ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Morphology of Respirable Suspended Particulate Matter(RSPM) Emitted from Household fuels and their Health Implications

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Abstract

The present work is on morphological study of particulate emitted in three different households for different fuels (Kerosene, Biomass and LPG). Three sampling stations were considered in Mysore city. Indoor concentration of Respirable Suspended Particulate Matter (RSPM) emitted from all the three fuels were monitored using Personal air sampler. Sampling before, during and after cooking was carried out for 2 hours. The average indoor concentrations before, during and after cooking were found to be 67.93, 298.40 and 95.15µg/m^3 respectively for kerosene. The average Indoor concentrations before, during and after cooking was found to be 67.06, 1484.89 and 485.768µg/m^3 while the average concentrations for Indoor before, during and after cooking were found to be 53.03 µg/m^3, 62.17 µg/m^{3}and 57.22µg/m^3 respectively for LPG. Biomass seems to emit high concentrations of RSPM followed by kerosene and LPG. To characterize the morphology of RSPM, filter papers were examined using Scanning Electron Microscopy. From these SEM images, it can observed that particles has a propensity to form flocculated aggregates, referred to as '**spherules**' less than 100nm in equivalent spherical diameter (ESD), called as nanosized PM, where as Individual particles or '**spherulites**', are less than 10nm in ESD. As there is greater pulmonary deposition efficiency of NPs, with their large surface area (SA) leads to cardiopulmonary toxicity. These PM may be able to cross the air barrier in the respiratory tract, which may lead to health effects such as inflammation , cardiac disruption and even may lead to death.

Keywords: RSPM, Biomass, SEM, Spherules.

Introduction

In everyday life our lungs are exposed to more air borne particles. Combustion of coal, gas, oil, traffic and manufacturing processes give off dust, fumes, vapors and gases are the common airborne pollutants. Researches on environmental conditions is disclosing a surprising and disturbing factor on human health is that the quality of air in our homes and offices is much more important than ever suspected. Environmental health researchers have discovered that indoor air is often two to five times more polluted than outdoor air, and can be up to thousand times more contaminated in extreme cases. Many of us spend up to 90% of our time indoors, the health risks associated with indoor air quality far surpass the risks related to outdoor air contamination. In developing countries, exposure to smoke is arguably the greatest indoor air pollution problem. In a number of households, burning of wood, crop residues or animal dung is often undertaken without adequate ventilation. Biomass remains the primary energy source in the developing countries; biomass contributes one third of primary energy in India. Due to incomplete combustion, the use of biomass fuel in traditional stoves produce high level of indoor air pollutants which is responsible for more than 1.6 million of deaths and 2.7% of global burden of diseases (WHO, 2006).The common indoor air pollutants are the combustion pollutants like CO, NO_X, SO_X and particulate matter (PM_{10}, $PM_{2.5}$ and $PM_{1.0}$). Increased indoor air pollution can occur because of poor air mixing in the stove especially when the stove is not well ventilated, with high concentration of Respirable Suspended Particulate Matter (RSPM) often exceeding the Indoor Air Quality Standards set by U.S. Environmental Protection Agency.

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Most of the studies were carried out on monitoring the concentrations of Indoor Air Pollutants, not much research has been done on morphological characteristic of particulates in Indoor Air. In this scenario, the present work focuses on morphological characteristic of particulate pollution.

Materials and methods

Study Area

In the present work, western part of Mysore city is considered as the study area. Mysore is the second-largest city in the state of Karnataka, India. Located at the base of the Chamundi Hills about 146 km (91 mi) southwest of the state capital Bangalore, it is spread across an area of 128.42 km^2 (50 sq mi). Mean Sea Level (altitude) of Mysore city is765m, Latitude is 12.3024º N and Longitude is 76.6386º E.

Sampling Stations

Three sampling stations were considered in a part of Mysore city for three different fuels i.e., Kerosene, Biomass and LPG in three different households. Figure 1. shows the location of sampling stations in Mysore city.

Figure 1 Locations of Sampling Stations

Indoor Air Sampling

Indoor sampling of PM concentration is done for a particular time period of 2 hours before cooking, during cooking and after cooking for different fuels. The equipment used for the indoor sampling was Personal Air Sampler (APS2) shown in Figure 2.

Figure 2 Personal Air Sampler

Personal Air Sampler is the equipment used for indoor PM sampling which consists of two parts pump and cyclone head. The contaminated air is drawn by a small diaphragm pump through the sample collector placed near the breathing zone. The pump can aspirate at least 1m^3 of air in eight hours. This ensures that an adequate amount of the contaminant is collected for analysis. The cyclone is clipped to a occupant's collar or pocket as close to the breathing zone as possible and the pump is clipped to the occupant's belt or placed in a protective pouch. The pump is activated and the occupant wears the apparatus during the entire sampling period. It is designed for a 50% cut-point. The respirable fraction of the dust is collected on a filter disc of 37mm diameter held in an aluminum cassette. After sampling, the used cassette, can be posted to a laboratory for gravimetric assessment, and subsequently reused with a new filter disc. The oversize particles fall into grit pot and are also available for evaluation.

Initially flow rate of 1.9 L/min is fixed in the pump. The pre - weighed filter paper of 37mm diameter is placed in the filter cassette of the cyclone head. The sampler is switched on and sampling time is fixed for two hours before, during and after cooking period. Then the filter paper is weighed for the final weight. Using the following equations indoor concentration of PM is found,

Concentration of Particulate Matter,

$$C = (\text{Final weight of filter paper} - \text{Initial weight}) / V \quad (1)$$

Volume of air sampled, $V = (Q/1000) * T$ (2)

Where, T = time period in hours

Q = flow rate in m^3/min

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Scanning Electron microscopy

To characterize the morphology of RSPM, filter paper were examined using Scanning Electron Microscopy (LEO 435-VP, England, UK) at Central Laboratory Facility, CFTRI, Mysore. Small pieces of filter material were mounted on metallic stub, gold coated (~ 100 Å) with sputter coater (Polaron Sputter Coat System, Model 5001,England) and viewed under SEM 435 VP (Leo 40 Electron Microscopy Ltd. Cambridge, UK) at 10 kV. Each sample was scanned with an electron beam. During scanning, electrons are emitted from the surface. The number of emitted electrons determines the brightness of the image on the monitor. In this analysis, the emitted electrons were recorded by a detector. Electrons high sensitivity enables this detector to produce an ‘‘element contrast picture’’. Heavy elements and compounds reflect more electrons than light elements, and thus appear lighter in the image.

Results and discussion

This section presents the results of indoor RSPM concentration emitted from the fuels used in the different households. The permissible limit for indoor RSPM concentration according to WHO (World Health Organization) is 35 µg/m^3.

A Figure 3, 4, 5 shows the average indoor RSPM concentration for the fuels Kerosene, Biomass and LPG respectively. The indoor RSPM concentration in the biomass fuel household is very high when compared to other fuels; it is due to very low ventilation and incomplete combustion of the fuel.

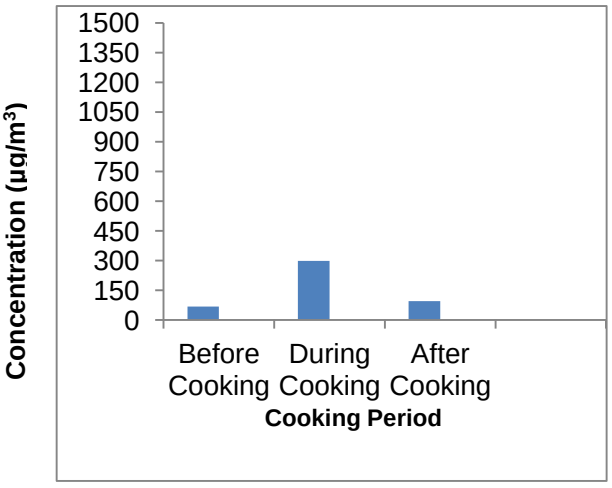

Figure 3 Indoor Average RSPM Concentration in Kerosene Household

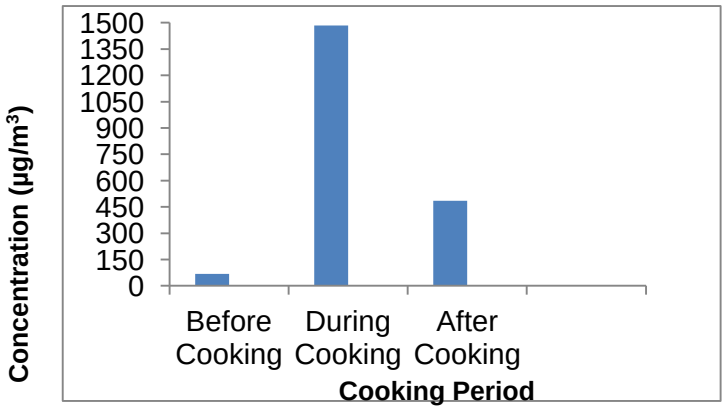

Figure 4 Indoor Average RSPM Concentration in Biomass Household

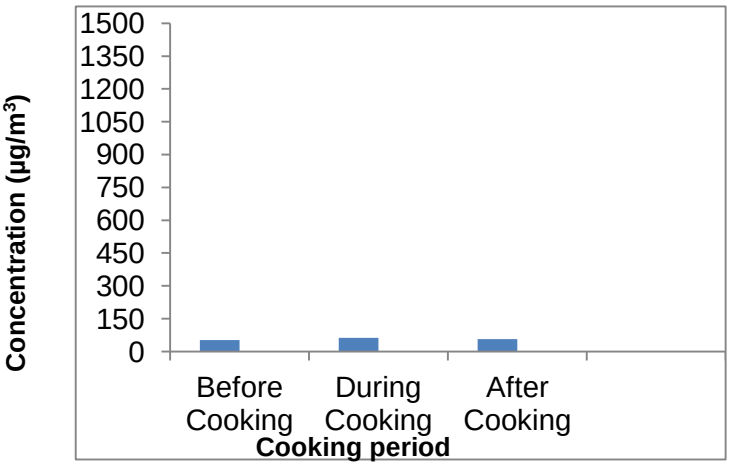

Figure 5 Indoor Average RSPM Concentration in LPG Household

Morphological Analysis

Morphological study reveals that particles are mainly from anthropogenic activities (e.g. combustion). This activity releases UFPs within the PM_{10} metric are considered to be ‘nanoparticles’ (NPs; particles less than 100nm in at least one dimension) but the anthropogenic NPs are further defined as having an equivalent spherical diameter of less than 100nm. Figure 6 shows the comparision of control filter paper where glass fibres are clear, with filter paper having RSPM emitted by biomass and kerosene attached to glass fibers.

From these SEM images, it can observed that particles has a propensity to form flocculated aggregates, referred to as ‘**spherules**’ less than 100nm in equivalent spherical diameter (ESD), called as nanosized PM, where as Individual particles or ‘**spherulites**’, are less than 10nm in ESD. As there is greater pulmonary deposition efficiency of NPs, with their large surface area (SA) leads to

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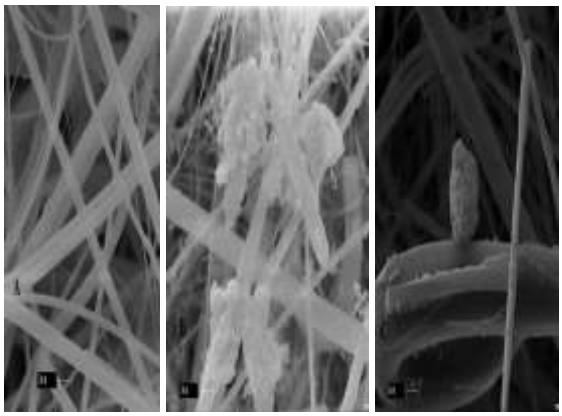

Figure 6 Comparision of Control Filter Paper (A) and Filter Paper having RSPM Emitted during Cooking using Biomass (B) and Kerosene (C) as Fuel

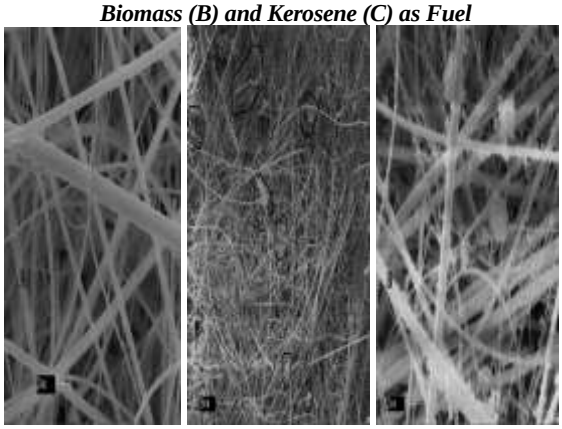

Figure 7 SEM images at various magnification showing Spherules Emitted by Biomass during Cooking

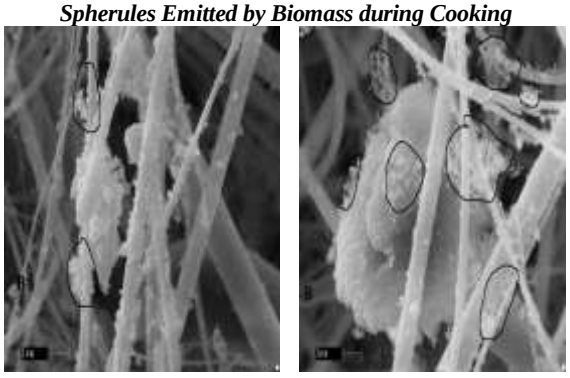

Figure 8 SEM Images reveals about concentration of RSPM and morphology of particles emitted by Biomass

Figure 9 SEM images at various magnification showing Spherules Emitted from Kerosene during Cooking

Typical images generated with SEM shown in Figure 7 and Figure 9 reveals that high RSPM load was observed with Biomass than Kerosene used household. It also reveals that the concentration of particulates smaller than 1 µm is more. Figure 8 and 9 shows the morphology of RSPM, particulates emitted by biomass are irregular shaped when compared with Kerosene generated.

Conclusion

Monitoring of air emissions from different fuels has been carried out. The emitted PM from biomass fuel and kerosene fuel has been subjected to morphological study. Morphological studies have been conducted using Scanning Electron Microscopy.

From our investigation it can be concluded that, the concentration of RSPM having aerodynamic size less than 1µm, which can be spherulites. These spherulites were more in concentration during combustion of biomass when compared to kerosene. The results are indicated the presence of spherules. These spherules will have severe health impact on people.

Acknowledgements

We are grateful to the PESCE, Mandya and CFTRI, Mysore, for making their facilities available for this research work.

References

1. *Anna Ruth Pickett and Michelle L. Bell, "Assessment of indoor air pollution in homes with infants", Int. J. Environ. Res. Public Health, Vol. 8, pp 4502-4520, 2011.*

2. *A. Estokova, N. Stevulova and L. Kubincova, " Particulate matter investigation in indoor environment", Global NEST Journal, Vol. 12, No. 1, pp 20-26, 2010.*

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
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3. *B. F. Yu, Z. B. Hu, M. Liu, H. L. Yang, Q. X. Kong, Y. H. Liu, "Review of research on air-conditioning systems and indoor air quality control for human health", Science Direct, Vol. 32, pp 3-20, 2009.*
4. *Congrong He, Lidia Morawska, Dale Gilbert, "Particle deposition rates in residential houses", Atmospheric Environment 39(21), pp 3891-3899, 2005.*
5. *Deshpande, B., H.C. Frey, Y. Cao, and Z. Liu, "Modeling of the Penetration of Ambient $PM_{2.5}$ to Indoor Residential Microenvironment", Global NEST Journal, Vol. 16 pp 40-48, 2009.*
6. *E. Diapouli, A. Chaloulakou and N. Spyrellis, "Indoor and outdoor PM concentrations at a residential environment, in the Athens area", Global NEST Journal, Vol. 10, No. 2, pp 201-208, 2008.*
7. *Evangelia Diapouli, Konstantinos Eleftheriadis, Angeliki A. Karanasiou, Sterios Vratolis, Ove Hermansen, Ian Colbeck and Mihalis Lazaridis, "Indoor and outdoor particle number and mass concentrations in Athens sources, sinks and variability of aerosol parameters", Aerosol and Air Quality Research, Vol. 11, pp 632-642, 2011.*
8. *IEH , Airborne Particles: Exposure in the Home and Health Effects, Leicester, UK, MRC Institute for Environment And Health, University of Leicester, 94 Regent Road, Leicester: ISBN 1 899110 33 X, 2003.*
9. *Klára Slezáková, Suspended Particles in Outdoor And Indoor Air: Characterization to Support Epidemiological Studies, A Dissertation Presented To The Faculdade De Engenharia Da Universidade Do Porto for The Degree of Philosophy Doctor in Engineering Sciences, 2009*
10. *Marie-Eve Heroux, Nina Clark, Keith Van Ryswyk, Ranjeeta Mallick, Nicolas L. Gilbert, Ian Harrison, Kathleen Rispler, Daniel Wang, Angelos Anastassopoulos, Mireille Guay, Morgan MacNeill and Amanda J. Wheeler, "Predictors of indoor air concentrations in smoking and Non-smoking residences", Int. J. Environ. Res. Public Health Vol. 7, pp 3080-3099, 2010*
11. *Mondal N. K., Konar S., Banerjee A. and Datta J. K., "A comparative assessment of status of indoor air pollution of few selected families of rural and urban area of Burdwan town and its adjoining area", International Journal of Environmental Sciences, Vol. 1, No. 5, pp 736-743, 2011*
12. *Mahmoud Mohammadyan, Mike Ashmore and Bijan Shabankhani, "Indoor $PM_{2.5}$ concentrations in the office, cafe, and home", International Journal of Occupational Hygiene, Vol. 10, pp 57-62, 2010*
13. *M. Mohammadyan, "Personal exposure and indoor home particulate matter: a review", Iranica Journal of Energy & Environment, pp 246-254, 2012*
14. *M. Jantunen, O. Heanninen, K. Koistinen, J. H. Hashim, "Fine PM measurements: personal and indoor air monitoring", Global NEST Journal Vol. 49, pp 993–1007, 2002*
15. *Nicole A. H. Janssen, Gerard Hoek, Bert Brunekreef, Hendrik Harssema, Iwan Mensink, and Arjan Zuidhof, "Personal sampling of particles in adults: relation among personal, indoor and outdoor air concentrations", American Journal of Epidemiology Vol. 147, No. 6, pp 537-547, 1998*
16. *Nigel Bruce, Lynnette Neufeld, Erick Boy and Chris West, "Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala", International Journal of Epidemiology, Vol. 27, pp 454-458, 1998*
17. *Radha Goyal, Mukesh Khare and Prashant Kumar, "Indoor air quality: current status, missing links and future road map for India", J Civil Environ Eng, Vol. 2, 2012*
18. *S. K. Akagi, R. J. Yokelson, C. Wiedinmyer, M. J. Alvarado, J. S. Reid, T. Karl, J. D. Crounse, and P. O. Wennberg, "Emission factors for open and domestic biomass burning for use in atmospheric models", Atmos. Chem. Phys., Vol 11, pp 4039–4072, 2011*
19. *Tripti Pachauri, Vyoma Singla, Aparna Satsangi, Anita Lakhani, K. Maharaj Kumari, "SEM-EDX Characterization of Individual Coarse Particles in Agra, India", Aerosol and Air Quality Research, Volume 13, pp523–536, 2013*