Determination of Elements (Cd, Cu, Fe, Pb and Zn) in Universiti Teknologi MARA (UiTM) Hostel Shah Alam, Malaysia

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ABSTRACT

The purpose of this study is to determine the concentration of the selected elemental composition in a multi-storey hostel. Dust samples were taken from three random rooms at each level of the student hostel by sweeping the floor. The concentrations of elements (Cd, Cu, Fe, Pb and Zn) were determined by using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) after digestion with nitric acid and sulfuric acid solutions. Dust samples analysis has shown the different levels of sampling point does not affect the concentration of the elements. The concentration of elements in investigated microenvironment was in the order of Fe > Zn > Cu > Pb > Cd. The correlation analysis was applied to elements variable in order to identify the sources of an airborne contaminant. It was discovered the strong positive correlation between Cu-Zn which indicates the sources come from traffic emission and street dust. This result was supported by the Principal Component Analysis (PCA) that revealed the presence of elements in the student hostel originated from the outdoor sources.

Keywords: *indoor air pollution, multi-storey hostel, element, ICP-OES, PCA*

INTRODUCTION

Over recent years, indoor air pollution has been gained attention due to the greater impact than outdoor air pollution. Studies have shown that exposure of occupants to indoor air pollutants is 100 times higher than their exposure to outdoor air pollutants. Concentration of indoor air pollutions was found to be 2–4 times higher than that of outdoor air pollutants. With respect to this, the United State Environmental Protection Agency (USEPA), 2013 have consistently ranked indoor air pollution among the top five environmental risks to public health.

Indoor air pollutants are influenced by many building and environmental factors, such as outdoor particles source characteristics and concentrations, air leakage rates, indoor particle deposition and resuspension, indoor air exchange rates and/or ventilation system design [1, 2]. Meanwhile, the appearing of contaminants in the indoor environment is contributed by the combination of exterior and interior sources. The contaminants from outside like pollutants from vehicles, industry activities, road dust and soil dust. Internally, the most common sources include adhesives, upholstery, carpeting, copy machines, manufactured wood products, pesticides, cleaning agents [3]. Environmental tobacco smoke, respirable particulate matter, combustion by-products from stove, fireplace and unvented space heater also increase the chemical contamination internally. Synthetic fragrances in personal care products or in cleaning and maintenance products also contribute to the contamination [4].

Poor indoor air quality has closely connected to the “sick building syndrome” (SBS). The term of SBS is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illnesses or cause can be identified. The illnesses include allergic reactions, respiratory problems, eye irritation, sinusitis, bronchitis and pneumonia [5].

The demand of current lifestyle encourages contemporary urban societies to spend most of their time indoors resulting in a growing concern about elements contamination in the indoor environment [6]. Despite this, relatively little research has been done in Malaysia on the quality of air in homes and offices to ascertain the effects of indoor air quality to the respective occupant’s building. In this context, a university student’s life should not be excluded. Dormitories or hostel is a residential building for the university’s student in several years until they complete their studies. Hostel is not the same as other types of residential building such a house whereas it is developed in a small space as the building is designed with bedrooms only. Hence, most of the student activities especially studying are done in the respective bedroom. Small spaces are expected to trap more pollutants compared to the wide spaces due to the limitation of pollutants dispersion area. The increase of pollutants in the bedroom space could affect the overall academic performance of the students [7].

Thus, in this study, the determination of elements from indoor dust sample of hostel building was carried out. Since there are limited data on dust contaminant in the multi-storey hostel and the location of this hostel that lies in an urban area which is Shah Alam plays a significant purpose to conduct this study.

EXPERIMENTAL

Sampling site

The west coast center of Peninsular Malaysia, Shah Alam, located about 25 to 30 km west of the country's capital which is Kuala Lumpur. As the capital city of Selangor state, Shah Alas has experienced a rapid urbanization and industrialization in the last decades with approximately 584,350 inhabitants. The study area mainly lies in the Shah Alam city. Block 4b of Melati College, UiTM Shah Alam is a multi-story dormitory which is consists of ten levels with 57 rooms each level and occupied by two students in each room. For the dust collection, three rooms were randomly selected at each level.

Sample collection

Using a clean plastic brush and pan, dust was collected inside the dormitory rooms by sweeping the floor and any accessible furniture that exposed to the dust like study desk and wardrobe. The collected dust was kept in the sealed plastic bag, then, brought to the laboratory, placed in a desiccator for 24 h, sieved through a 100-m screen, and eventually oven dried at 70ºC for 24 h. Oven dried the sample can remove the moisture.

Sample and data analysis

There are five elements were determined in this experiment which are Cd, Cu, Fe, Pb and Zn. The concentrations of elements were measured by using the Optima 5300 DV Inductively Coupled Plasma-Optical Emission Spectrophotometer (ICP-OES) (Perkin Elmer, USA). The sequential spectrometer was used with following parameters: power, 1450 W; demountable quartz torch, Ar/Ar/Ar; coolant gas Ar, 17.0 L min−1; auxiliary gas Ar, 0.2 L min−1; nebulizer gas Ar, 0.6 L min−1; sample flow rate, 2.0 mL min−1; integration time, 10 s min/20 s max and read delay, 60 s. The wavelengths (plasma view) for Cd: 214.440 nm (axial), Cu: 324.752 nm (radial), Fe: 273.955 nm (axial), Pb: 220.353 nm (axial) and Zn: 206.200 nm (axial).

A Spectro flame optical emission spectrometer, ICP Model Optima 5300 DV (Perkin Elmer, USA) only can analyses the sample in the liquid medium. So that, about 0.5 g of the fine portion of the dust was added into the aqua regia acid solution of 6 ml of 65% HNO_3 and 2 ml of 96% H_2SO_4 and digested by using microwave digester at 200ºC for 1 hour. Immediately after digestion, the extract was cooled before filtering through Whatman No. 42 filter papers. The filtering process is very important to prevent any small particles from causing blockages of ICP-OES. The filtrate was then made up to a volume of 25 mL by the dilution with the deionized water and was analyzed for element concentration by using ICP-OES through the comparison of the sample solution with a blank solution. The procedures of sample preparation were repeated without adding the collected dust sample in preparation of the blank solution. Data were analyzed for analysis of variance (ANOVA), correlation function and factor analysis using statistical functions in Microsoft Excel and Statistical packages for the Social Sciences (SPSS), including.

RESULTS AND DISCUSSION

Elements concentration

The mean concentration of elements in the indoor dust of multi-story hostel was presented in Table 1. The result showed that there is no specific relationship between the heights of the sampling location with the concentration of elements.

Table 1: Descriptive statistics of elements concentration (N=30)

Element	Min (mg/kg)	Max (mg/kg)	Mean (mg/kg)	S.D.
Cd	1.58	20.00	8.11	6.74
Cu	54.92	179.92	128.60	45.99
Fe	1960.00	5838.00	3007.13	1099.70
Pb	9.00	46.42	17.44	11.93
Zn	474.42	1258.67	813.53	240.75

S.D. – Standard Deviation

The frequency of cleaning activities and occupant's lifestyle are the factors that resulted in the variation of elemental concentrations in the multi-story hostel rooms. As stated by [8], the concentration of contaminants like heavy metals in the indoor environment can be reduced by regularly cleaning activities. Study by [9] proved that the concentration of heavy metals in houses that conducted daily cleaning activities was significantly lower than houses that doing irregular cleaning activities. Besides that, different methods of cleaning process also influence the variation of contaminants in the indoor environment. Wet cleaning method such as mopping can remove 100% indoor dusts instead of the sweeping method that only removing 90% of dust [8].

In this study, iron (Fe) was identified as the highest concentration which is 3007.13 mg/kg and followed by Zn with the mean concentration of 813.53 mg/kg. Fe is the abundant element in the Earth's crust [10, 11]. Indoor sources such as sweeping, cooking, cleaning and dusting have resulted in the highest of Fe concentration at the sampling location. From the observation, there are some rooms having carpets and this, tend to accumulate a higher concentration of heavy metals by trapping the dust on the carpet's surface. There are also some students that bring their own furniture in the hostel led to the discrepancy of heavy metals concentration in the sampling locations. As found by [12], indoor environment with carpet was accumulated more heavy metals than the indoor environment with no carpet. Besides that, many studies concurred that the accumulation of heavy metal in indoor environment comes from outdoor sources. Wind is believed as the medium of transportation in moving of outdoor sources into indoor environment [13]. Thus, soil and dust street are the sources of accumulation of Fe in hostel rooms.

The location of the hostel is near to the road affects the presence of these elements in the indoor environment. Hence, other metals such as zinc (Zn), copper (Cu) and lead (Pb) are closely related to automobile emissions. Literatures stated that Zn usually caused by the wear and tear of vulcanized rubber tires, lubricating oils, and corrosion of vehicular parts [14, 15 and 16]. The main indoor sources of Cu are tobacco smoke and electric motors in vacuum cleaner and fans [17], Meanwhile, car components, tire abrasion, lubricants corrosion of cars, engine wear, thrust bearing, brushing, bearing metals and brake dust also believed as the existence of Cu in the indoor environment of the hostel.

Universal pollutant of Pb in an urban environment such in Shah Alam are caused by fossil fuels combustion mainly from the motor vehicle gasoline, then, also emitted from the industrial activities, geogenic dust and construction debris [18 and 19]. Studies conducted by [20 and 21] remarks that indoor Pb sources are damaged paint, carpet, cable sheathing and usage in plumbing, ceramic-ware, plastics and furnishing.

Cadmium has been widely dispersed into the environment through the air by its mining and smelting as well as by other man-made routes: usage of phosphate fertilizers, presence in sewage sludge, and. various industrial uses such as NiCd batteries, plating, pigments and plastics [22 and 23]. Since this study area is far away from industrial, agriculture and landfill areas, it gives a reason the lower concentration of Cd which is indoor sources such as usage of detergents and electrical components initiated the accumulation of this element in hostel rooms.

Elements in dust originated from the indoor and outdoor sources. However, in this study, outdoor sources believe as the major influence in the accumulation of heavy metals in hostel rooms. This hostel is non-air-conditioned rooms that having open ventilation that prepare the routes for heavy metals entering hostel building from outdoor sources. While recognizing the fact that, the movement of occupant’s in and out from building also contributed the elements concentration in the building, its contribution was less obvious from the contribution from ambient sources [24].

Correlation coefficient analysis

Correlation values were used to determine the common sources of different pollutants. Basically, strong and positive correlations between two elements show that elements contribute by the same sources.

Table 2: Correlation matrix for elements concentration

Element (mg/kg)	Cd	Cu	Fe	Pb	Zn
Cd	1	-0.07	-0.17	-0.45	-0.22
Cu		1	0.25	0.11	0.64*
Fe			1	0.27	0.49
Pb				1	0.39
Zn					1

* Correlation is significant at the 0.05 level (2-tailed)

For example, Table 2 indicated that all metal pairs show positive relations except for Cu-Cd, Fe-Cd, Pb-Cd and Zn-Cd and Zn-Cu pair is most significantly related (0.64) at 95% or higher confidence level. A possible reason for this is their origin (Fe, Cu, Pb and Zn) from automobile emissions. The pairing of Cd with all other elements revealed negative relations means that an emission of Cd originated from indoor sources which are a usage of detergents and electrical components.

Factor analysis

The possible contributing factors towards the element concentrations and to determine which elements have a common origin can be identified by using Principle Component Analysis. The principal component matrix analysis was presented in Table 3. Two factors that obtained eigenvalues > 1 were extracted. The total variance explained by these two factors was 69.10% which is the first factor with the greatest amount of variance is 45.42% that highly loaded by Zn and moderately by Cu, Pb and Fe. This factor may indicate a source of mixed origin including air-borne emission commenced from mobile vehicle, road dust and soil dust.

Table 3: Component matrix of elements concentration

Item/Component	Factor 1	Factor 2
Eigen Value	2.27	1.18
Explained Variances (%)	45.42	23.68
Cd	-0.50	0.68
Cu	0.65	0.57
Fe	0.66	0.12
Pb	0.64	-0.55
Zn	0.87	0.29

The second factor showed 23.68% of the variances where Cd, Cu, and Pb are moderately loaded and have been distributed between the first and second factor with moderate load value. As a conclusion, all of the measured elements in this study come from anthropogenic sources.

CONCLUSION

The elements that are found in the indoor dust of multi-storey hostel are Fe, Pb, Zn, Cu and Cd. The concentration of these elements is in order of Fe> Zn> Cu> Pb> Cd. Data analyses revealed that the major of indoor air pollutants possible sources is influent by outdoor sources such as the mobile vehicle, street dust and soil dust and slightly affects from the indoor sources such paint, cleaning activities, electrical components and furnishing. There is no specific trend between the concentrations of elements with the different elevation of sampling areas. The reasons for this result are the different frequency of cleaning activities and ventilation of the building. Since the exposure of elements into students have long-term effects and affect their study performance, action should be taken to avoid or minimize the potential risk of this silent epidemic. Accordingly, good housekeeping practices by sweeping or mopping the floor regularly and maintain a good ventilation system by closing those windows that are facing major roads should be taken into attention in order to reduce the exposure of these elements into occupants.

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