین مولد برق (PGC) و خطوط تردد اتوبوس مشخص شد. انبار اداره مرکزی کووالالامپور به عنوان مرکز کنترل انتخاب و نمونه بردار و سایر ابزار نمونه‌گیری با حجم کم برای اندازه‌گیری غلظت آلاینده‌های هوا استفاده شد. این بررسی مشخص نمود که سه آلاینده هوا یعنی آرسنیک، سرب و PM_{10} با غلظت بالاتر از حد استاندارد ذرات معلق، وجود دارند. بالاترین غلظت PM_{10} و سرب در خط PGC با مقادیر به ترتیب ۰/۰۳±۰/۴۹ میلی گرم بر مترمکعب و ۵/۱۳±۱۶۰ میکروگرم بر مترمکعب ثبت شده و بالاترین غلظت آرسنیک گزارش شده در خطوط اتوبوس به مقدار ۱۵/۵±۳۶ میکروگرم بر مترمکعب بوده است. نتایج تست‌های آماری نشان داده است که فقط غلطت آرسنیک تفاوت قابل ملاحظه‌ای در بین مکان‌های اندازه گیری نمونه داشته است. تست عملکرد ریه، مقدار ظرفیت حیاتی اجباری (FVC) و مقدار هوای خروجی ریه در اولین ثانیه بازدم اجباری تحت عنوان FEV_1 برای گروه در معرض نهاده شده، پایین تر از حد نرمال بوده است. این یافته‌ها نشان داد که کارگران انبار سطح تنفسی کمتری در مقایسه با کارکنان انبار شرکت دارا بودند. آنالیز آماری نشان‌دهنده یک تفاوت فاحش بین تشخیص دم سنجی(اسپیرومتری) کارمندانی که بیش از ده سال سابقه فعالیت در مکان مورد مطالعه را داشته و کارمندانی که برای ده سال و کمتر از شروع فعالیت‌شان سپری شده است، وجود دارد. در نتیجه، کارگران انباری که طی مدت طولانی در معرض آلاینده‌های هوا قرار داشته‌اند، سطح تنفسی پایینی داشته‌اند.