CMA4CH 2014, Mediterraneum Meeting
Employ the Multivariate Analysis and Chemometrics in Cultural Heritage and Environment Fields
5th ed., Rome, Italy, Europe, 14-17 December 2014

Chemical Characterization of Indoor Particulate Matter and Ashes in Traditional Houses of Mt. Everest Region in Central Southern Himalaya (Nepal): Results and Source Apportionment

P. Fermo[1], P. Ielpo[2,3], R. Gonzalez[1], D. Comunian[1], G. Tartari[4], G. Viviano[4]
[1]Department of Chemistry, University of Milan , 20133, Milan, Italy
[2]Water Research Institute, National Research Council, 70132, Bari, Italy
[3]Institute of Atmospheric sciences and Climate, National Research Council, 73100, Lecce, Italy
[4]Water Research Institute, National Research Council, 20861, Brugherio, Italy

Abstract

In a preliminary sampling campaign, carried out during June 2012, inside traditional households located in four villages of Mt. Everest region in central southern Himalaya (Nepal), particulate matter (PM) depositions have been collected together with outdoor depositions nearby each house. Chemical characterization of PM depositions for major ions, organic carbon, elemental carbon, metals content and PAHs (Polycyclic Aromatic Hydrocarbons) allowed identifying the chimney ashes, meat cooking and secondary particulate as major contributes to indoor PM.

Introduction

Although the Tibetan plateau is normally considered as one of the most clean regions of the world, recent studies revealed a serious indoor air pollution due to combustion of solid biomass fuels, especially animal dung [1]. Biomass burning for cooking and heating often results in severe indoor air pollution. The kitchens are equipped mainly with open fireplaces for cooking lacking of a chimney and contributing to PM emission. Previous studies have pointed out the poor quality of indoor air in the traditional houses in Sagarmatha (Everest) National Park and Buffer Zone (SNPBZ) in Nepal [2].

Moreover studies performed in Nepal for regions using solid fuel for cooking and heating, indicate significant contributions from indoor sources to outdoor air pollution in the area as well. Aim of the present study is to characterize the chemical composition of particulate matter (PM) and relative ashes generated indoor from the combustion of different fuels.

Materials & Methods

A preliminary sampling campaign has been carried out during June 2012 in order to collect PM depositions inside traditional households located in four villages (Phakding, Namche Bazar, Tukla, Pangboche) placed in SNPBZ. For each village three houses equipped with traditional stoves have been selected. The kind of fuel (different types of wood, kerosene, yak dung) burnt in each open fireplaces was also known. Outdoor PM depositions have been also collected in the vicinity of each house. Both indoor and outdoor samples were collected directly from surfaces (for example from shelves, stove plate and inside the chimney). Chemical characterization on PM samples has been performed as concerns major ions by IC, OC (Organic Carbon) and EC (Elemental Carbon) by TGA-FT/IR, levoglucosan by HPAEC-PAD, PAHs by GC-MS and metals by IPC-MS. Statistical techniques such as PCA (Principal Component Analysis), APCS (Absolute Principal Component Scores), PMF (Positive Matrix Factorization), CA (Cluster Analysis) have been used in order to better characterize indoor pollution sources.

Results

From the comparison between indoor and outdoors samples OC values were higher in the PM indoor depositions than in the outdoor ones (figure 1) confirming the contribution of different indoor sources.

All analytical data (i.e. ions, metals, OC and EC) acquired have been submitted to multivariate treatments such as PCA and HCA. From the score plot (figure 2) a separation of

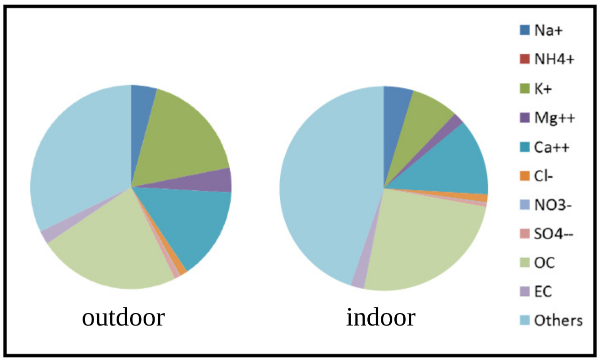

Figure 1: average chemical composition of outdoor and indoor samples.

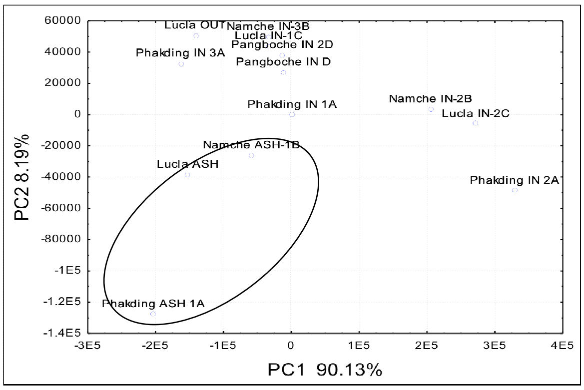

Figure 2: PCA score plot for all the analysed samples.

ashes samples (black circle in figure 2), characterized by higher values of Ca, K and EC (as evident from the loading plot not shown) is observable. On this purpose it is worth noting that ashes usually present different physical and chemical characteristic depending on the biomass used and on combustion conditions (furnace temperature profile, residence time of fuels and gases, biomass mixture, fuel feeding systems and gas treatment systems, among other factors). Furthermore indoor samples are divided into two main groups: in particular samples on the right side are characterized by higher OC values (figure 2) confirming the contribution of this variable to indoor samples.

Results from this preliminary sampling campaign seem to suggest that chimney ashes, meat cooking and secondary particulate contribute to indoor PM. In fact chrysene, considered among PAHs a meat cooking marker, showed higher values for indoor PM deposition that for outdoor ones.

Conclusions

These preliminary results show how some considerations concerning indoor sources can be drawn analyzing PM depositions. The main contribution to indoor PM seems attributed to chimney ashes, meat cooking and secondary particulate. In the future, an extensive monitoring campaign will be planned in order to acquire exhaustive information on the indoor pollution to which the inhabitants living in these traditional houses are exposed.

References

1) S.N. Sinha, P.K. Kulkarni, S.H. Shah, N.M. Desai, G.M. Patel, M.M. Mansuri, H.N. Saiyed, Environmental monitoring of benzene and toluene produced in indoor air due to combustion of solid biomass fuels, *Sci. Total. Environ.*, 357(1-3), (2006), 280-287.
2) F. Salerno, G. Viviano, S. Thakuri, B. Flury, R.K. Maskey, S.N. Khanal, D. Bhuju, M. Carrer, Silu. Bhochhibhoya, M.T. Melis, F. Giannino, A. Staiano, F. Carteni, S. Mazzoleni, A. Cogo, A. Sapkota, S. Shrestha, R.K. Pandey, E.C. Manfredi, Energy, forest, and indoor air pollution models for Sagarmatha National Park and buffer zone, Nepal, *Mt. Res. Dev.*, 30(2), (2010), 113-126.