



Assessment of indoor pollutants generated from bio and synthetic fuels in selected villages of Burdwan, West Bengal

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Abstract

The objective of the present study was to access the pollutant generated from bio-fuels like bamboo sticks, cow dung, paddy straw, carbon dust cake, gobar gas, jute stick, and mustard stick and synthetic fuel like LPG during cooking in rural villages of Burdwan, West Bengal, India and its fluctuation in living room. The average SO_2 released from the fuels was found in the following order: bamboo stick > cow dung > paddy straw > carbon cake > gobar gas > jute stick > LPG > mustard stick; NO_2 emission was in the following order : mustard stick > carbon dust cake > paddy straw > cow dung cake > LPG, jute stick > gobar gas > bamboo stick > and SPM was obtained in the following sequence : cow dung cake > bamboo stick > carbon dust cake > gobar gas > LPG > mustard stick > paddy straw > jute stick, respectively. The highest living room to kitchen room (L/K) ratio of SO_2 , NO_2 and SPM was found in LPG, gobar gas, jute stick respectively in 2009 and followed by bamboo stick > paddy straw > jute stick > cow dung cake, respectively in 2010. Results of this study suggest that different fuels released different amount of air pollutants, but more extensive study is needed to confirm the relationship between fuels and released air pollutants.

Key words

Bio-fuel, Indoor pollution, L/K ratio, NO_x , SO_2 , SPM, Synthetic fuel,

Introduction

Indoor air quality (IAQ) is a issue of public concern because individuals spend most of their time indoors, and airtight buildings increase the probability for accumulation of indoor generated pollutants (Tian *et al.*, 2008). It is estimated that globally, almost 3 billion people rely on biomass (wood, charcoal, crop residues, and dung) and coal as their primary source of domestic energy (Reddy *et al.*, 1996; WRI, 1998). However, the use of LPG in rural villages increased progressively in present time (Mondal *et al.*, 2011). Among the solid bio-fuels wood contribute maximum indoor air pollutants than carbon cake (Mondal, *et al.*, 2011a). Biomass accounts for more than one-half of domestic energy in many developing countries and for as much as 95% in some lower income ones (Reddy *et al.*, 1996). Biomass and coal smoke contain a large number of pollutants and known health hazards, including particulate matter, carbon

monoxide, nitrogen dioxide, sulfur dioxides (mainly from coal), formaldehyde, and polycyclic, organic matter, including carcinogens such as benzo[a]pyrene (Ezzati *et al.*, 2000; Smith *et al.*, 2000). The kitchen size and its ventilation rate effect pollutant concentrations and transport to the living room (Tian *et al.*, 2008). The relatively very small size kitchen room of the target population enhance the influence of the emissions and spreading of hazardous pollutants from cooking activities. Keeping above information in mind, the objective of the present study was to estimate pollutants (SO_2 , NO_2 and SPM) generated from the bio and synthetic-fuels used by the villagers and to calculate L/K ratio.

Materials and Methods

Study area : The study was conducted in 4 villages (Shibpur dighirpar, Nowabhat, Phagupur and Jhungti) of Burdwan

district. The villagers used different biofuels and synthetic fuel like : bamboo stick, gobar gas, cow dung, carbon cake, mustard stick, paddy straw, LPG and jute stick for cooking purpose.

Sampling and procedure : The sampling was done in the month of February and March of both 2009 and 2010. Total sampling period was sixteen days (1 hour per day). The indoor air quality was monitored using portable high volume sampler (Envirotech-APM-821, India) fitted with filter paper for suspended particulate matter (SPM). The SPM present in the air thus got deposited on the surface of filter paper. The filter paper was reweighed after sampling which gives the amount of SPM in the indoor air. SO_2 concentration was analyzed by modified West and Gaeke (1956) pararosaniline method. Initially SO_2 was absorbed in absorbing solution of potassium tetrachloromercurate. The complex was made to react with pararosaniline and formaldehyde to form intensely coloured pararosaniline methyl sulphonic acid. Finally the absorbance of the solution was measured at wavelength of 560 nm. Initially NO_2 was absorbed in the mixture of sodium hydroxide and sodium arsenite solution where it formed a stable solution of sodium arsenite and was determined at a wavelength 540 nm by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide and N(1 naphthyl) ethylenediamine dihydrochloride (Morgeson, 1977).

The L/K ratio was calculated by dividing the concentration of pollutants in living room by the concentration of pollutants in kitchen. The results are expressed as mean \pm SE of sixteen samples and Pearson correlation coefficient by using computer software (SPSS 7.5). Probability values of <0.01 and <0.05 were considered to be significant.

Results and Discussion

Pollutants concentration was determined from burning of bio and synthetic fuels and highest average SO_2

concentration was recorded in bamboo stick ($39.74 \mu\text{g m}^{-3}$) and lowest in mustard stick ($12.47 \mu\text{g m}^{-3}$). However, the concentration of SO_2 emitted was in the following sequence: bamboo stick ($39.74 \mu\text{g m}^{-3}$) > gobar gas ($35.75 \mu\text{g m}^{-3}$) > paddy straw ($34.9 \mu\text{g m}^{-3}$) > jute stick ($28.55 \mu\text{g m}^{-3}$) > LPG ($22.34 \mu\text{g m}^{-3}$) > coal dust cake ($19.67 \mu\text{g m}^{-3}$) > mustard stick ($12.47 \mu\text{g m}^{-3}$) (Table 1). This variation in different fuels was due to different composition of biomass and synthetic gas. Similar variation was noted in case of NO_2 (Table 1). The fuel like mustard stick showed highest ($32.84 \mu\text{g m}^{-3}$) emission of NO_2 followed by paddy straw ($30.28 \mu\text{g m}^{-3}$), coal dust cake ($26.48 \mu\text{g m}^{-3}$), LPG ($26.68 \mu\text{g m}^{-3}$), cow dung cake ($25.09 \mu\text{g m}^{-3}$), jute stick ($23.75 \mu\text{g m}^{-3}$), gobar gas ($20.55 \mu\text{g m}^{-3}$) and lowest in bamboo stick ($18.93 \mu\text{g m}^{-3}$). Different amount of gas released due to bio-fuel causes respiratory problems in women (Bruce *et al.*, 1998). Variation of SPM (Table 1) was also noticed and it was found highest in case of cow dung cake ($472.14 \mu\text{g m}^{-3}$) and lowest in jute stick ($23.43 \mu\text{g m}^{-3}$). However, the experimental SPM level followed the sequence: cow dung cake ($472.14 \mu\text{g m}^{-3}$) > coal dust cake ($134.5 \mu\text{g m}^{-3}$) > bamboo stick ($132.4 \mu\text{g m}^{-3}$) > gobar gas ($114.5 \mu\text{g m}^{-3}$) > LPG ($64.39 \mu\text{g m}^{-3}$) > paddy straw ($38.68 \mu\text{g m}^{-3}$) > mustard stick ($33.24 \mu\text{g m}^{-3}$) > jute stick ($23.43 \mu\text{g m}^{-3}$). Such higher level of SPM in case of cow dung cake was earlier reported by Mondal *et al.* (2011a). Results indicated that the indoor SO_2 , NO_2 and SPM levels were low when compared with National Ambient Air Quality Standards (CPCB, 2012). The similar SPM level (even higher) inside the kitchen was reported by Kumar *et al.* (2007) and further confirmed it as a cause of respiratory problem among children. Sisenando *et al.* (2011) reported that biomass burning is sole responsible for such high level of particulate matter and has genotoxic potential. Moreover, WHO has recommend a permissible exposure limit of 100 to $150 \mu\text{g m}^{-3}$ of total suspended particles in 24 hrs for the general population (WHO, 1987). The average SO_2 concentration was $26.35 \mu\text{g m}^{-3}$ and $30.68 \mu\text{g m}^{-3}$ in 2009 and 2010, respectively. Similarly, average NO_2 and SPM concentration was $27.31 \mu\text{g m}^{-3}$ and $181.13 \mu\text{g m}^{-3}$ in 2009 and $25.14 \mu\text{g m}^{-3}$

Table 1 : Mean values of pollutants (SO_2 , NO_2 and SPM) emitted from different fuels used in 4 villages of Burdwan

Fuel	2009			2010		
	SO_2	NO_2	SPM	SO_2	NO_2	SPM
Bamboo stick	50.40 ± 5.96	20.578 ± 0.515	168.11 ± 12.145	44.32 ± 3.439	22.12 ± 3.206	121.12 ± 12.353
Gobar gas	16.04 ± 0.693	18.35 ± 0.859	121.50 ± 13.319	18.21 ± 1.219	25.21 ± 3.043	133.42 ± 3.346
Cow dung cake	32.08 ± 0.879	27.85 ± 1.575	668.92 ± 129.60	44.01 ± 2.331	20.32 ± 1.049	466.78 ± 73.882
Coal dust cake	16.04 ± 1.072	32.88 ± 0.367	144.51 ± 5.235	20.21 ± 10.266	30.12 ± 0.325	134.42 ± 4.625
Mustard stick	16.04 ± 0.75	38.17 ± 0.926	20.00 ± 4.005	13.21 ± 0.896	40.47 ± 3.798	36.01 ± 4.307
Paddy straw	32.075 ± 0.532	28.94 ± 0.748	25.963 ± 0.913	41.78 ± 1.744	25.32 ± 0.608	22.37 ± 1.481
LPG	16.04 ± 1.529	24.949 ± 2.46	83.34 ± 6.833	33.11 ± 1.047	19.76 ± 6.115	63.36 ± 10.769
Jute stick	32.08 ± 6.89	26.73 ± 1.584	16.64 ± 1.742	30.61 ± 0.942	17.77 ± 1.173	21.22 ± 4.547

Values are mean of 16 observations \pm SE

and $187.33 \mu\text{g m}^{-3}$ in 2010 respectively. Studies have demonstrated that increase in air pollution levels can cause intensive respiratory diseases among children (Braga *et al.*, 2001) and also biomass generated pollutants to be a significant source of public health hazards, specially to the people those are working in the kitchen (Hasan *et al.*, 2012).

L/K ratio : This L/K ratio is extremely important to evaluate the impact or transport of pollutants generated in one of rooms to the other (Tian *et al.*, 2008). The relative pollutants concentration relationship between living room and kitchen room demonstrate that the relationship of the three pollutants in living room and kitchen room. The L/K ratio of SO_2 varied between 0.82–1.07 in 2009 and 0.32–0.75 in 2010. Again, L/K ratio of NO_2 ranged between 0.69–0.93 in 2009 and 0.37–0.87 in 2010. But much higher level of L/K ratio for SPM was found between 1.01–1.66 in 2009 and 0.74–1.17 in 2010, respectively (Table 3).

In 2009, the highest L/K ratio (1.07) for SO_2 was found in LPG, although this particular fuel was considered as green fuel. The high value of L/K in this particular fuel was due to some secondary source from where pollution was generated, one such possible source was smoking inside the room. But in 2010, the same fuel showed much less L/K ratio inside the room (Table 3). The L/K ratio of NO_2 in 2009 and 2010 was found highest in case of gobar gas and jute stick. But

Table 2 : Mean values of indoor air pollutants (mg m^{-3}) in kitchen and living room generated from bio-fuels in 4 villages of Burdwan 2009 and 2010

Pollutants	Place	N	2009	2010
SO_2	Kitchen	8	$26.35 \pm 4.43^*$	$30.68 \pm 4.36^*$
	Living room	8	24.46 ± 3.65	17.71 ± 3.82
NO_2	Kitchen	8	$27.31 \pm 2.25^{\text{NS}}$	$25.14 \pm 2.59^*$
	Living room	8	21.15 ± 1.62	12.59 ± 0.78
SPM	Kitchen	8	$181.13 \pm 76.83^*$	$187.33 \pm 43.34^*$
	Living room	8	192.04 ± 79.90	193.03 ± 51.65

*Significant at $P < 0.01$, NS: non significant; Values are mean of eight observations \pm SE

Table 3 : Living room–kitchen room (L/K) ratio of different pollutants in 2009 and 2010

L/K ratio of different fuel	2009			2010		
	SO_2	NO_2	SPM	SO_2	NO_2	SPM
Bamboo stick	0.82	0.89	1.02	0.75	0.54	1.08
Gobar gas	0.88	0.93	1.01	0.56	0.53	1.17
Cow dung cake	0.94	0.69	1.05	0.41	0.76	1.16
Coal dust cake	0.98	0.69	1.08	0.33	0.39	1.64
Mustard stick	0.92	0.82	1.30	0.32	0.33	0.74
Paddy straw	0.93	0.77	1.20	0.75	0.37	1.00
LPG	1.07	0.72	1.07	0.46	0.52	0.67
Jute stick	1.02	0.76	1.66	0.74	0.87	0.81

highest L/K ratio of SPM was recorded for jute stick and carbon cake in 2009 and 2010 respectively. On the other hand, the correlation coefficient (data not given) value indicate high positive relationship ($p < 0.01$) between living room and kitchen room in case of SO_2 and SPM in both 2009 and 2010 (Table 2). Smoking and poor ventilation as reported by Mullen *et al.* (2011) may be the reason for variations. This is probably due to kitchen room and living room pattern (Figure not given). Sometimes it was observed that the pollutants concentration was much higher in living room than kitchen room. This was probably due to in-house air flow and other indoor activity like smoking and poor ventilation in kitchen room and living room (Mullen *et al.*, 2011).

Our results suggest that both bio and synthetic fuels generate significant amount of indoor air pollutants. Therefore, it is strongly recommended that either the villagers should reduce their use of fuels or use it in open or use smoke less stove, further they should not carry or allow any child below five years of age during cooking hours.

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