Pertanika J. Sci. & Technol. 27 (4): 1941 - 1954 (2019)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Concentration of Heavy Metals in Street Dust and Surface Soils in Urban and Peri-Urban Regions in the Kuala Lumpur Metropolitan Area

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ABSTRACT

The present study aims to determine the level of heavy metals in surface soils and street dust from selected urban and peri-urban locations in the metropolitan city of Kuala Lumpur. Samples were collected from 15 different locations, where Kuala Lumpur City Centre (KLCC) served as the centre point while other locations were located at specific distances from the centre. Surface soils and street dust were collected to detect the level of contamination based on five elements (Zn, Cu, Pb, Cd and Fe). Results indicated that the metal distribution displayed a descending trend as follows: [Fe] > [Zn] > [Pb] > [Cu] > [Cd] and [Fe] > [Zn] > [Cu] > [Pb] > [Cd] in the surface soil and street dust samples, respectively. Geoaccumulation index (Igeo), contamination factor (CF) and pollution load index (PLI) were calculated. Based on the Igeo index, Fe in both samples was found to cause no pollution in all study sites. In surface soils, CF showed all sites were contaminated with Cd in both soil and street dust. In conclusion, the soil sample was polluted with metals while no pollution was found in the street dust in all sites sampled. Further intensive studies are recommended in order to determine other factors which may cause contamination.

Keywords: City centre, heavy metals, peri-urban, street dust, surface soil

ARTICLE INFO

Article history:
Received: 2 December 2018
Accepted: 30 January 2019
Published: 21 October 2019

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ISSN: 0128-7680
e-ISSN: 2231-8526

INTRODUCTION

As one of the fastest growing cities in Southeast-Asia (Asean Up, 2017; Wilson, 2018), the Kuala Lumpur metropolitan area is proudly structured with a landscape of skyscrapers, as well as steel and glass buildings. Its geographical area is occupied with industrial/ commercial activities, traffic load and development in a number of residential areas. It is no surprise that this global city has been categorized under high Human Development Index (HDI) with an estimation of 1.76 million people in 2016 within a 243 km^2 area (Anonymous, 2017; Department of Statistics Malaysia [DOSM], 2016). Consequently, undergoing projects in developing areas, or the so-called peri-urban areas, are vital in ensuring that the human capacity is parallel with the social and economic development in Kuala Lumpur.

While the acceleration of development occurs, the issue that comes to light is the growing repercussions of the human activities in developed areas (Janaydeh et al., 2016). The pollutant discharge from the urbanization process to the environmental surroundings is believed to cause a significant threat to mankind (Christoforidis & Stamatis, 2009; Udechukwu et al., 2015). One of the chief pollutants in urban areas nowadays is heavy metal.

To deal with this pollutant, it is important to know the sources of the pollutant, and the type of metals found in that particular area. Furthermore, a collection of street dust and surface soils are believed to give the reflection of environmental conditions (Yu et al., 2012) by assessing the health hazard associated with the availability of particular metals. Moreover, previous studies have revealed that metals from the samples-are a reflection of street dust and soil samples around the urban area which were expected from urban emissions (e.g. traffic emissions, industrial discharges, domestic heating, waste incineration, and many more) (Chen et al., 2005; Christoforidis & Stamatis, 2009; Li et al., 2001), while, the activities resulting from agricultural land is the main source of metals in rural areas (Chen et al., 2016). However, there is limited information regarding the level and sources of pollution in peri-urban areas.

Hence, the present study aims to determine the concentration of selected metals (Zn, Fe, Cd, Pb and Cu) in street dust and surface soil samples and to evaluate the interconnection of metals released in urban areas, which is affecting the availability of metals in peri-urban metropolitan areas of Kuala Lumpur.

MATERIALS AND METHODS

Study Area Descriptions and Samples Collection

Located in Peninsular Malaysia, the Federal Territory of Kuala Lumpur is one of the 14 states of Malaysia (Figure 1). In this metropolitan city, the KLCC skyscraper has been chosen as the centre for location sampling as this structure proudly represents the urbanisation of Kuala Lumpur. Hence, about 15 specific locations were chosen within the KL metropolitan area which was based on a 2, 4, and 8 km radius ring from the city centre, KLCC (Figure 2) including the peri-urban areas within this city. All the 15 locations of the study areas are described in Table 1.

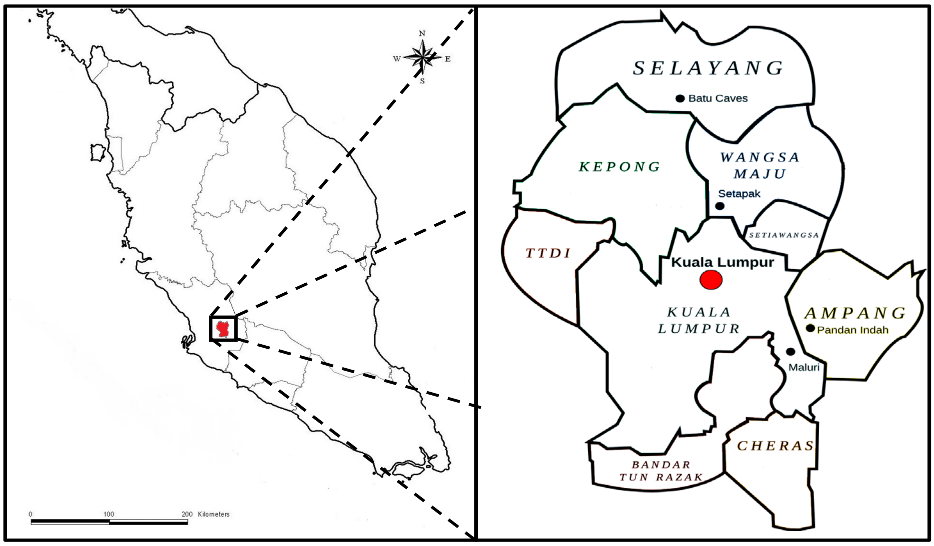

Figure 1. Kuala Lumpur metropolitan area

Figure 2. Radius ring of the 15 locations within the study area in Kuala Lumpur

Table 1
Description of each study site

Site no.	Geographic locations (N,E)	Description area	Traffic load	Land uses
1	3.159162, 101.711182	Kuala Lumpur City Centre (KLCC)	Heavy	Commercial area, Tourism area
2	3.150712, 101.689948	Parlimen Road	Moderate	Commercial area
3	3.137101, 101.703295	Imbi Road	Heavy	Commercial area
4	3.176986, 101.710896	Temerloh Road	Low	Recreational area
5	3.179541, 101.721193	Sultan Yahya Petra Road	Heavy	Commercial area, Residential area, Industrial area
6	3.201768, 101.720317	Genting-Klang Road	Heavy	Commercial area, Residential area
7	3.126773, 101.678706	Bangsar Road	Heavy	Commercial area, Residential area
8	3.153396, 101.757273	Ampang Road	Moderate	Residential area
9	3.19038, 101.680763	Sultan Azlan Shah Road	Moderate	Residential area, Commercial area
10	3.214067, 101.641241	Kepong Road	Heavy	Commercial area, Residential area
11	3.079295 101.665211	Puchong Road	Heavy	Commercial area, Residential area
12	3.068612, 101.743021	Alam Damai Road	Moderate	Commercial area
13	3.243951, 101.720619	Gombak Road	Moderate	Commercial area, Residential area
14	3.066855, 101.706701	Sungai Besi Expressway (SBE)	Heavy	Commercial area
15	3.115239, 101.727888	Cheras Road	Heavy	Commercial area, Residential area

Street dusts were collected through leaf collection from roadside trees (Moreno et al., 2003; Ram et al., 2014; Tanushree et al., 2011) and a scoop was used in order to collect the surface soil at every study site. Surface soils were collected within a 5cm depth from the top of the roadside soil area. Both samples were brought back to the laboratory for subsequent preparation and analysis.

Samples Preparation and Analysis

Collected leaves were divided into two categories, washed and unwashed. Then, both types of samples (leaf and soil) were dried in an oven for approximately 2-3 days at 60˚C temperature, for the purpose of removing trapped moisture. After that, the leaves sample were cut/ ground into small pieces using a mortar and pestle while surface soil samples were ground and sieved prior to acid-digestion experiment. Both samples were digested based on the method described by Abubakar et al. (2018). Filtered digested samples were then analysed using the Atomic Absorption Spectroscopic (AAS) (Shimadzu 6800) for selected elements (Cu, Zn, Cd, Pb and Fe).

Quality Assurance and Quality Control

All the glassware and plastic ware were soaked with 10 ml of nitric acid for decontamination purposes. The reagent blank was prepared for each acid-digestion set. Meanwhile, samples and standard reference material (SRM 1646a) were digested in tri-replicates each. The recovery percentage for each of the selected heavy metals is satisfactory: Cu (103.63%), Zn (97.29%), Cd (90.77%), Pb (90.38%) and Fe (95.46%), respectively.

Data Analysis

Data were analysed using a statistical software, SPSS ver. 22. One-way ANOVA was performed while correlation analysis was conducted to find the possible relationship amongst the variables.

Pollution Indices

Geoaccumulation index (Igeo), Contamination factor (CF) and Pollution Load Index (PLI) were determined. All the formulas and calculations are referring to the previous studies as stated below:

i. Igeo calculation was adapted from the study proposed by Muller (1969). Hence, the background value of the metals (Cu, 48; Zn, 95; Pb, 20; Ni, 68 and Cd, 0.30) was chosen referring to Muller (1969).

ii. The Contamination Factor (CF) is an index which is expressed as the ratio of metal concentration over background value. The calculation of this index was based on the study by Abubakar et al. (2018) and Turekian and Wedepohl (1961).

iii. Meanwhile, the Pollution Load Index (PLI) is an ecological tool to assess the extent of metal pollution or numbers of metal at a particular study area (Abubakar et al., 2018; Cabrera et al., 1999).

RESULTS AND DISCUSSIONS

Concentration of Metals Content in Street Dust

The concentration of analyzed elements was determined from all 15 study sites in Kuala Lumpur metropolitan areas. Assessment of metals in street dust samples showed that metal pollution resulted from human modernization exploits. In general, element content abundance can be ranked as follows: [Fe] > [Zn] > [Cu] > [Pb] > [Cd].

Iron (Fe) is an element found highest in street dust samples. This metal's abundance possibly comes from brake dust, vehicle rust and motorcar exhaust (Garg et al., 2000; Hopke et al., 1980; Weber et al., 2000). In this study, the concentration of Fe was found to be highest at site no. 3 while lowest at site no. 2 (Table 2). As described in Table 1, site no. 3 is located at Imbi Road which is loaded with heavy traffic and commercial development areas. Besides, samples were collected at the road junction and near to LRT and KL monorail lanes. Having a huge number of vehicles on the road and located in a commercial area, are the reasons Fe element was found highest in the street dust samples. Emission of vehicles (brake dust, exhaust) happened to increase the availability of this element and thus contaminating this study area. In addition to that, site no. 2 (Parlimen Road) reflected the lowest concentration of Fe. The samples were collected near to the pavement at the roadside which is a small road, moderately loaded with vehicles. This sampled area is surrounded by green trees and grass planted along the road. Moderate in traffic load, the green surrounding helps to regulate the cycle of air and the concentration of Fe is the lowest among all study sites.

Table 2

Concentration of metals (mean ± S.D) (µg.g-1) found in the street dust samples from all 15 study sites

Sites	Zn	Cu	Pb	Cd	Fe
1	24.68 ± 1.23	6.85 ± 0.34	1.56 ± 0.08	0.20 ± 0.01	144 ± 7.20
2	4.59 ± 0.23	11.34 ± 0.57	5.76 ± 0.29	0.87 ± 0.04	2 ± 0.10
3	4.31 ± 0.22	4.30 ± 0.22	3.84 ± 0.19	0.66 ± 0.03	921 ± 46.05
4	14.37 ± 0.72	7.54 ± 0.38	1.8 ± 0.09	1.67 ± 0.08	84 ± 4.20
5	43.76 ± 2.19	7.87 ± 0.39	1.02 ± 0.05	0.26 ± 0.01	12 ± 0.60
6	113.48 ± 5.67	2.72 ± 0.14	8.82 ± 0.44	1.34 ± 0.07	123 ± 6.15
7	80.57 ± 4.03	6.39 ± 0.32	2.28 ± 0.11	1.00 ± 0.05	389 ± 19.45
8	1.43 ± 0.07	2.14 ± 0.11	0.9 ± 0.05	1.27 ± 0.06	276 ± 13.80
9	17.68 ± 0.88	4.30 ± 0.21	7.74 ± 0.39	1.15 ± 0.06	200 ± 10.00
10	1.44 ± 0.07	3.44 ± 0.17	2.58 ± 0.13	1.53 ± 0.08	262 ± 13.10
11	96.64 ± 4.83	11.60 ± 0.58	0.18 ± 0.01	1.81 ± 0.09	59 ± 2.95
12	16.49 ± 0.82	9.85 ± 0.49	1.2 ± 0.06	0.21 ± 0.01	199 ± 9.95
13	28.28 ± 1.41	1.07 ± 0.05	0.42 ± 0.02	0.59 ± 0.03	156 ± 7.80
14	21.28 ± 1.06	18.10 ± 0.91	3.66 ± 0.18	0.07 ± 0.00	260 ± 13.00
15	22.77 ± 1.14	9.08 ± 0.45	5.34 ± 0.27	1.13 ± 0.06	75 ± 3.75

Zinc (Zn) is one of the most significant pollutants found in street dust studies. Availability of this pollutant is believed to be caused by tire treads. In the vulcanizing process, zinc oxide (ZnO) acts as an activator in vehicle tire production (Adachi & Tainosho, 2004). Hence, in this study, Zn was found to be the second highest element with a high concentration at site no. 6 and lowest at site no. 8. Site no. 6 represents Genting-Klang Road which was described as a heavy traffic load area (Table 1). Increasing the number of traffic on the road and human activities in the area have increased the availability of Zn found in street dust which contributes as one of the sources of heavy metal pollution (Zheng et al., 2010).

The metal content of Cu in street dust was well assessed. This element possibly resulted from the corrosion of metallic parts of vehicles (e.g engine wear, thrust bearing, brushing and bearing metals) (Al-Khashman, 2004, 2007; Al-Khashman & Shawabkeh, 2006). The level of copper in street dust samples was high at study site no. 14. This site represents the Sungai Besi Expressway (SBE) Road which is one of the highways in Klang Valley. Traffic load is high in this area and believed to have cause the high metal loading, especially copper. Copper was found to be the lowest among all 15 sites especially for site no. 13 (Gombak Road). This area was low in copper content which might be due to the traffic load and the effects of human activities nearby.

Generally, lead (Pb) and cadmium (Cd) are low in concentration for all sites. Pb is said to be the element most concerned in heavy metal pollution (Christoforidis & Stamatis, 2009). Detection of this metal is directly associated with the emission of the exhaust vehicle and industrial emissions released. Pb metal is believed to be released from the combustion of gasoline that contains tetraethyl lead (anti-knock agent) (Al-Khashman, 2007; Janaydeh et al., 2018; Tüzen, 2003). Meanwhile, the availability of Cd metals polluted in the environment comes from combustion products (motor vehicles, carburettors) (Charlesworth et al., 2003; Shinggu et al., 2007). From the data collection, both elements have reflected the low mean concentration of elements polluting the KL metropolitan area. Based on Table 2, site no. 11 (Puchong Road) shows the highest Cd metal while low in Pb content. Site no. 6 was highest in Pb content while site no. 14 showed low levels of Cd.

Concentration of Metals Content in Surface Soil

The surface of the soil in an urban and peri-urban area has been significantly disturbed by the metal pollution through some anthropogenic emissions. All the atmospheric pollutant definitely ends up on the soil surface eventually swept by the water causing water pollution (e.g groundwater, freshwater, ocean). Mean concentration of 5 selected elements were well determined. Besides that, CRM recoveries for metals in street dust samples varied from 87-102%. The decreasing trend of assessment elements is as follows, [Fe] > [Zn] > [Pb] > [Cu] > [Cd].

Fe content showed the highest level in the soil samples at all study sites as this element was naturally abundant and can be found in high value in uncontaminated areas. However, this study found that this high concentration of Fe could be caused by human activities such as emissions and combustions. It was highest at site no. 1 (KLCC), but the lowest was at site no. 10 (Kepong Road). It is no surprise that Fe was high in topsoil at the KLCC site as seen and been predicted during its early constructions; while Kepong Road holds the lowest record for Fe.

Zn element was the highest at site no. 5 (Sultan Yahya Petra Road), while being the lowest at site no. 14 (SBE). It is due to locality of site no. 5 which is surrounded by residential areas, commercial areas and also industrial activities which is compounded with the active load of traffic on the road. This varies from the SBE site that has predicted sources of outcome from traffic emissions.

Lead metal loading in soil samples was shown highest in samples from site no. 8 (Ampang Road), lowest in the sample from site no. 13 (Gombak Road). Vehicle emission from the combustion of leaded gasoline has given the impact to the level of lead in the soil surface of the study site. Even though the traffic load is moderate in this area, this traffic lane becomes a busy road during peak hours compared to site no. 13 and this contributes to the accumulation of combustion products released to the atmosphere, which contains lead.

Table 3

Concentration of metals (mean ± S.D) (µg g-1) found in the surface soil samples from all 15 study sites

Sites	Zn	Cu	Pb	Cd	Fe*
1	257.00 ± 12.85	26.75 ± 1.34	64.14 ± 3.21	3.94 ± 0.20	15.89± 0.79
2	281.53 ± 14.07	23.35 ± 1.17	104.22 ± 5.21	4.01 ± 0.20	9.07± 0.45
3	303.48 ± 15.17	18.70 ± 0.94	74.04 ± 3.70	2.87 ± 0.14	12.72± 0.64
4	264.76 ± 13.23	29.75 ± 1.49	166.62 ± 8.33	3.94 ± 0.20	8.21± 0.41
5	81.17 ± 4.05	8.14 ± 0.41	41.34 ± 2.07	3.80 ± 0.19	8.17± 0.41
6	298.94 ± 14.94	31.00 ± 1.55	49.74 ± 2.49	3.99 ± 0.20	12.69± 0.63
7	254.32 ± 12.71	36.45 ± 1.82	123.84 ± 6.19	2.80 ± 0.14	11.92± 0.60
8	366.80 ± 18.34	67.10 ± 3.36	312.00 ± 15.60	4.47 ± 0.22	10.25± 0.51
9	299.48 ± 14.97	94.65 ± 4.73	130.50 ± 6.53	3.74 ± 0.19	6.78± 0.34
10	200.76 ± 10.03	17.37 ± 0.87	68.76 ± 3.44	3.87 ± 0.19	3.88± 0.19
11	143.69 ± 7.18	58.86 ± 2.94	195.48 ± 9.77	3.00 ± 0.15	13.42± 0.67
12	262.38 ± 13.11	11.03 ± 0.55	110.34 ± 5.52	4.41 ± 0.22	10.22± 0.51
13	237.35 ± 11.86	19.02± 0.95	37.02 ± 1.85	3.52 ± 0.18	8.07± 0.40
14	452.88 ± 22.64	91.60 ± 4.58	111.24 ± 5.56	3.40 ± 0.17	4.95± 0.25
15	282.96 ± 14.14	51.55 ± 2.58	113.94 ± 5.70	3.87 ± 0.19	5.25± 0.26

Note: Concentration of Fe is in mg.g-1

In soil samples, out of 15 study sites, copper showed the highest concentration at site no. 9, while lowest at site no. 5 (Table 3). Site no. 9 represents Sultan Azlan Shah Road. It is described as an area with moderate traffic load, surrounded by residential and commercial areas. Ongoing construction in this area has played a vital role in contributing to the input of copper to the soil surroundings even though the main sources of copper are believed to come from vehicle parts. Cd had the least concentration of an element found from all 15 sites. Data showed that Cd element was similar for all study sites (Table 3).

Correlation Analysis amongst Heavy Metal Elements in Street Dusts and Surface Soils

The relationship between metals in street dust and soil surface samples were investigated (Table 4). In street dust samples, mostly, all the metal elements have shown a negative relationship and a small positive relationship value amongst each other. Meanwhile, in surface soil samples, there is a moderate positive correlation between elements Cu and Zn (0.652) and Pb and Cu (0.494) while the other elements showed a slightly positive relationship. This shows that the distribution of Cu pollutant in soil samples is related to the presence of Pb and Zn, as the main sources of these three elements are mainly sources from the vehicle usages on the road.

Table 4
Interelement correlations for street dust and surface soil samples from the whole study areas

Elements	Zn	Cu	Pb	Cd	Fe
Street dust					
Zn	1.000				
Cu	-0.137	1.000			
Pb	-0.170	-0.194	1.000		
Cd	0.242	-0.005	0.041	1.000	
Fe	-0.008	-0.233	0.129	0.052	1.000
Surface Soil					
Zn	1.000				
Cu	0.652	1.000			
Pb	0.199	0.494	1.000		
Cd	-0.028	-0.133	0.168	1.000	
Fe	-0.158	-0.224	0.061	-0.132	1.000

Note: Significant level, p-value (p=0.05)

Assessment of Metals Contamination in Samples

Assessment of element contamination in street dust samples was evaluated (Table 5). From the Igeo assessment, all the 15 study sites with the presence of these elements (Zn, Cu, Pb and Fe) were recognized as unpolluted areas. Meanwhile, Cd with the lowest value of element concentration has recorded moderate to strongly polluted areas; whereas site no. 11 was reported to be strongly polluted, site nos. 4, 6, 7, 8, 9, 10 moderately polluted and while areas categorized as unpolluted to moderately polluted where found at study sites 2, 3 and 13. By referring to the contamination factor (CF), street dusts in KL metropolitan area had low contamination with respect to Cu, Pb, Fe and Zn (except at site no. 6 and 11); moderate contamination with Cd at site 2, 3 and 13; considerable contamination at site 4, 6, 7, 8, 9, 10 and 15; while very high contamination of Cd at site no. 11. Another assessment was evaluated using the pollution load index (PLI). Overall, all the areas of Kuala Lumpur were categorized as areas with no metal pollution.

However, in surface soil samples, it does reflect a different evaluation (Table 6). For Igeo calculation, all 15 sites were unpolluted with Fe, Cu (except site no. 9, 14) and Zn at the site no. 5. While Cd element was strongly polluted at study site no. 1, 2, 4, 5, 6, 8, 9, 10, 12 and 15. For the next assessment, CF generally showed that there were no contamination of Fe at all study sites, and no contamination of Cu at most study sites. All sites were very highly contaminated with Cd, Pb for selected sites (4, 7, 8, 9, 11). PLI concluded that all study sites were categorized as polluted areas with the presence of heavy metals in surface soils.

Table 5

Summary of Igeo, CF and PLI for street dust samples in 15 sampling sites

			I_{geo}					CF			PLI
Sites	Zn	Cu	Pb	Cd	Fe	Zn	Cu	Pb	Cd	Fe	
1	-2.53	-3.301	-4.265	-1.184	-8.94	0.2598	0.152	0.078	0.660	0.0031	0.091
2	-4.96	-2.574	-2.381	0.945	-15.11	0.0483	0.252	0.288	2.888	0.0000	0.053
3	-5.05	-3.972	-2.966	0.553	-6.26	0.0454	0.096	0.192	2.200	0.0195	0.129
4	-3.31	-3.162	-4.059	1.889	-9.72	0.1513	0.168	0.09	5.555	0.0018	0.118
5	-1.70	-3.101	-4.878	-0.769	-12.53	0.4606	0.175	0.051	0.880	0.0003	0.062
6	-0.33	-4.636	-1.766	1.570	-9.17	1.1945	0.060	0.441	4.455	0.0026	0.206
7	-0.82	-3.401	-3.718	1.149	-7.51	0.8482	0.142	0.114	3.328	0.0082	0.207
8	-6.64	-4.979	-5.059	1.497	-8.00	0.0151	0.048	0.045	4.235	0.0058	0.060
9	-3.01	-3.974	-1.955	1.350	-8.47	0.1862	0.095	0.387	3.823	0.0042	0.162
10	-6.63	-4.297	-3.540	1.770	-8.08	0.0152	0.076	0.129	5.115	0.0056	0.084
11	-0.56	-2.541	-7.381	2.005	-10.23	1.0173	0.258	0.009	6.023	0.0013	0.112
12	-3.11	-2.777	-4.644	-1.127	-8.47	0.1736	0.219	0.06	0.687	0.0042	0.092
13	-2.33	-5.979	-6.158	0.401	-8.83	0.2977	0.024	0.021	1.980	0.0033	0.063
14	-2.74	-1.899	-3.035	-2.599	-8.09	0.2241	0.402	0.183	0.248	0.0055	0.118
15	-2.65	-2.894	-2.490	1.328	-9.88	0.2397	0.202	0.267	3.767	0.0016	0.151

Table 6

Summary of Igeo, CF and PLI for surface soil samples in 15 sampling site

	I_{geo}					CF					PLI
Sites	Zn	Cu	Pb	Cd	Fe	Zn	Cu	Pb	Cd	Fe	
1	0.85	-1.34	1.096	3.128	-2.156	2.705	0.594	3.207	13.117	0.337	4.592
2	0.98	-1.53	1.797	3.155	-2.965	2.964	0.519	5.211	13.363	0.192	4.596
3	1.09	-1.85	1.303	2.674	-2.477	3.195	0.416	3.702	9.570	0.269	4.472
4	0.89	-1.18	2.474	3.128	-3.108	2.787	0.661	8.331	13.117	0.174	4.729
5	-0.81	-3.05	0.463	3.079	-3.115	0.854	0.181	2.067	12.677	0.173	2.674
6	1.07	-1.12	0.729	3.149	-2.480	3.147	0.689	2.487	13.310	0.269	5.340
7	0.84	-0.89	2.045	2.635	-2.570	2.677	0.810	6.192	9.320	0.253	4.721
8	1.36	-0.01	3.379	3.313	-2.788	3.861	1.491	15.600	14.903	0.217	5.890
9	1.07	0.49	2.121	3.054	-3.384	3.152	2.103	6.525	12.457	0.144	6.595
10	0.49	-1.96	1.197	3.104	-4.190	2.113	0.386	3.438	12.897	0.082	4.152
11	0.01	-0.20	2.704	2.738	-2.399	1.513	1.308	9.774	10.010	0.284	3.494
12	0.88	-2.61	1.879	3.291	-2.792	2.762	0.245	5.517	14.685	0.217	3.896
13	0.74	-1.83	0.303	2.968	-3.133	2.498	0.423	1.851	11.733	0.171	3.690
14	1.67	0.44	1.891	2.917	-3.838	4.767	2.036	5.562	11.330	0.105	6.764
15	0.99	-0.39	1.925	3.104	-3.754	2.979	1.146	5.697	12.897	0.111	5.645

CONCLUSIONS

This study revealed that soil samples from all study sites were polluted with metals while, street dust did not indicate any signs of metal pollution in the surrounding atmosphere. Thus, at this moment, the distribution of metals through emissions from human activities in the Kuala Lumpur metropolitan area is not influenced by the urban areas around KLCC; based on the metal concentration recorded in street dust samples from all locations. However, in all the locations within the KL metropolitan area showing moderate to heavy traffic load and moderate to large human capacity, the presence of metal pollutants in street dust and soil samples varied depending on the surroundings. As a suggestion, the continuous assessment of metal concentration in street dust samples in the KL metropolitan area is encouraged to ensure that the data recorded is up-to-date. Meanwhile, an immediate response would be to carry out surface soil cleaning as to remediate the metal contaminated soils.

ACKNOWLEDGEMENT

This study was supported by Putra Grant - Putra Group Initiative (IPB) (Reference no.: GP-IPB/2014/9433801) funded by Universiti Putra Malaysia.

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