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Primarily Elemental Composition of Dust in Riyadh City

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Abstract. The aerosol particles in the ambient air are considered as the main causes of asthma and allergic diseases. The elemental composition of indoor and outdoor dust in Riyadh will be a good indicator for air quality and some health effects in this city. The analysis of the dust samples was performed using x-ray fluorescence (XRF) technique. The results show a similar composition of the indoor and outdoor dust which most of it has mineral origin. It was observed that the concentration of Iron, Fe, increases in all indoor samples in detriment of a decrease in the concentration of calcium, Ca, compared to outdoor samples. For the heavy elements, only small traces of lead were detected.

Introduction

Most epidemiological studies have shown that the composition of home dust is very important for the observed health effects. The chemical composition and size of aerosol particles in the ambient air were considered as the main causes of asthma and allergic diseases [1, 2]. In general, the indoor dust is a mixture of several elements of different origins [3], such as minerals, residue of combustion and microscopic organisms. The knowledge of chemical content of indoor and outdoor provides a link to understand relationships between particles matter of the dust, air quality and heath effects.

In the last three decades, the growth and the building construction in Riyadh city were very fast. The population became more than three millions and the area of the city crossed the 1600 km^2. Therefore, it becomes interesting to analyze the effect of this development in the air quantity. For this purpose, some indoor and outdoor dust samples were collected and analyzed.

A primarily elemental analysis of the dust collected from different regions of the city was required to design a global environmental study plan. Therefore, the aim of this paper is to present these primarily results of the most elements present indoor and outdoor. The study of PM_{10} and may be $PM_{2.5}$ (particles less than 10 and 2.5 µm in diameter) concentration in the ambient air will be conducted later on.

The elemental composition of dust samples were performed using the x-ray fluorescence technique (XRF). This technique is known as the best non-destructive and multi-elements analysis method used with success in many activities including environmental studies. This method is based on minimal effort in sample perpetration, short measurement times and high sensitivity. It is able to determine wide range of concentration; from few ppm up to 100% of all elements present in the analyzed sample [4, 5].

Material and Method

The indoor dust samples were simply collected from the air conditioner filters of normal residential houses at different regions of Riyadh city. The collected dust samples can be from any room except the kitchen. The outdoor dust samples were collected from the outside of the houses and wiped from wall or floor.

The XRF detection system used in this study is composed of laser x-ray tube with its controller, silicon photodiode Si-PIN detector with the power supply unit and amplifier, multichannel analyzer (MCA) and a computer. The maximum voltage and current of the laser x-ray tube are 35kv and 100 µAmp with solid silver target and an end window. The Si-PIN detector and its preamplifier are thermoelectrically cooled for better detection performance [6, 7]. The detector has very thin beryllium window (25 µm) to enable soft x-ray detection. The resolution obtained with 12 µs shaping time constant is about 220 ev at 5.9 kev peak of ^{55}Fe which can be more or less with higher shaping time constant. The pocket MCA used in this study is a portable one driven by its software through the computer. This MCA has very small volume but it is very preferment which holds 16k data channels and can store up to 128 spectra. The computer was used to drive the MCA and perform qualitative and quantitative analysis.

The two software's Pma and XRF.FP were used to perform qualitative and quantitative analysis respectively [8]. The first one is used to drive the MCA, most input/output function, and to identify elements after energy calibration. The second one (FP) is designed for quantitative analysis where a complete XRF analysis is possible, with or without standards, using an internal data base of fundamental parameters (FP) [9].

The energy calibration was determined using the x-ray lines of one set of standard pure elements covering the energy range from 1 to 30 Kev. The fitting of the experimental points was able to calculate the calibration factor and the zero offset of the diction system given in the form of the following linear expression:

$$E\,(Kev) = -0.0596 \quad + 0.0150 * X\ (Channel)$$

The quantitative calibration coefficients determined by the XRF.FP software utilizes the fundamental parameters calibration method. This method uses the calculated primary spectra parameters rather than the measured data. To perform this calculation the database of the condition setting (geometry, x-ray tube futures and detector type and size... etc) is required. Also, it is necessary to provide one or two experimental data from a pure or less concentrated standard to validate the fundamental parameters calculation. In our case, the experimental data was given by the measurement of almost pure standard elements. This quantitative calibration was used to determine the elemental concentration of all analyzed dust samples.

Results and Discussion

The results of the indoor and outdoor dust samples analysis are presented in Table 1 and Table 2, respectively. Note that, the uncertainties of the concentrations in those tables were varying from 2 to 3% at high concentration and from 3 to 5% at low concentration. It can be observed that both elements and their concentrations are similar in the two tables except for Fe and Ca. The concentration of Fe increases in all indoor samples in detriment of a decrease in the concentration of Ca in outdoor sample. The Fe enrichment can be explained by the presence of furniture such as carpet, moquet and the building material. The traces of lead Pb observed inside and outside were suspected from the combustion of gasoline in the car’s engine.

Table 1. Elemental composition of indoor dust in Riyadh City

	Concentration %				
Elements	North	East	South	West	Center
Ca	46.65	47.18	42.58	41.06	48.22
Ti	1.18	1.48	2.18	1.62	1.41
Fe	41.09	35.58	37.97	45.53	36.03
Zn	6.39	8.09	8.86	5.64.	5.98
Sr	3.03	3.14	4.09	4.04	3.21
Pb	3.67	4.53	4.31	2.11	5.14

Table 2. Elemental composition of outdoor dust in Riyadh City

	Concentration %					
Elements	**North**	**East**	**South**	**West**	**Center**	**Desert**
Ca	57.21	58.32	61.37	60.68	54.07	66.41
Ti	1.21	1.17	0.92	0.87	0.97	1.47
Fe	32.61	29.45	30.22	32.25	31.85	25.61
Zn	3.13	4.41	2.48	1.15	4.46	0.74
Sr	3.58	4.34	3.08	3.51	5.19	5.77
Pb	2.27	2.31	1.93	1.55	3.47	0

Figure 1 represents the superposition of two spectra of indoor and outdoor dust samples of the center region in Riyadh City. Fig. 2 shows the spectrum of the dust sample collected from outside of the city (desert).

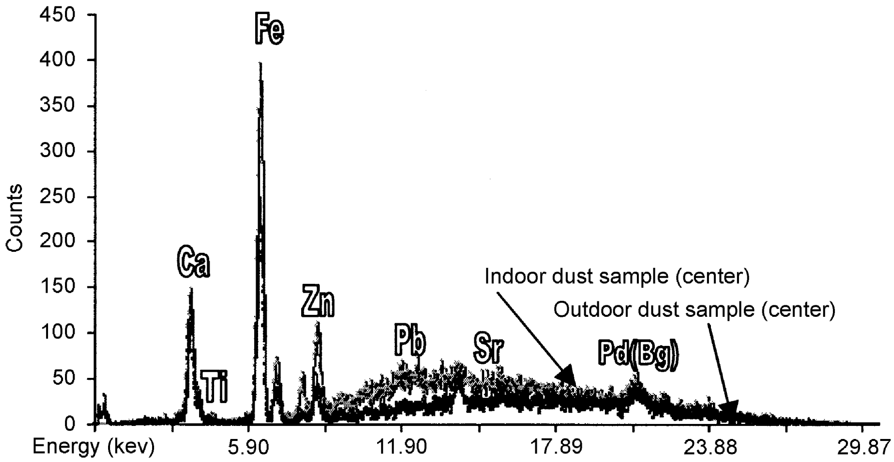

Fig. `1. The superposition of indoor and outdoor dust samples of the center region of Riyadh City.

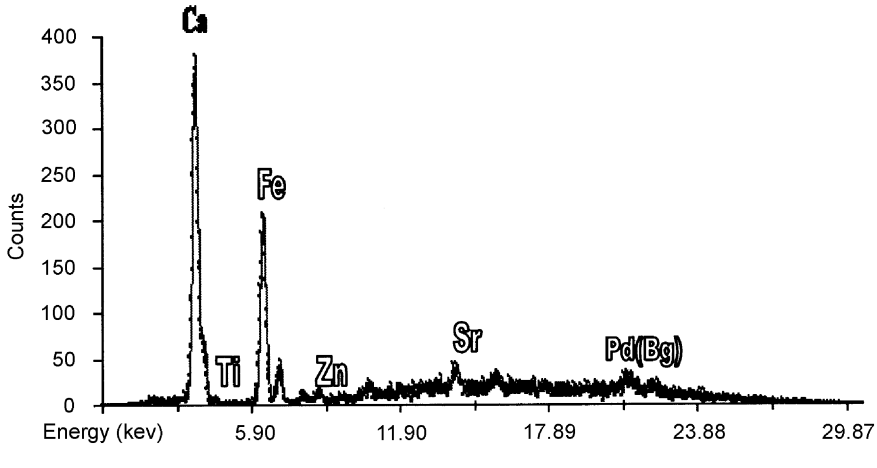

Fig. 2. Spectrum of the dust sample collected outside of the city (desert).

The most elements present in the dust (Ca, Ti, Fe, Zn, Sr) seem to be from mineral origin. This is confirmed by the analysis of the same desert dust samples collected outside of the city. Thus, desert dust is composed of fine particles of sand, which can be transported easily by the wind. The elemental composition of this dust is presented in the last column of Table 2. The elemental concentrations of those samples were very close to that of the outdoors dust samples collected in the city.

Conclusion

The multi-element analysis method used, XRF, is very powerful for elemental composition of dust. This method was simple, fast and able to determine very low concentration without special sample preparation.

The elemental composition of indoor dust samples collected in residential houses at Riyadh city is similar in both, elements and concentration except for Fe and Ca. The concentration of Fe increases in all indoor dust samples in detriment of a decrease of the Ca concentration comparatively to outdoor samples. The most elements present in the dust seem to be from mineral origin and very close in composition and concentration to that obtained from the desert dust collected outside of the city.

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تحليل أولي لعناصر الغبار في مدينة الرياض

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ملخص البحث. يعتبر الغبار العالق بالهواء من أهم مسببات أمراض الربو والحساسية، وسيكون تحليل عناصر الغبار الداخلي والخارجي في مدينة الرياض مؤشراً على نوعية الهواء، وبعض المؤثرات الصحية الأخرى .

وتم تحليل عينات الغبار عن طريق تقنية الأشعة السينية المفلورة المميزة (XRF). تظهر نتائج هذا التحليل الأولي أن العناصر الموجودة في الغبار الداخلي والخارجي متشابهة جداً، ومصدر أكثرها من التربة، ولوحظ أن تركيز الحديد يتزايد، بينما يتناقص تركيز الكالسيوم في جميع عينات الغبار الداخلي مقارنة بالغبار الخارجي، أما بخصوص العناصر الثقيلة فقد تم الكشف عن بقايا للرصاص فقط.