ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Size Distribution Characterization of Indoor Aerosol Particles

Hyam Nazmy*(1), Mona Moustafa(1), Amer Mohamed(1), Abdel-Rahman Ahmed(1), and Mostafa Yuness(1,2)

(1) Physics Department, Faculty of Science, Minia University, Minia/Egypt.
(2) Ural Federal University, Mira St.19, 620002 Yekaterinburg, Russia.

Manuscript Info ***Abstract***

Manuscript History:

Received: 15 August 2014
Final Accepted: 26 September 2014
Published Online: October 2014

Key words:

Size distribution; Inhalable particles; Elemental analysis; Aerosol Characterization; Bernerimpactor; Sierra sampler; Indoor aerosols.

***Corresponding Author**

Hyam Nazmy
E-mail:
Hyamnazmy@yahoo.com

Mass concentration and Elemental characteristics of aerosols were investigated in indoor air of El-Minia University. Berner Impactor and Sierra sampler are used as aerosol samplers with flow rates of 1.7 and 78 m^3/h respectively. The collected samples by Berner impactor were analyzed for seven metal and toxic elements (Pb, Mn, Fe, Cu, K, Ca and Ba) using atomic absorption technique. In addition, twenty one elements analyzed using X-ray fluorescence spectrometry in filters which collected by Sierra sampler. Particles with an aerodynamic diameter <2 µm were predominant, thus accounting for more than 80% of the total aerosol mass concentration found in inhalable range. Ca, S, Cl, Mg and Ba represent the highest percentages. Soil dust is the most ubiquitous sources of Ca, Fe, Al and Mg. The other elements are mainly from natural and traffic road.

INTRODUCTION

Aerosol particles are responsible for carrying and transportation of radioactive and chemical elements, toxic gases and microorganisms [1]. So it's related to human health impacts have become a major concern not only for researchers but also for governments and the general public [2]. The chemical composition of aerosol particles regulates the toxicity of any specific element [3-6]. Effects of inhaled aerosols depend on the specific chemical species, the concentration, the duration of exposure, and the site of deposition within the respiratory tract [7]. Particle size is the most important factor determines the location of the deposited particles as well as the mechanism of deposition [8]. Since many people spend most of their time indoors, in locations, homes, offices and other occupational environments [9-10]. Also numerous epidemiological studies have demonstrated the association between particle mass (PM) concentration in outdoor air and the occurrence of health related problems and/or diseases. However, much less is known about indoor PM concentrations and associated health risks. In particular, data are needed on air quality [11]. Therefore, the objectives of this paper are to examine the size distribution of aerosol particles as well as to investigate the elemental composition of aerosols in indoor air.

METHODOLOGY

Low pressure Berner cascade impactor was used as an aerosol sampler to determine the mass size distribution and mass concentration of atmospheric aerosols. The impactor consists of eight size fractionating stages (cut-off diameters of the impactor stages are 82, 157, 270, 650, 1110, 2350, 4250 and 5960 nm) and operates at a flow rate of 1.7 m^3/h (figure.1). An accurate method of the impactor calibration has been in the isotope laboratory Gottingen University, Germany [12]. More description about sampling procedure for aerosol particles by Berner cascade impactor was explained briefly in [13, 14, 15]

Total particulate suspended matter has been sampled with high volume samplers (General Metal Works, Sierra Impactor Sibata, model HVC1000) operating at a flow of about 78 m^3/h through Whitman 41 cellulose filters of 16 x 20 cm in size. Measurements were performed from April to August 2012, about 20 runs through this period, the sampling time of each run is 6 h. Measurements were performed in El-Minia University, 10 meter above the ground level (environmental radiation Labe) at physics department. The surface area of the Labe is about 50 m^2. The university is located in the middle of El-Minia city in Upper Egypt.

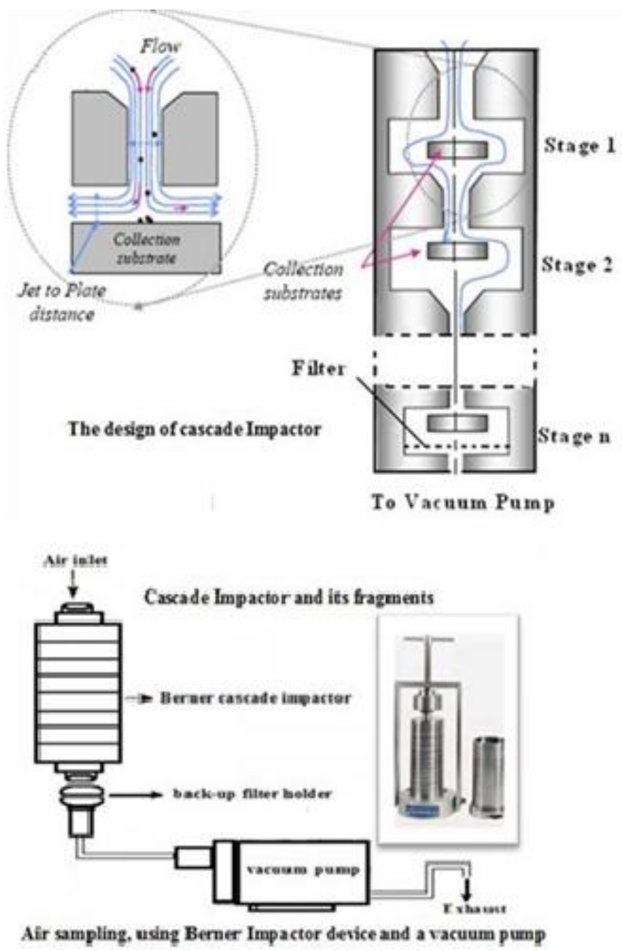

Figure (1): Aerosol sampling set-up using Berner low pressure cascade impactor.

Filters and foils were weighted before and after sampling (m_1 and m_2) using a sensitive balance model Mettler analytical AE240 Dual Range Balance and with knowing the impactor flow rate (Q) we can calculate the mass concentration(C) as follow:

$$C = \frac{m}{Q.t} .... \mu g / m^3 \quad (1)$$

Atomic Absorption Spectroscopy (ZEEnit 700 -Analytik Jena model) and Wavelength Dispersive X-Ray Fluorescence (Axios- Panalytical model) were used for the elemental analysis of aerosol particles. The samples collected by low pressure Berner cascade Impactor were analyzed by atomic absorption spectroscopy for seven elements including Lead (Pb), Manganese (Mn), Iron (Fe), Copper (Cu),Potassium (K), Calcium (Ca) and Barium (Ba) . The sample was cut into small pieces. 5ml diluted HCl (1+1) was added to the sample and gently heated on hotplate till complete dissolution. Few drops of HNO_3 are added to the solution. The solution is transferred to auto sampler cup and completed to 10 mL deionized water) . National Institute for Standards, NIS-Egypt). Parameters of the mass size distribution, Mass Median Aerodynamic Diameter (MMAD) and Geometric Standard Deviation (GSD) were given by the following equations (2 and 3) [16].

$$\ln MMAD = \frac{\Sigma n_i \ln d_i}{\Sigma n_i} \quad (2)$$

$$\ln(GSD) = \left[\frac{\Sigma n_i (\ln d_i - \ln MMAD)^2}{\Sigma n_i} \right]^{\frac{1}{2}} \quad (3)$$

where MMAD is the Mass Median Diameter, n_i and d_i are the fraction and cutoff diameter of the stage i in addition to GSD is the Geometric Standard Deviation. MMAD is defined as the diameter at 50% cumulative fractions. GSD of the size distribution is defined as the diameter at 84% cumulative mass divided by the diameter obtained at 50%.

RESULTS AND DISCUTION

Low pressure Berner cascade impactor was used as size sampler for indoor aerosol particles, in El-Minia University, from April 2012 to Augast 2012 (four runs were conducted in each month). The average mass concentration of aerosol particles is 315.5±17 µg/m^3. Figure.2 shows the average mass concentrations of the seven measured elements. Aerosol samples were analyzed by atomic absorption for seven elements (Pb, Mn, Fe, Cu, K, Ca, Ba). Mass size distribution of PM, Pb, Mn, Fe, Cu, K, Ca and Ba in indoor air are presented in figure. 3. All mass size distributions of elements are found as bi-modal log normal size distribution corresponding to accumulation and coarse modes. Accumulation mode, consisting of long-lived particles of sizes of a few tenths of a micrometer (100 nm $<D_p<$ 2000 nm). These particles stay in the atmosphere approximately up to 2 weeks and compete for condensation and coagulation with the particles of the nucleation mode. Due to the larger surface of the accumulation mode particles, the heterogeneous coagulation with them exceeds homogeneous coagulation. On the other hand, the particles in coarse mode ($D_p>$ 2000 nm), are generated by mechanical processes such as erosion, and resuspension and are removed by sedimentation and washout. The coarse particles are characterized by a high deposition velocity and they have short residence times. On contrary, the residence time of aerosols in the accumulation mode depends on their size, chemistry and height in the atmosphere. These particles remain in the atmosphere longer than the other size categories.

The parameters of elemental mass size distribution, mass median aerodynamic diameter of the accumulation mode, $MMAD_A$ with its geometric standard deviation GSD_A and mass median aerodynamic diameter of the coarse mode, $MMAD_C$ with its geometric standard deviation GSD_C are summarized in Table (1). Particles with an aerodynamic diameter <2000 nm were predominant, thus accounting for more than 80% of the total aerosol mass concentration found in inhalable range as shown in figure. 3. The primary target of inhaled aerosols in the human body with respect to health effects is the respiratory system. Nevertheless, most of the deposited mass appears eventually in the extra thoracic region of the respiratory system [8]. Average mass concentrations of elements are shown in figure. 3. The concentrations ranged from 0.42 ng/m^3 for Ba to 176.25 ng/m^3 for Fe. The highest concentration is obtained for Fe (176.25 ng/m^3) followed by Mn (24.25 ng/m^3), K (5.80 ng/m^3), Cu (1.63 ng/m^3), Ca (1.10 ng/m^3), Pb (0.43 ng/m^3), and Ba (0.42 ng/m^3) (figure. 2).

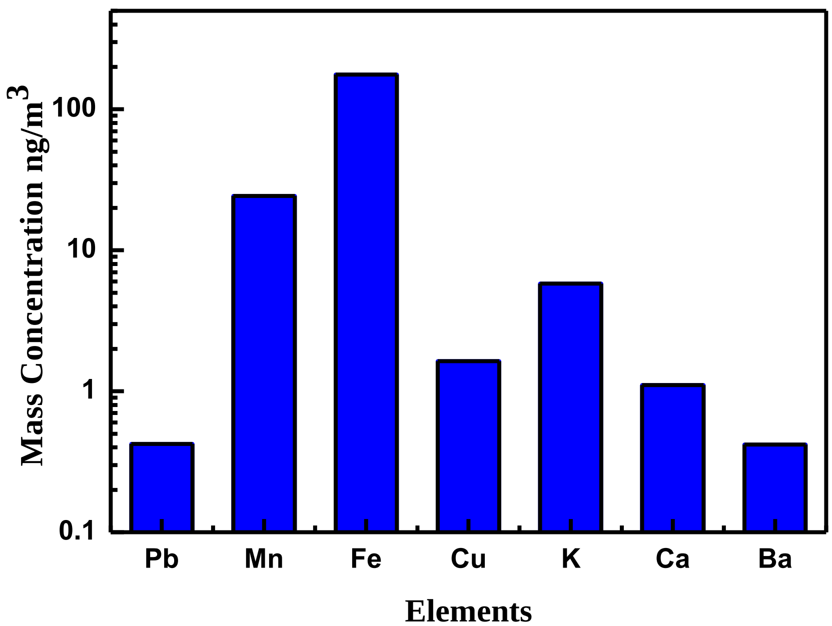

Figure (2): Mass concentration of elements in aerosols collected by Berner impactor.

Table (1): Average mass size distribution parameters of elements and particulates mater (PM) in indoor air.

	Accumulation		Coarse	
Element	**MMAD$_A$(nm)**	**GSD$_A$**	**MMAD$_C$(nm)**	**GSD$_C$**
PM	220.3	1.9	3627.6	1.46
Pb	500	2.4	4353.3	1.39
Mn	198	2	4012.9	1.45
Fe	210.7	2	4381.2	1.22
Cu	181.4	1.84	4057.2	1.41
K	308.9	1.72	4803.1	1.22
Ca	138	2	3792.9	1.55
Ba	264	2.47	2984.2	1.43

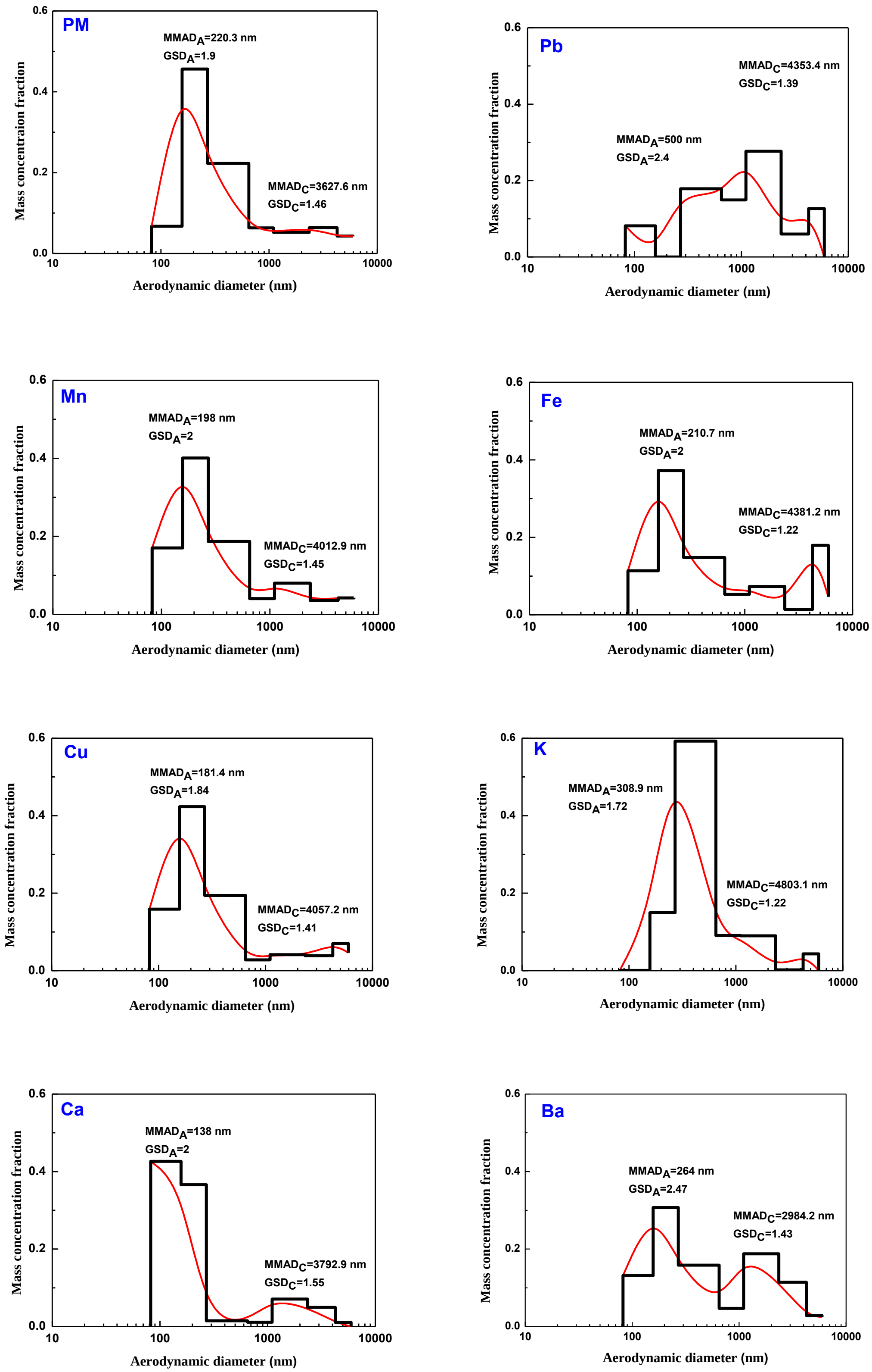

Figure (3): Mass size distribution of PM, Pb, Mn, Fe, Ca, Cu, K and Ba in indoor air.

In the same time, Total Aerosol particles are sampled in indoor using Hi-Volume sampler (Sierra Impactor) and samples were analyzed by wavelength x-ray fluorescence. The average mass concentration of total aerosol particles in indoor is 918.8±30 μg/m^3. Elements mass concentrations are shown in figure. 4. The mean concentrations ranged from 0.33 μg/m^3 for Sr to166.37 μg/m^3 for Ca.

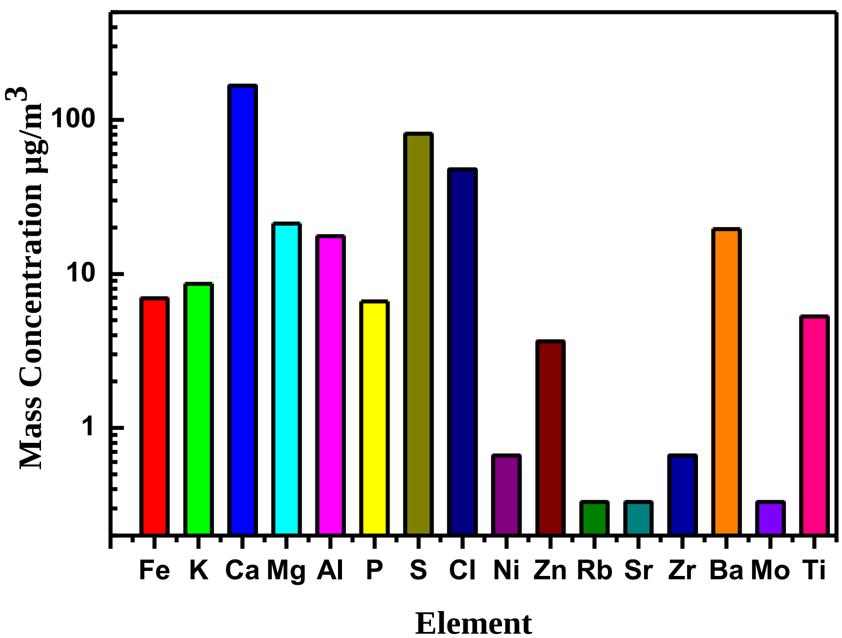

Figure (4): Mass concentration of elements in TSP collected by Sierra sampler.

Major sources of indoor airborne identified by source apportionment methods include infiltration of outdoor air, smoking and other indoor sources. The "other" indoor sources were unidentified, but may have included activities such as cleaning, dusting, vacuuming, and hobbies.

CONCLUSION

In this paper, characteristics of aerosol particles were reported in indoor air of El-Minia University using low pressure Berner cascade and Sierra impactors are used as aerosol samplers with flow rates of 1.7 and 78 m^3/h respectively. Seven elements were investigated including Ca, Ba, Fe, K, Cu, Mn and Pb using atomic absorption technique. The mass size distributions of the investigated elements were bi-modal log normal distribution corresponding to the accumulation and coarse modes. In addition, twenty one elements were analyzed by using X-ray fluorescence spectrometry. Ca, S, Cl, Mg and Ba represent the highest percentages.

ACKNOWLEDGEMENT

Authors want to thank faculty of science, El-Minia University, Egypt for both logistic and financial support through the project of continuous improvement and quality assurance PCIQA.

REFERENCES

[1] Aryal, R., Aeri, K., Byeong-Kyu, Lee., Mohammad, K. and Simon B. (2013) Characteristics of Atmospheric Particulate Matter and Metals in Industrial Sites in Korea, *Environment and Pollution*. (2) 4: ISSN 1927-0909, E-ISSN 1927-0917, Published by Canadian Center of Science and Education.

[2] Mbengue, S., Alleman, L.Y. and Flament, P. (2014) Size-distributed metallic elements in submicronic and ultrafine atmospheric particles from urban and industrial areas in northern France. *Atmospheric Research* (135) 136: 35–47.

[3] EC. (1997) Working Group on Lead, Air Quality Daughter Directives-Position Paper on Lead. *European Commission, DG XI*.

[4] WHO, World Health Organization (2004) Health aspects of air pollution-answers to follow-up questions from CAFÉ. Report on a WHO Working Group meeting, EUR/04/5046026, *World Health Organization.*

[5] ATSDR. (2002) Toxicological profile of Copper.Agency for Toxic Substances and Disease Registry.*Division of Toxicology, Atlanta, USA.*

[6] Samara, C., and Voutsa, D. (2005) Size distribution of airborne particulate matter and associated heavy metals in the roadside environment. *Chemosphere*, 59, 1197–1206.

[7] Toscano, G., Moret, I., Gambaro, A., Barbante, C. and Capodaglio, G. (2011) Distribution and seasonal variability of trace elements in atmospheric particulate in the Venice Lagoon. *Chemosphere*, 85, 1518–1524.

[8] Salma, I., Bal/ash/azy, I., Winkler-Heil, R., Hofmann, W. and Zaray, G. (2002) Effect of particle mass size distribution of aerosols in the human respiratory system. *J. Aerosol Sci.* 33,119-132.

[9] Tran, D.T., Alleman, L.Y., Coddeville and P., Galloo, J. (2012) Elemental characterization and source identification of size resolved atmospheric particles in French classrooms. *Atmospheric Environment*, 54, 250-259.

[10] Branis, M., Rezacova, P. and Domasova, M., (2005) the effect of outdoor air and indoor human activity on mass concentrations of PM10, PM2.5, and PM1 in a classroom. *Environmental Research*, 99, 143–149.

[11] Fromme, H., Twardella, D., Dietrich, S. , Heitmann, D., Schierl, R., Liebl, B. and Ruden, H. (2007) Particulate matter in the indoor air of classrooms exploratory results from Munich and surrounding area. *Atmospheric Environment*, 41, 854–866.

[12] Reineking, A., Scheibel, H. G., Hussin, A., Becker, K. H. and Porstendörfer, J. (1984) Measurements of Stage Efficiency Functions Including Interstage Losses for Sierra and BernerImpactor and Evaluation of Data by Modified Simplex Method, *J. Aerosol Sci.* 15, 376.

[13] Mohamed, A., Ahmed, A. A., Ali, A. E., Yuness M. (2008) attached and unattached activity size distribution of short-lived radon progeny (214Pb) and evaluation of deposition fraction. Journal of Nuclear and Radiation Physics. 3(2):101-108.

[14] Amer Mohamed, Moustafa Abd El-hady, Mona Moustafa, Mostafa Yuness. (2014) Deposition pattern of inhaled radon progeny size distribution in human lung. Journal of Radiation Research and Applied Sciences. 7(3). 333-337.

[15] Hyam Nazmy, Mona Moustafa, Amer Mohamed, Abdel-rahman Ahmed, Mostafa Yuness. (2014) size distribution characterization of outdoor aerosol particles. International journal of scientific and technology research. ISSN 2277-8616.3(4). 238-241.

[16] Hinds, W. C. (1999) Aerosol Technology. Properties, Behavior, and Measurement of Airborne Particles 2ndedn. *Wiley, New York.*