

Determination of Elements in Indoor Dust at Residential Buildings Nearby a Quarry Site

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Abstract

Fifteen residence houses at different distances from a nearby limestone quarry were chosen to determine the concentration of elements in an indoor dust study. The samples were collected using a brush and a plastic dust pan. The elements concentrations were determined by wet digestion method with analysis using inductively coupled plasma–optical emission spectrometer (ICP-OES). The results show that the mean elements concentrations in residences houses were in the range 7.96 - 21.19, 0.21 - 0.83, 1.29 - 4.57, 0.14 - 0.26, 0.01 - 0.04 and 0.01 - 0.03 mgkg⁻¹ for Ca, Mg, Fe, Ni, Pb and Zn respectively. The elements concentration in the investigated residential buildings areas were followed the order Ca > Fe > Mg > Zn > Ni > Pb. The evaluation of the elements contamination status of the indoor dust was carried out by using the geoaccumulation index (Igeo). Geoaccumulation index (Igeo) reveal that indoor dust of residential buildings was strongly polluted (Igeo > 5) with Ca, Mg and Fe.

Keywords: Elements, Indoor Dust, Geoaccumulation index, Residential, Quarry

1. Introduction

Rapid economic progress and the increased population growth, had made many residential development and township to expand and grow. This expansion had caused many residential areas be built near the quarry site [1]. Residents living nearby have no choice but to face environmental issues, such as noise and air pollution resulting from the nearby quarry activities. Quarrying is the process of obtaining quarry resources such as rocks which can be found on or below the land surface [2]. The quarrying process consists of stockpiling, loading, transportation and processing of minerals material of the quarry [3]. All of these processes will contribute to the emission of quarry mining dust.

Dust consist of solid matter or particulate in the form of fine powder (less 100 µm), lying on the ground or on the surface of objects or blown about by natural forces or mechanical forces [4]. Indoor dust is a repository for environmental pollutants such as elements that may accumulate indoors and is an important pathway of exposure to metal for human. Elements exist in the environment naturally as trace elements in rocks and soils, however they also are released to the environment as a result of human activities. The sources of elements of indoor dust were came from outdoor and indoor sources. Some elements in indoor dust are toxic and it can affect residents health especially children and old people.

Outdoor surrounding and residents' activities can give contribution to the indoor dust at the same time effects elements concentration. The outdoor activities such as quarrying, industrial and construction activities produced dust and have high possible to penetrate indoor environment.

This study involved fifteen residential buildings. The sample of indoor dust were collected about 0.2 g in each house and tested in the laboratory. Six elements consist of Ca, Mg, Fe, Ni, Pb and Zn were identifying in the ICP-OES analysis. This study was aimed

to identify and measure the concentration of elements in indoor dust and to calculate the Geo-accumulation Index (Igeo) to evaluation the contamination status of elements in indoor dust at residential buildings nearby the quarry sites.

2. Methodology

2.1. Site sampling

This study was conducted at Kuala Langat, Selangor. The vicinity around Kuala Langat is a developing area consists of residential area, quarry mining area, education centre and commercial building. Limestone quarry was located nearby effected residents to quarrying activities. Fifteen houses located at Bandar Saujana Putra were randomly selected. Figure 1 show the location of Bandar Saujana Putra, Kuala Langat. In the white circle show the quarrying mining area.



Fig 1: Location Residential and Quarry Mining Area.

2.2 Sample Collection

Indoor dust was collected from fifteen houses at different distance from the nearby quarry sites. Using a clean plastic brush and pan,

dust was collected inside the residential building by sweeping the living area floor were most accessible to the occupants. The indoor dust was then transferred into a resealable plastic bag, brought to the laboratory and placed in a desiccator for 24 h, sieved through a 0.5 mm stainless steel sieve to remove extraneous matter, and finally oven dried at 105 °C for 24 h. Table 1 show the units of houses and units of dust samples.

Table 1: The selected houses to collect sample

Distance (m)	Unit of houses	Unit of samples
200	3	9
400	3	9
600	3	9
800	3	9
1000	3	9
Total	15	45

2.3 Analysis of sample

The 0.2 g of dust was dissolved in a 9 mL mixture of 65 % nitric acid and 3 mL mixture of 37 % hydrochloric acid on a hot plate for an hour. The digestion extract was let to cool, and then filtered through a small filter funnel. The filtrates were transferred carefully to a 25 cm³ volumetric flask and were dilute up to the graduation mark with distilled water and was analysed for elements content by using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) to determine the concentration of Ca, Mg, Fe, Ni, Pb and Zn. The blank experiment was carried out by repeating the procedure for sample preparation without the sample. The composition of the blank solution was compared with the sample solution to identify the elemental composition of elements in the dusts.

2.4 Geoaccumulation Index

Geo-accumulation Index (Igeo) formula was using to determine the contamination status of elements in indoor dust at residential buildings nearby the quarry sites. The formula to calculate Igeo value:

$$Geochemical\ index = \log_2 [Cn / 1.5Bn]$$

Cn= Concentration of elements

Bn= Background value of elements

Cn is the measured concentration of the element in indoor dust, Bn is the geochemical background value and the constant 1.5 were to analyse natural fluctuations in the content of a given substance in the environment and to detect very small anthropogenic influence. Table 2 show the Geo-accumulation Index Classification.

Table 2: The Geo-accumulation Index Classification

Igeo	Igeo Class	Pollution Intensity
>5	6	Very highly polluted
4 < Igeo < 5	5	Highly polluted to very highly polluted
3 < Igeo < 4	4	Highly polluted
2 < Igeo < 3	3	Moderately polluted to highly polluted
1 < Igeo < 2	2	Moderately polluted
0 < Igeo < 1	1	Unpolluted to moderately polluted
< 0	0	Unpolluted

3 Findings

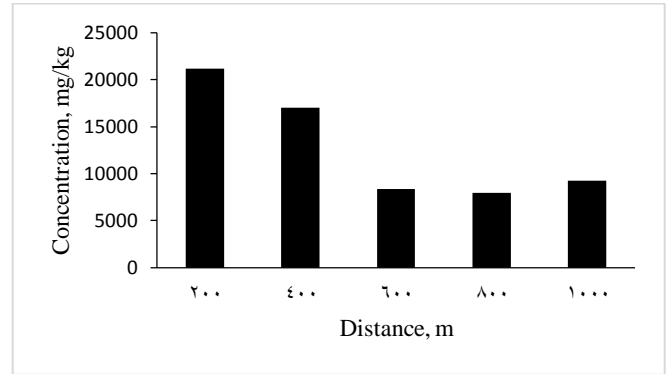
3.1 Concentration of Elements in Indoor Dust

The concentrations of six elements in the indoor dust sample are summarized in Table 3. The results show that the elements concentrations in residences houses at different distance were in the range 7961.70 - 21189.58, 214.91 – 830.69, 1288.57 – 4569.64, 140.2 – 260.03, 8.76 – 51.83 and 9.91– 27.31 mg/kg for Ca, Mg,

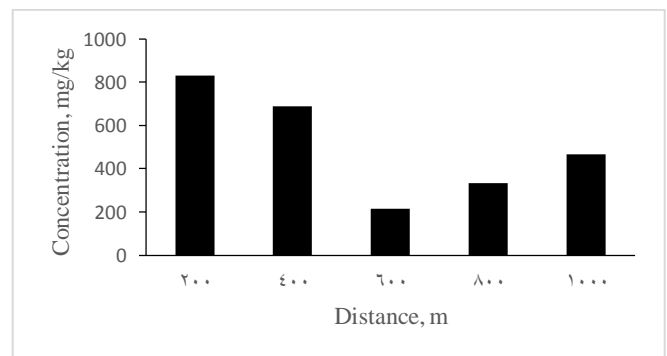
Fe, Ni, Pb and Zn respectively. The elements mean concentration in the investigated residential buildings areas were followed the order Ca > Fe > Mg > Zn > Pb > Ni.

Table 3: The mean of elements concentration in Indoor Dust (mg/kg)

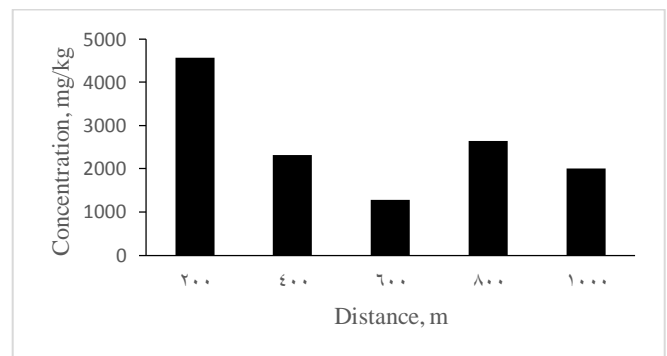
Distance (m)	Ca	Mg	Fe	Zn	Pb	Ni
200	21189.58	830.69	4569.64	260.03	38.24	27.31
400	17036.12	689.45	2312.87	165.42	51.83	9.91
600	8345.52	214.91	1288.57	185.39	8.76	11.24
800	7961.70	332.39	2639.22	162.71	24.71	13.84
1000	9233.39	465.38	2011.54	140.2	16.47	11.91



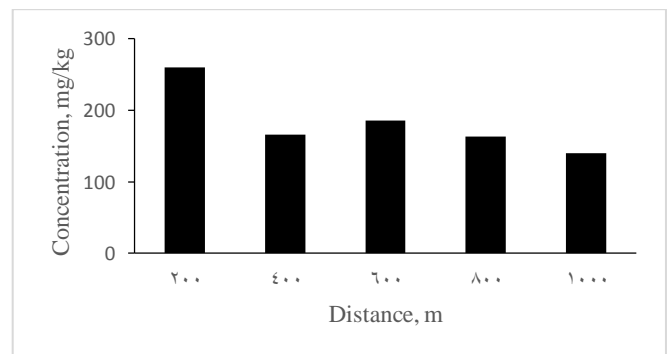
(a) Ca



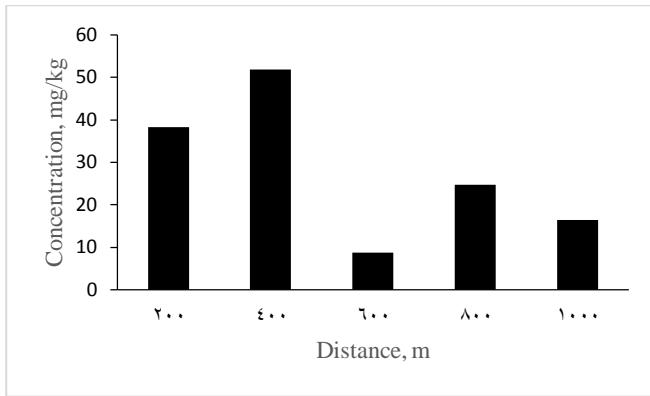
(b) Mg



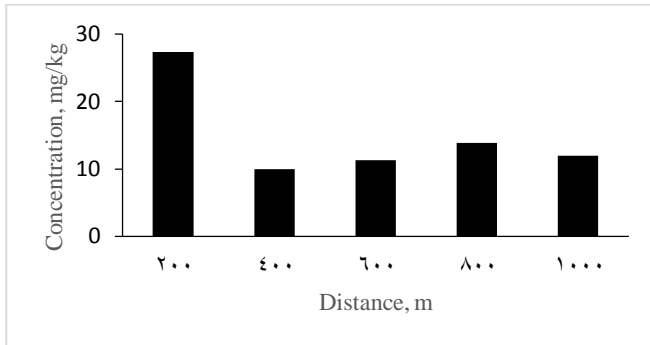
(c) Fe



(d) Zn



(e) Pb



(f) Ni

Fig 2: (a)-(f) Summary of concentration of elements in indoor dust of residential building at different distances.

Table 3 show the mean values of selected elements in indoor dust at residential buildings at different distance nearby the quarry sites. All elements except Pb show higher mean values concentration at the residential building which close (200 m) to nearby quarry sites. **Fig 2** show bar chart mean values concentration for each elements of indoor dust in residential building at different distance from nearby quarry sites. The bar chart of Ca, Mg and Fe concentration shown almost similar pattern towards the distance. Higher concentration were measured at the building which closed to the quarry sites (200 m and 400 m) compare to others houses.

The higher mean concentration values of elements Ca and Mg may be influenced by the nearby quarry activities. This quarry dust may enter the indoor environment through openings and cracks. Throughout the literature, the source of Ca and Mg in the ambient air and indoor dust was attribute to the quarry activities [5; 6]. Quarry activities such as blasting, stockpiling, loading, transportation and processing of minerals material may produce dust to the surrounding environment and nearby neighbourhood [7, 8].

The highest concentration of Fe not only due to nearby quarry activities but also from the street dust that can be associated with the movement of vehicle. It is supported by Darus *et al* [9], he stated that the street dust and soil have a vital role within the concentration of Fe build up in indoor dust within the residential building. This can be attributed to the soil in the investigated area being rich in Fe.

Other elements such as Zn, Pb and Ni were related to street dust and vehicle emission. The possible source of these elements in dust were believed to be from vehicle components such as brake wear, tire wear, clutch wear, road surface wear, and corrosion of other vehicle components respectively in air of street dust [10]. The movement of resident and quarry vehicle in and out daily may contributed to Zn, Pb, Ni elements in indoor dust.

Although element in indoor dust at residential building could be derived from indoor and outdoor sources, the result of this study indicated that major influence was from outdoor sources which can be suggested from quarry activities and street dust. The main possible routes of these elements entering the residential building were through the open windows for cooling and ventilation.

3.2 Geo-accumulation Index (Igeo)

Geo-accumulation index can be used to determine whether the dust is polluted or unpolluted with the elements contain in indoor dust. Table 4 show the mean Geo-accumulation index (Igeo) of elements in indoor dust at residential houses was presented

Table 4: The mean Geo-accumulation index (Igeo)

Distance (m)	Ca	Mg	Fe	Ni	Pb	Zn
200 m	13.20	10.11	9.57	-1.46	-0.46	0.95
400 m	12.89	9.84	8.59	-2.92	-0.02	0.29
600 m	11.86	8.16	7.75	-2.74	-2.58	1.37
800 m	11.79	8.79	8.78	-2.44	-1.09	1.21
1000 m	12.00	9.28	8.39	0.30	-1.37	0.05

Table 4 shows Igeo values for Ca, Mg, Fe, Ni, Pb and Ni of indoor dust. Three elements Ca, Mg, Fe were classified into very strongly contaminated in indoor dust may due to contributions of quarry limestone since the residential houses is adjacent with the limestone quarry sites. Similar finding also being reported by Bluvshstein *et al* [3], they found that the enrichment of Ca and Mg was anticipated because the contributions of limestone quarry at area nearby.

4. Conclusion

The elements analysis of indoor dust sample in selected residential building in this study help to explain the influence of nearby quarry activities to the concentration of elements of indoor dust. The results show the concentration of indoor dust at fifteen houses at difference distance were in range of 7961.70 - 21189.58, 214.91 - 830.69, 1288.57 - 4569.64, 140.2 - 260.03, 8.76 - 51.83 and 9.91- 27.31 mg/kg for Ca, Mg, Fe, Ni, Pb and Zn respectively. The result of elements indoor dust concentration in investigated areas were in order Ca > Fe > Mg > Zn > Pb > Ni. The elements of indoor dust concentrations in all the investigated areas indicated the major sources of indoor dust pollutants are from outdoor anthropogenic activities mainly through quarry nearby activities and vehicular movements (street dust). The results of Geo-accumulation index also reveal that indoor dust of residential buildings was strongly polluted (Igeo > 5) with Ca, Mg and Fe.

A good housekeeping practice such as frequent wet mopping and vacuuming and good maintenance of ventilation system by closing those windows that are facing quarry sites and main roads should be taken into consideration in order to reduce penetration of outdoor dust into indoor environment.

Recommendations by relevant authority to measure and monitor the ambient air quality that may be influenced by quarry activities at nearby sites. Further research should also be undertaken with the objectives of getting information of outdoor and indoor airborne particle and their relationship with indoor dust. This information would serve as catalyst for more better understanding on the impact of quarry activities to the nearby residential areas.

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References

- [1] Wan Zulasmin Wan Ibrahim 2009 Towards Sustainable Quarry Industry in Malaysia. Malaysia, Jurutera.pp 42-46

- [2] Banez J., Ajaon, S. M., Bilolo, J. R., Dailyn, J. M. (2010). Quarrying and Its Environmental Effects.
- [3] Bluvshstein, N., Mahrer, Y., Sandler, A., Rytwo G. (2011). Evaluating the Impact Of A Limestone Quarry On Suspended And Accumulated Dust. *Atmospheric Environment* 45(9): 1732-1739.
- [4] Adekola, F.A. and Dosumu, O.O. (2001). Heavy metal determination in household dust from Ilorin City, Nigeria. *J. Nigeria Society for Experimental Biology*. 3 (1) : 217 – 221.
- [5] Bluvshstein, N., Mahrer, Y., Sandler, A., Rytwo, G. (2011). Evaluating the impact of a limestone quarry on suspended and accumulated dust. *Atmospheric Environment* 45 (9): 1732-1739.
- [6] Peng, X., Shi, G.L., Jia, Z., Liu, Y., Shi, X.R., Xu, J., Feng, Y.C. 2016. Influence of quarry mining dust on PM_{2.5} in a city adjacent to a limestone quarry: Seasonal characteristics and source contributions. *Science of The Total Environment*. 550: 940-949
- [7] Nartey, V. K., Nanor, J. N., Klake, R. K. (2012). Effects of Quarry Activities on some Selected Communities in the Lower Manya Krobo District of the Eastern Region of Ghana. *Atmospheric and Climate Sciences* 02(03): 362-372.
- [8] Olusegun, O., Adeniyi, & Adeola, G 2009 Impact of Granite Quarrying on the Health of Workers and Nearby Residents in Abeokuta Ogun State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 2(1), 1–11.
- [9] Darus, F. M., Nasir, R. A., Sumari, S. M., Ismail, Z. S., Omar, N. A. (2012). Heavy Metals Composition of Indoor Dust in Nursery Schools Building. *Procedia - Social and Behavioral Sciences* 38: 169-175.
- [10] Glišović, J., Pešić, R., Lukić, J., Miloradović, D. 2016. Airborne Wear Particles from Automotive Brake Systems: Environmental and Health Issues. *International conference on Quality of Life*. 289 – 295.