Research Paper

Volume : 3 | Issue : 2 | February 2014 • ISSN No 2277 - 8179

Assessment of indoor NO_2 in kitchens of Households using different modes of cooking in Jammu, India

Environmental Science

KEYWORDS : Kitchens, NO_2, Indoor air pollution

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ABSTRACT

The present study has been carried to assess indoor NO2 levels in kitchen of the households using different modes of cooking in Jammu using Handy Air Sampler Envirotech APM 821 with air flow rate of 1.5 LPM from 6am to 2pm. Except for kitchens using fuelwood indoor NO2 in all the kitchens was observed to be within the prescribed limits of 60µg/m3 as laid down by CPCB. The calculated values of average indoor NO2 in all the four types of kitchens were observed to be statistically significant (p <0.05) except between LPG using kitchen and Kerosene oil using kitchen which exhibited insignificant (p > 0.05) differences

INTRODUCTION

Indoor air pollution is the fourth-leading cause of premature death in the developing world. Women and their small children are at increased risk due to the amount of time spent close to the stove in the kitchen. Indoor air pollution was responsible for more than 1.6 million annual deaths and 2.7% of global burden of diseases (WHO, 2006). Indoor air pollution from solid fuel use is the tenth largest threat to public health (WHO, 2007a). Hence, exposure to indoor air pollution from the combustion of biofuels is a significant public health hazard predominately affecting the poor in both rural and urban communities in developing countries. There is strong evidence that smoke from biofuels can cause acute lower respiratory infection in childhood. (Fullerton et al. 2008; WHO, 2006; 2007b; Smith and Mehta, 2003). Indoor air pollution from the burning of solid fuels kills over 1.6 million people predominately women and children each year. This is more than three people per minute. It is a death toll almost as great as that caused by unsafe water and sanitation and greater than that caused by malaria. Women are two to four times more likely to suffer Chronic Obstructive Pulmonary Disease (COPD) when exposed to indoor smoke pollution. In the present study attempt has been made to assess indoor NO_2 levels in kitchen of the households using different modes of cooking in Jammu so as to propose suggestive measures regarding indoor air pollution abatement strategies.

MATERIALS AND METHODLOGY

The study area was divided into four zones to cover all the households using different modes of cooking in the kitchens i.e Zone I (HL- Household using LPG in the kitchen), Zone II (HH- Household using electric heater in the kitchen), Zone III (HF- Household using fuelwood in the kitchen) and Zone IV (HK- Household using kerosene oil in the kitchen). Five households were selected randomly and in each household sampling of air was done thrice to determine indoor NO_2 using Handy Air Sampler Envirotech APM 821 with air flow rate of 1.5 LPM. The sampling was done eight hourly (6am to 2pm).

For determination of NO_2 Jacob and Hocheiser modified method (APHA,1987) was used. The NO_2 in µg/m³ was calculated using following formula.

NO_2 (µg /m³) = NO_2 (µg /ml)x Ax10³

V X 0.82

Where, A = Absorbing reagent taken for sampling

0.82 = Overall average Efficiency

and $V = \frac{(F_1 + F_2)}{2} \times T$

Where, V = Volume of air passed through absorbing reagent in litre.

F_1 = Initial flow rate before sampling

F_2 = Final flow rate after sampling

Complied average values of NO_2 were used to calculate IPI using formula (Moghissi, 1991)

$IPI = 1/n (C_1/L_1 + C_2/L_2 .... C_n/L_n)$

Where, IPI = Indoor Pollution Index

C = Concentration of pollutants

L= Concentration limit for pollutants

n = no. of pollutants included in the computation

The ranges used were

0.1 - 0.1 - Good
0.2 - 0.2 - Moderate
0.3 - 0.4 – Unhealthy
0.4 and above -Hazardous

RESULTS AND DISSCUSION

The analysis of the data of average indoor NO_2 of different zones of study area revealed that Zone III (HF) i.e kitchen using fuelwood exhibited maximum average indoor NO_2 of 60.62 ± 19.94µg/m³ with a range of 21.17 - 95.98µg/m³ followed by Zone I (HL) i.e kitchen using LPG exhibited average indoor NO_2 value of 9.31 ± 2.35 µg/m³ with a range 6.74 - 15.3µg/m³ and Zone IV (HK) i.e kitchen using kerosene oil with average indoor NO_2 of 7.98 ± 3.70µg/m³ with a range of 4.35 - 19.93 µg/m³ whereas the minimum average indoor NO_2 with value of 2.96 ± 1.60µg/m³ with a range of 1.52 -5.61 µg/m³ was exhibited by Zone II (HH) i.e kitchen using electric heater (Table I). Except for kitchens using fuelwood indoor NO_2 in all the kitchens was observed to be within the prescribed limits of 60 µg/m³ as laid down by CPCB. Even the kitchen using fuelwood exhibited slightly higher value as compared with the prescribed value of CPCB. Bonnett et al. (2008) also reported reduction in NO_2 levels due to heater replacement in New Zealand. Mohan et al. (1992) also observed indoor NO_2 within prescribed limits of CPCB in Pune city.

The critical analysis of compiled data of different kitchens of the study area revealed that LPG using kitchen with electrical chimney fitted ventilators exhibited minimum indoor NO_2 of 7.65 ± 0.602 µg/m³ with a range of 6.96 - 8.07 µg/m³ followed by LPG using kitchen with exhaust fan fitted ventilator which exhibited average indoor NO_2 of 9.10 ± 1.93µg/m³ with a range of 6.74-

12.23 μg/m³ whereas the LPG using kitchen with ventilator without exhaust fan exhibited higher value of 11.60 ± 3.36 μg/m³ with a range of 8.71 - 15.3μg/m³. This critical analysis of the data clearly revealed that ventilators with improved mechanical devices for the removal of emissions during cooking played significant role in the abatement of indoor NO_2 in the kitchens as well as households. However all the three types of LPG using kitchens exhibited indoor NO_2 within the prescribed limits of 60μg/m³ as laid down by CPCB

Similarly, electric heater using kitchen with exhaust fan exhibited lowest value of indoor NO_2 (2.03 ± 0.29 μg/m³) and electric heater using kitchen with ventilator without exhaust fan exhibited higher values of indoor NO_2 (2.38 ± 1.01μg/m³) whereas electric heater using kitchens without ventilator exhibited highest indoor NO_2 (5.61± 0.80 μg/m³) but all the values were within the prescribed limits of 60μg/m³ as laid down by CPCB. The present observation find support from work of Shima and Adachi (1998)who observed higher indoor NO_2 in homes with unvented heaters than in homes with vented heaters. Pandey et al. (1999) while studying ambient air quality of Lucknow also reported concentration of NO_x within the permissible limits

On comparative basis the fuelwood using kitchens without ventilator exhibited highest indoor NO_2 (68.13 ± 21.58μg/m³) as compared with that (49.35± 10.68μg/m³) of fuelwood using kitchen with ventilator but without exhaust fan.

Similarly, the kerosene oil using kitchens without ventilator exhibited higher value (10.04 ± 5.25μg/m³) as compared with that (6.61 ±1.22 μg/m³) of kerosene oil using kitchen with ventilator without exhaust fan. This further signifies the importance of mechanical ventilation to improve indoor air quality

The calculation of Indoor Air Pollution Index (IPI) for the average NO_2 only for all the kitchens of study area rated the value of 0.15 for kitchen using LPG (Zone HL), 0.04 for kitchen using electric heater (Zone HH), 1.01 for kitchen using fuelwood (Zone HF) and 0.13 for kitchen only for all the kitchens of study area rated the value of 0.15 for kitchen using LPG fuelwood (Zone HF) and 0.13 for kitchen using kerosene oil (Zone HK) accordingly the status of LPG using kitchen and kerosene oil using kitchen was read off as 'moderate', for electric heater using kitchen as good and for fuelwood using kitchen as 'hazardous'. (Table II)

Statistical analysis of data of average indoor NO_2 using T-test revealed that all the differences in values of average indoor NO_2 in all the four types of kitchens were significant ($p < 0.05$) except between LPG using kitchen and Kerosene oil using kitchen which exhibited insignificant ($p > 0.05$) differences. (Table III)

CONCLUSION

Households with fuelwood using kitchens without ventilators exhibited maximum average concentration of NO_2 (68.13 ± 21.58μg/m³).Households kitchen with exhaust fan fitted ventilators exhibited minimum concentration of NO_2 Except for kitchens using fuelwood indoor NO_2 in all the kitchens was observed to be within the prescribed limits of 60 μg/m³ as laid down by CPCB.

SUGGESTIVE MEASURES

The concentration of indoor air pollutants can be reduced by the use of

- improved cooking stoves,
- use of smoke hoods, chimney stoves,
- better behavioural practices such as using dried wood, use of smaller size fuelwood, use of lidsduring cooking, use of pressure cooker to reduce cooking time,
- regular maintenance of the stove, chimney and hood,
- use of cheap and clean sources for cooking such as biogas,
- well ventilated kitchens.

With these approaches, the indoor air pollution can be reduced thereby decreasing the risk of health hazards to the people.

Table I: Average indoor NO_2 in Kitchens of study area

House No.	Average indoor NO_2 (μg/m³) in kitchen using LPG(Zone HL)	Average indoor NO_2 (μg/m³) in kitchen using Electric Heater (Zone HH)	Average indoor NO_2 (μg/m³) in kitchen using Fuelwood (Zone HF)	Average indoor NO_2 (μg/m³) in kitchen using Kerosene (Zone HK)
House No. 1	11.60 ±3.36 (8.71-15.3)	2.66± 0.841 (1.95-3.59)	57.26± 37.47 (21.17-95.98)	6.21 ±0.84 (5.26-6.86)
House No.2	7.52± 0.80 (6.74-8.35)	2.97 ±1.25 (1.75-4.25)	71.99 ±13.42 (57.16-83.07)	6.58± 1.93 (4.35-7.76)
House No.3	8.24± 0.36 (7.91-8.64)	2.03± 0.29 (1.70-2.27)	75.16±2.51 (72.27-76.76)	11.52± 7.57 (5.22-19.93)
House No.4	11.55± 0.59 (11.13-12.23)	1.52± 0.22 (1.31-1.76)	40.77± 5.11 (35.14-45.12)	7.05± 1.01 (5.94-7.91)
House No.5	7.65 ±0.602 (6.96-8.07)	5.61±0.80 (4.83-6.44)	57.93 ±6.21 (53.07-64.93)	8.57 ±2.23 (6.15-10.55)
Average indoor NO_2 (μg/m³)	9.31± 2.35 (6.74-15.3)	2.96 ±1.60 (1.52-5.61)	60.62± 19.94 (21.17-95.98)	7.98± 3.70 (4.35-19.93)

Table II: Indoor Pollution Index (IPI) for NO_2

Zone/ Type of kitchen	IPI for NO_2	Status
Zone HL (kitchen using LPG)	0.15	Moderate
Zone HH (kitchen using Electric Heater)	0.04	Good
Zone HF (kitchen using Fuelwood)	1.01	Hazardous
Zone HK (kitchen using Kerosene oil)	0.13	Moderate

Table III: T-Test: paired two samples for means of NO_2

	Mean Difference	Std. deviation	Sig. 2-tailed (p)	Statistical Value(p<0.05)
LPG – Electric heater	6.35	3.22	.000	Significant
LPG – Fuelwood	-51.31	21.82	.000	Significant
LPG – Kerosene oil	1.32	3.77	.196	Insignificant
Electric heater –Kerosene oil	-5.03	4.07	.000	Significant
Fuelwood-Kerosene oil	52.63	21.33	.000	Significant
Fuelwood – Electric heater	57.66	20.04	.000	Significant

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