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RESEARCH ARTICLE

Indoor Air Quality Assessment of Some Commercial Kitchens of Jaipur City

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Abstract

Indoor air pollutants associated with combustion of solid fuels in households and commercial kitchens of developing countries are now recognized as a major source of health risks to the exposed populations. Assessment of indoor air quality in kitchens is of great significance due to its negative effects on health of the workers exposed to it for several hours. For this purpose, a study was conducted at the commercial kitchens of five restaurants (R1, R2, R3, R4 and R5) using *tandoor* for preparing chapattis and non vegetarian dishes at Mansarovar area in Jaipur, Rajasthan. The major objective of the study was to measure the concentrations of suspended particulate matter, Sulphur dioxide and Nitrogen dioxide and the effect of ventilation pattern and height of the kitchen on the indoor air quality. The result showed that the improper ventilation pattern and inadequate height significantly deteriorate the indoor air quality. Air pollutants were sampled using the Handy sampler (Envirotech APM821).The levels of SPM,NO_2 and SO_2 were found high at R3, ranging between 8.9 to 10.5($\mu g/m^3$),11.25 to 16.3($\mu g/m^3$) and 48.3 to 69.0($\mu g/m^3$) respectively. These levels were the highest as compared to the concentrations of SPM,NO_2 and SO_2 at other sites R1,R2,R4 and R5, ranging between 4.82 to 10.5($\mu g/m^3$),4.12to11.23 ($\mu g/m^3$), and 8.98 to12.03($\mu g/m^3$) respectively. The reason behind this is low roof height and poor ventilation pattern at R3 where they are not using any kind of exhaust fan or canopy hood system unlike R1,R2,R4 and R5 were they are using exhaust and hood system as well as the height of the kitchens is relatively more.

Key words

Air Pollutants, Indoor air quality, Suspended particulate matter

Introduction

Air quality and link between human health is well established. Indoor air pollution is recognized as a significant source of potential health risks to exposed populations throughout the world. The major sources of indoor air pollution worldwide include combustion of fuels, tobacco, and coal poor ventilation systems; furnishings and construction materials (Rehaili, 2005). The most significant issue that concerns indoor air quality of developing countries is that of exposure to pollutants released during combustion of solid fuels, including biomass (wood, dung, and crop residues) or coal used for cooking and heating (Kirk and Mehta, 2003; Padilla *et al*, 2010; Qin *et al*, 1991; Raiyani *et al*, 1993). It is estimated that use of open fires with these fuels exposes nearly 2 billion people in the world to enhanced concentrations of particulate matter and gases, up to 10-20 times higher than health-based guideline values available for typical urban outdoor concentrations (Bruce *et al*, 2000; Rehaili, 2005). Several recent studies have shown strong associations between biomass fuel combustion and increased incidence of chronic bronchitis and acute respiratory infections in developing countries. The stoves, chullah or *tandoor* in restaurants used for cooking are not energy efficient. The fuels do not burn completely. The incomplete combustion of biomass releases complex mixture of organic compounds, which include suspended particulate matter, sulphur dioxide, nitrogen dioxide, carbon monoxide, poly organic material (POM), poly aromatic hydrocarbons (PAH), formaldehyde etc. (Ghasemkhani and Naseri, 2008; Zhu and Wang, 2003). The biomass may also contain intrinsic contaminants such as sulphur, trace metals, etc. There is strong evidence that chronic

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exposure to indoor air pollutants increases the risk of a range of respiratory illnesses, including acute lower respiratory infections (ALRI) in children and chronic obstructive pulmonary disease (COPD) in adults. In addition, chronic exposure to coal smoke results in increased risk for lung cancer. About 36% of ALRI, 22% of COPD and 1.5% of cancers of the trachea, lung and bronchus are caused by exposure to indoor air pollution (Nakatsuka *et al*, 1991; Hu and Liu, 1998; Ormstad, 2000; Bruce *et al*, 2000; Milz *et al*, 2007). Other conditions attributed to indoor air pollution include increased susceptibility to asthma and middle ear infections in children, and tuberculosis, cataracts, and cancers of the nasopharynx and larynx in adults (Junfeng and Smith, 2003; Khanzadeh, 2003). Some studies have also implicated indoor air pollution in low birth weight and perinatal mortality. Many studies indicate that particulate matter (especially respirable particulate matter) may be the single best available indicator of overall indoor air pollution levels associated with biomass combustion. NO_2 is a deep lung irritant because of its limited solubility and high oxidative potential. Exposures to high concentrations may promote severe acute lung damages and, in some cases, even death. Children, the elderly and the ill are the segments of the population more affected by NO_2 exposure because of the long periods of time spent indoors (Kumar *et al*, 2008; Lee and Chan, 1998). Poor ventilation systems aggravate the conditions. Poor circulation of air increases the concentration of pollutants, badly affecting the health of individuals exposed to it.

In the case of many commercial kitchens, attention is not paid on the environmental quality which affects the workers as well as the costumers. Due to lack of funds and space, exhaust fans, fume hoods or even windows are not provided for proper ventilation of the kitchens where the time spend by cooks and other workers exceed more than eight hours. workers are constantly exposed to poor air quality which leads to several pulmonary and cardiac diseases.

Material and Methods

The study was conducted in five restaurants of Jaipur city, Rajasthan. The city located at 26.92°N 75.82°E and has an average elevation of 431 metres (1417 ft). It has a hot semi-arid climate.

The present study was conducted for seven months convering two seasons, Winter and summer (November -May 2010). Kitchens of five restaurants of Mansarovar area where tandoors are used were selected for the study. The raw material used as fuel for tandoor was coal. Air quality parameters studied were Suspended particulate matter, sulphur dioxide and nitrogen dioxide using the Handy sampler(Envirotech APM821).Analysis of SPM was done gravimetrically while sulphur dioxide and nitrogen dioxide were analyzed using IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur dioxide and IS 5182 Part 6 Methods for Measurement of Air Pollution: Oxides of nitrogen. The samples for SPM were collected for 8 hours and for SO_2 and NO_2 the duration was 4 hours when the restaurant had maximum number of costumers.

The minimum and maximum temperature and relative humidity were also monitored to study their effect on the concentration of pollutants. The ventilation pattern of each kitchen was also observed to correlate the effect of ventilation on the air quality in the kitchens.

Results and Discussion

The table 1 summarizes the specifications of the five restaurants investigated in the study. The specification taken are responsible for the concentration of pollutants in the kitchens

Table 1. General information of the restaurants

Specifications	Restaurants				
	R1	R2	R3	R4	R5
Average occupancy capacity	50	100	40	50	70
No of employees	3	5	2	4	5
Average area of the kitchen(m^2)	50	60	35	50	66
Canopy hood system	nil	yes	nil	nil	yes
Fan system	-	yes	Nil	yes	yes
Ventilation	yes	yes	Nil	yes	yes
No. of doors	1	1	1	2	2
No. of windows	1	nil	nil	1	nil
Height of the kitchen(feets)	12	15	9	15	15

Table 2. Concentrations of SPM, SO_2 and NO_2

Restaurant	Winter			Summer		
	Conc.of SO_2 in ($\mu g/m^3$)	Conc.of NO_2 in ($\mu g/m^3$)	Conc.of SPM in ($\mu g/m^3$)	Conc.of SO_2 in ($\mu g/m^3$)	Conc.of NO_2 in ($\mu g/m^3$)	Conc.of SPM in ($\mu g/m^3$)
R1	12.03	11.23	8.96	10.24	8.50	7.89
R2	10.22	9.67	7.25	12.48	8.24	7.04
R3	69.0	16.88	10.5	48.3	11.25	8.09
R4	24.06	8.35	4.62	5.55	3.88	5.20
R5	8.98	4.25	6.21	8.66	7.60	4.12

Table 3. Environmental conditions of the kitchens

Rest aura nt	Summer			Winter		
	Temperature °C		Relative humidity (%)	Temperature °C		Relative humidity (%)
	Ambient	Indoor		Ambient	Indoor	
R1	32	40	60.6	20	25	31.2
R2	35	42	62.2	19	26	32.9
R3	37	46	65.6	20	29	35.3
R4	33	37	58.3	18	25	31.5
R5	32	43	61.4	19	26	31.3

In the present study, the kitchens used coal as the source of fuel in the *tandoor* which is a well known source SO_2,NO_2, SPM and RSPM. The results show elevated levels of all the pollutants. The effect of temperature and ventilation is also prominent from the results obtained. As observed from the result, (Table 2) the restaurant R3 shows the maximum concentrations of the pollutants and minimum concentration is observed in R5.The reason behind these results can be due to the conditions prevailing in the kitchens. In the case of R3, as shown in the table 1, the kitchen has very low roof height, there is no exhaust fan or fume hood, there are no windows and there is a single door in the kitchen. All these factors do not allow the pollutants emitted from the tandoor to disperse and they get trapped in the kitchen deteriorating the air quality. In the case of R5 the quality of air is better than the others as the basic conditions in this kitchen is better with a high roof height, exhaust fan, fume hood, presence of windows and two doors. In this case the area is larger than others allowing proper circulation of air as well as the exhaust fan and fume hood does not allow the pollutants to concentrate inside the kitchen. Temperature and relative humidity also play an important role in air pollutant dispersion. In summers the levels of pollutants are lower than in winters (Table 3). While sampling in the kitchens, the workers were also enquired about their health which revealed that workers are suffering from respiratory disorders and some skin problems. The reason behind this is their exposure to poor air quality for long hours. Thus the study reveals that indoor air quality is dependent on several factors but the most important is the ventilation pattern.

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