ROLE OF SOCIO-ECONOMIC PARAMETERS IN THE MITIGATION OF INDOOR CARBONACEOUS AEROSOLS IN A RURAL VILLAGE OF INDIA

KOPAL VERMA* AND UMESH C. KULSHRESTHA

School Of Environmental Sciences

Jawaharlal Nehru University

New Delhi, INDIA

*kopal38@gmail.Com

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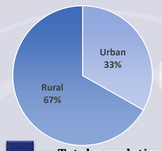
ABSTRACT

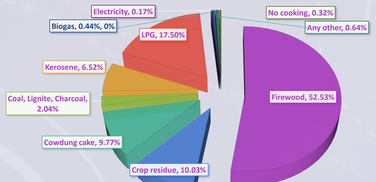
Solid Biomass Fuel (SBF) burning is majorly responsible for the indoor air pollution and high disease burden in rural areas of India. This study has made an effort to find out the association of carbonaceous aerosol (CA) emissions with the socio-economic factors in the households of a rural village, Baggi in Himachal Pradesh, India. Also, the emissions of Organic Carbon (OC) and Elemental Carbon (EC) were evaluated for different types and combination of fuel combustion for cooking and heating purposes. Enhanced average concentrations of OC (240 µg/m3) and EC (118.4 µg/m3) were found with sole biomass burning (wood) on the Chullah (traditional low-budget cookstoves) due to inefficient and incomplete combustion. Although, a stark reduction of 53% in OC and 41% in EC was noticed when a combination of biomass and Liquefied Petroleum Fuel (LPG) was used for cooking. With LPG, the concentrations of OC and EC significantly declined to as low as 38.1 µg/m3 and 31.6 µg/m3 respectively. Also, an excellent inter-relationship was identified between the socio-economic parameters such as the kitchen's ventilation, education, financial status, etc. and CA emissions. In the house with very good ventilation (2 wide windows), the total CA emissions were as low as 86.7µg/m3. Also, the family members were educated and financially affluent. On the other hand, the total CA emissions were escalated by a significant 75.9% where the ventilation facility was extremely poor (small window and slit in the roof), the family was limitedly educated, and financial status lied below poverty line. On an average, the women in this village were found to spend 5 hours per day in the kitchen area. The socio-economic parameters are necessarily important towards the mitigation indoor air pollution and hence carbonaceous aerosols.

INTRODUCTION

India is a rural major developing country (figure 1), and majority of the rural population is dependent on burning solid biomass fuel for cooking and heating. Figure 2 is a clear depiction of population using different types of fuel for cooking. A large fraction of population is dependent on burning biomass viz. firewood, crop residue, cow dung cake, etc. This study has focused on the carbonaceous emissions of hilly areas. The hilly areas of India have a major role to play in determining country's climatic conditions, by controlling or providing protection from various factors such as dust storms, wind, etc. The residents in hilly areas are compelled to use biomass for cooking and heating purposes as facilities of Liquefied Petroleum Gas (LPG) are difficult to avail regularly because of tough terrain, which then results in increase in carbonaceous aerosols in the immediate indoor environment.



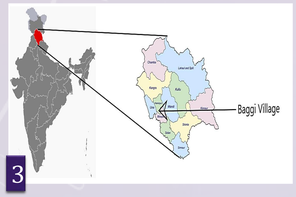
1 Total population of India



2 Different types of fuel used for cooking by the population of India

METHODOLOGY

This study focuses on studying carbonaceous aerosol concentration in selected houses of Baggi, a very small village in Hamirpur district, Himachal Pradesh (figure 3). This study is carried out in four houses which were asked to use different set of fuels for cooking. The indoor carbonaceous concentrations of these households were evaluated during morning, afternoon and evening times when usually the residents used to cook. The aerosol samples were collected on 42mm Quartz fibre filters mounted on filter holder connected to the suction pump for 3 hours. The arrangement for sampling assembly is shown in figure 4. The traditional cook stove i.e. *Chullah* is being shown in figure 5 and the fuel used cow dung cake or wood is shown in figure 6.



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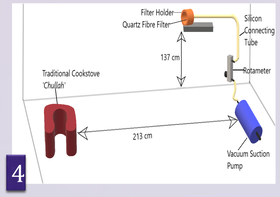

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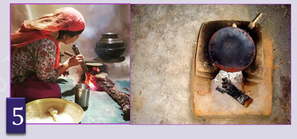

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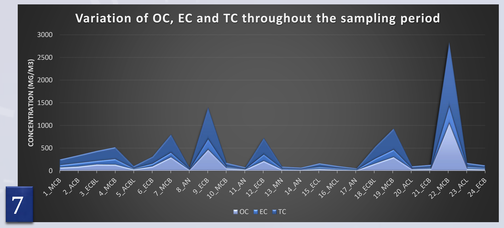
RESULTS

The variation of Organic Carbon(OC), Elemental Carbon (EC) and hence Total Carbon (TC) throughout the sampling period in figure 7 is suggesting that their concentrations peaks when biomass burning takes place, lowers down a bit when LPG is used along with biomass burning and forms a node of almost negligible concentration during non-cooking times.



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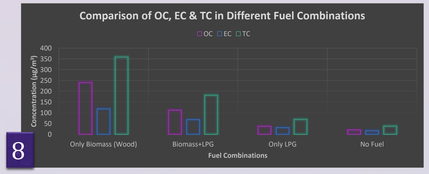
The residents were then advised to use different combination of fuels (figure 8). When biomass was burnt for cooking in *Chullah* the carbonaceous aerosol concentrations were the highest (OC=240µg/m^3; EC=118µg/m^3). When they were advised to cook partial meal on *Chullah* and partial meal on LPG, there was a considerable decrease in the concentrations (OC=112 µg/m^3 ; EC=68 µg/m^3). Although, there was a significant reduction of 84% in OC and 73% in EC concentrations when the residents cooked entire meal on LPG.



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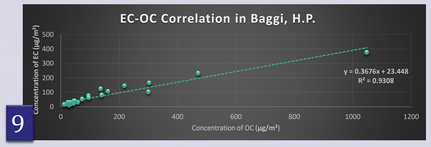
As shown in figure 9, there was an excellent correlation between OC and EC concentrations, with R^2 =0.93 which proves that OC and EC are coming from the same source.



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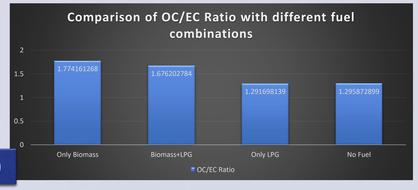
The OC/EC ratio values in figure 10 were also showing that if biomass burning is taking place then the ratio will be higher.



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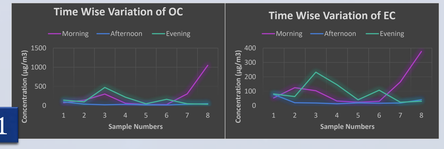
From figure 11, it is clear that the emissions of OC & EC are higher in morning and evening times as majorly cooking is being done in these times only and lower in afternoon when either cooking is not taking place at all or being done on LPG. Also, in morning and evening times samples with a mix of biomass and LPG are showing comparatively lower concentrations of OC & EC



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From table 12 it is very clear that, basic socio-economic parameters majorly decides the levels of indoor air pollution in a particular house. The house with highest income among the four houses was found to have the lowest carbonaceous emissions, because of the more availability of better resources and equipment for cooking. On the other hand, the house with lower ventilation, very low income and a person smoking 25-30 cigarettes in a day had the highest emissions of OC and EC both among all.

Socio-economic Parameters	HOUSE A	HOUSE B	HOUSE C	HOUSE D
OC	96.23856	182.9837	48.01634	251.9085
EC	69.4281	90.10784	38.68301	108.4542
TC	165.6667	273.0915	86.69935	360.3627
Monthly Income	1500	2000	100000	8500
No. of windows in kitchen	2	1	2	1
Average time spent in kitchen	8.5	4.5	4	3
Exposure per hour	19.4902	60.687	21.67484	120.1209
Smoking	NO	NO	NO	YES

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CONCLUSION

- This study concluded that the burning of biomass for cooking results into alarmingly high levels of carbonaceous aerosols in the indoor environment.
- Rural population is not well versed with the harmful effects of indoor air pollution on health which is being caused by *Chullah*'s smoke containing unburnt carbon (black carbon) and hence there is a dire need of bringing awareness to them.
- Because of the financial constraints, limited reach of government facilities and their conventional thought pattern, people here are compelled to continue with the traditional practices of cooking on *Chullah*.
- In spite of changing the overall techniques of cooking, which is not cost-effective, we can implement modest improvisations in their practices with the existing facilities which can bring significant reduction in carbonaceous aerosol emissions. This approach is called soft approach as is being done in this study.
- Question for the viewers: Which other such soft approach methods can you suggest to bring down the indoor air pollution in rural areas.

ACKNOWLEDGMENT

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ABOUT THE AUTHOR

Mrs. Kopal Verma Saini

PhD (5th Year)

Lab No. 303, Atmospheric Chemistry and Climate Change group

School of Environmental Sciences

Jawaharlal Nehru University. New Delhi-110067

Contact No. 9013098656. E-mail: kopal38@gmail.com