METAL CONCENTRATION IN INDOOR DUST OF UNIVERSITY HOSTEL

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Abstract

Indoor dust has received much attention and can act as a medium for contaminant deposition, including heavy metal. This study determines the concentration of selected metal in indoor dust collected from a hostel building at Universiti Teknologi MARA Cawangan Pahang, Malaysia. This study estimates the potential health risk of indoor dust exposure. Iron (Fe), copper (Cu), lead (Pb) and cadmium (Cd) were analysed using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Fe dominated the results with a range of 1.28-2.50 µg/g, followed by Cu (0.37-0.76 µg/g), Pb (0.02-0.09 µg/g), and Cd (0.01-0.05 µg/g). Enrichment factor (EF), with values less than 10, suggests a mix of anthropogenic and natural sources of metal origin. The total hazard quotients (HQ) were below the level of 1, indicating low non-carcinogenic risks to adults. A comprehensive indoor dust monitoring and health risk assessment could be proposed to minimise the exposure risk in the indoor environment.

Keyword: dust, hostel, metal, student's exposure

Introduction

Outdoor air often has a lower level of pollutants than indoor air (Gioda et al., 2011). Student performance and health status may be affected as they tend to stay longer in indoor environments (Zhong et al., 2014). Indoor pollutants can be influenced by outside sources and indoor activities. Indoor air pollutants may derive from various mixed sources such as human movement, building materials, building location, and outdoor activities such as combustion (Latif et al., 2009; Yang Razali et al., 2015; Mohamad et al., 2016).

Latif et al. (2014) suggested that air pollutants may be adsorbed onto particulate matter in the indoor environment and settle as indoor dust. The ventilation system influences the small particles suspended in a building in combination with human activities (Mohamad et al., 2016). This small particle can remain in the air for a longer time, thus, potentially disturbing occupant respiration (Matson, 2005). Some studies reported that exposure to indoor air pollutants correlates with health effects such as allergies, respiratory diseases, irritation, and cancer (Mohd Tahir et al., 2009; Young et al., 2011).

Metal composition in indoor dust needs to be determined and evaluated. Inadequate studies investigated the metal composition in indoor dust within university hostel buildings. Therefore, this study evaluates the concentration of Cd, Cu, Fe, and Pb present in indoor dust and estimates the potential sources. This study also attempts to assess the potential health effect related to exposure to indoor dust composition.

Materials and Methods

A total of 24 samples were collected from a student hostel building in Universiti Teknologi MARA Cawangan Pahang, Jengka Campus, Pahang, Malaysia. Dust samples were collected from level 1, level 4, and level 7 of a hostel building and taken from the upper surface of the cupboard, ceiling fan, and windows. These sampling sites were selected based on the highest number of students occupied in this hostel. The samples were taken twice a week for four consecutive weeks. All sampling regimes, sample preparation and analysis followed the method used by Sulaiman et al. (2017).

The concentration of metals (Cd, Cu, Fe, and Pb) was analysed in triplicates using an Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Topsoil (0.01 m depth) near to sampling location (< 10 m) were collected as the reference sample. The topsoil concentration of heavy metals was adopted as the Earth's crust ratio (Sulaiman et al., 2017). This reference sample was prepared and analysed using the same method as the dust samples. All the precaution measures considered to maintain the quality and validity of data obtained.

The enrichment factor (EF) was computed to classify the potential source and enrichment level of metal in samples. EF was estimated based on EF = Xi/R (dust) / Xi/R (background), where Xi dust is the concentration of the metal in indoor dust, and Xi background is the concentration of the metal in the reference sample. R dust and R backgrounds are the Fe concentration in the dust sample and reference sample, respectively. A one-way analysis of variance (ANOVA) was applied to evaluate any significant differences between the mean concentration of metals in the indoor dust among the sampling sites.

A health risk assessment was estimated to assess the non-carcinogenic hazards for adults. Inhalation, ingestion, and dermal contact pathways were selected to represent dust exposure by students. Each pathway calculation has been described in our previous study (Sulaiman et al., 2017). Exposure duration, exposure frequency, average time, ingestion and inhalation rates, the surface area of the skin, skin adherence factor, and dermal absorption factor values adopted from USEPA (2011). Hazard quotients (HQ) were calculated for each potential toxic metal concentration considering the average daily dose (ADD) and reference dose (RfD) based on HQ = ADD /RfD. Hazard Index (HI) as the cumulative non-carcinogenic risks obtained from the sum of the HQ values for all the exposure pathways (ingestion, inhalation, and dermal) also computed.

Results and Discussion

Table 1 shows the heavy metal concentrations (Cu, Cd, Fe, Pb) in indoor dust samples and surface soil from hostel buildings. Fe had the highest concentration in indoor dust, with concentration ranging from 1.28-2.50 µg/g, followed by Cu (0.37-0.76 µg/g), Pb (0.02-0.09 µg/g), and Cd (0.01-0.05 µg/g). Fe concentrations in the indoor dust showed significant differences ($p < 0.05$) among the sampling sites. High Fe concentration is expected in indoor dust as it is the most abundant element in the Earth's crust (Latif et al., 2009).

Table 1 Concentrations of Cd, Cu, Fe, and Pb in indoor dust and surface soil (mean ±standard deviation)

	Concentration (µg/g)			
Site	**Cd**	**Cu**	**Fe**	**Pb**
Level 1	0.05±0.005	0.76±0.04	2.03±0.05	0.09±0.01
Level 4	0.03±0.002	0.53±0.03	1.55±0.05	0.04±0.005
Level 7	0.01±0.007	0.37±0.02	1.28±0.07	0.03±0.006
Surface soil	0.02±0.001	0.50±0.01	2.50±0.02	0.02±0.001

Generally, concentrations of all metals showed decreasing trends as the level of sampling site increases. The Cu concentration was highest at Level 1 of the hostel building (0.76 µg/g), followed by 0.53 µg/g at Level 4 and 0.37 µg/g at Level 7. Cd and Pb concentrations appeared to have a similar trend. All elements (Cu, Cd, and Pb) also showed significant differences between sampling sites ($p < 0.05$). The decreasing trend of metal concentration in different building levels indicates that most activities and direct exposure to pollutants source have occurred at the lowest building level. Yang Razali et al. (2015) suggested the indoor dust composition may increase due to strong correlation between meteorological factors and dust entering the indoor environment.

Table 2 shows the enrichment factor (EF) values. EF less than 10 shows the element resulting from natural and anthropogenic origin (Mohamad et al., 2016). The degree of metal enrichment indicates as minimal (EF⩽2): moderate (2<EF⩽5); high (5<EF⩽20); and very high (EF>20) (Lu et al., 2014). Pb shows a high enrichment factor in dust samples collected from Level 1. Cd and Cu indicate minimal to moderate enrichment of metal concentration. The EF values suggested decreasing trends as the building level increased. Perhaps Level 1 shows the highest EF values due to the nearest exposure to pollutant sources such as fuel combustion and human movement. Vehicle emissions and the Pb–based paint might be the potential anthropogenic sources of indoor Pb (Latif et al., 2014; Sulaiman et al., 2016). Although the use of leaded fuel was barred in Malaysia since 2000, the residue can still be found in road dust (Sulaiman et al., 2020) and thus could suspend as an airborne pollutant (Latif et al. 2009). The situation could be worse with the movement activities of occupants (Zhong et al., 2014).

Table 2 The enrichment factor (EF) value of metal concentration on indoor dust

	Cd	**Cu**	**Pb**	**Fe**
Level 1	3.27	1.88	5.53	1
Level 4	2.23	1.72	3.49	1
Level 7	1.13	1.45	2.70	1

The potential non-carcinogenic health risks of indoor dust exposure by students shown in **Table 3**. HQ and HI were calculated to evaluate the non-carcinogenic health risks from Cd, Cu, and Pb. The HQ values for all metals at Level 1 were slightly higher than the HQ values of Level 4 and Level 7. The HQ values for Cu, Cd, and Pb were the highest, especially for Level 1. These metals were found to be accumulated in indoor dust, as estimated in the EF analysis, perhaps due to outside sources such as combustion (Zhong et al., 2014). Overall, the HQ and the HI values were less than unity (<1), indicating low non-carcinogenic risk to students. In the long-term, however, if the metal concentration increase, the potential health risk will increase too.

Table 3 Potential non-carcinogenic health risks of indoor dust exposure

Metal	**Level**	**HQingest**	**HQinhale**	**HQdermal**	**HI**
Cu	Level 1	2.62×10^{-5}			
	Level 4	1.82×10^{-5}			
	Level 7	1.27×10^{-5}			
Cd	Level 1	1.46×10^{-4}	1.07×10^{-6}		
	Level 4	7.57×10^{-5}	5.57×10^{-7}		
	Level 7	3.19×10^{-5}	2.35×10^{-7}		
Pb	Level 1	3.52×10^{-5}	5.18×10^{-9}	1.40×10^{-7}	
	Level 4	1.69×10^{-5}	2.49×10^{-9}	6.76×10^{-8}	
	Level 7	1.08×10^{-5}	1.59×10^{-9}	4.32×10^{-8}	
					3.76×10^{-4}

Conclusion

Heavy metal concentrations in indoor dust were, from most to least, Fe > Cu > Pb > Cd. Enrichment factor analysis suggested a combination of natural and anthropogenic origins of heavy metals in indoor dust. Low non-carcinogenic risks (HI < 1) observed for exposure of metal in indoor dust. A multivariate statistical approach such as principal component analysis may assist in analysing the origin of metal composition in indoor dust. Bio-availability metal form analysis should give a thorough health risk assessment.

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Conflict of interests

We declare there is no conflict of interest.

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