Research Paper

Volume : 3 | Issue : 10 | October 2014 • ISSN No 2277 - 8179

Quantitative assessment of SPM (Suspended particulate matter) and bacteria in urban area of Jammu (J&K, India)

Environmental science

KEYWORDS : SPM, Bacteria, Households, Correlation

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ABSTRACT

The study was carried out in the households of urban area of Jammu. Urban area was divided into five zones. At each zone three households were selected and each household (except one room accommodation) was divided into three sub-sites i.e. Living room, Kitchen and Bedroom. Sampling was undertaken by Handy air sampler APM 821. The average indoor SPM and bacteria in the households of the urban area of Jammu during two year study period exhibited significantly higher values ($p<0.05$) during second year study period. The average one room accommodation household exhibited higher value of bacterial count as compared with that of two room accommodation household during both first as well as second year study period. The households selected during the present study had differences in number of occupants, their eating habits and various outdoor sources which should be the reasons for irregular trends of correlation between SPM and bacteria.

1 Introduction

Our buildings have undergone radical changes over past few decades thereby resulting in less exchange of indoor air with outdoor air. This has resulted into accumulation of various air pollutants like dust, CO_2, bacteria etc. within the building. The levels of indoor air pollutants may be of particular concern because most people spend about 90% of their time indoors (Purohit and Ranjan, 2005).

In our country, housewives spend over 80% of their times in indoor environment, of which 4-6 hours is spent in kitchen for cooking purposes (Rao and Rao, 1998). In India, 5,89,000 people (i.e. 4,96,000 in rural areas and 93,000 in urban areas) die each year due to indoor air pollution (Sharma, 2005). An estimated 8,11,000 people had died worldwide prematurely from exposure to elevated levels of particulate matter in cities (Ezzati and Kammen, 2002).

SPM is any solid or liquid droplet with diameter between 0.002 µm and 100 µm suspended in air. It is a ubiquitous air pollutant, arising from both natural and anthropogenic sources (Santra, 2006). Biological pollutants like bacteria, viruses, fungi, pollens, house dust, and mite droppings are also found in indoor air. Sources of biological contaminants include air conditioning systems; humidifiers; air ducts; cooling towers; grass, tree and weed pollens; occupants; and household pets (Bhatia, 2007) as well as the outdoor air (Shelton et al., 2002).

Size of particulate matter is an important factor that influences particles deposition in respiratory tract and affects human health. Recent studies have reported a close association between levels of Particulate matter (PM) in air and adverse respiratory and cardiovascular effects including aggravated asthma, increase in respiratory symptoms like coughing and difficulty in breathing, chronic bronchitis, decreased lung function, premature death etc. in people. (Santra,2006).

The main concern about microbial growth in indoor environments is related to the strong link to the adverse health effects in the occupants (Douwes et al., 2003; Li and Yang, 2004). House dust can be considered reservoir for microbes. It is extremely dry but has optimal pH and organic material for microorganisms (Pieckova and Wilkins, 2004).

The present study has been carried out to assess the status and correlate indoor air SPM and bacteria in the households of urban area of Jammu, J&K, India.

2 Materials and Methods

Study area and sampling sites

Jammu is one of the fastest growing cities of India. It is situated on a hillock, on the bank of river Tawi. It is °24' and 75°18' East longitude and 32°50' and 33° 30' North latitude. Urban Area of Jammu was divided into five zones:- Zone UZI (Households located in Residential Area); Zone UZII (Households located in Commercial Area); Zone UZIII (Households located near Crossings in Commercial Area); Zone UZIV (Households located near National Highway I-A); Zone UZV (One room accommodation Households).

At each zone three households were selected and each household (except Zone UZV) was divided into three sub-sites i.e. Living room, Kitchen and Bedroom. All households had concrete walls, wooden doors and wooden windows with glass panes. Indoor samples were collected under conditions of normal room use and no attempt to reduce ventilation prior to sample collection was made. In the kitchen of each household, mode of cooking was LPG and heater, whereas heater and wood were used for cooking in one room accommodation. The number of occupants varies from 4 to 5 in all sampling households with at least one child in each household. Weekends and holidays represent high occupancy in households.

Sampling method

At each sub-site and Zone UZ the sampling of air was done twice during April-September and during October-March of first year (2008-2009) as well as second year (2009-2010) study period using Handy Air Sampler APM 821 separately for SPM and Bacteria. Sampling was done between 9 a.m to 3 p.m at a height of 4 ft above the ground at a flow rate of 1.5 L min-1 (LPM). Relative Humidity was expressed in percentage and it was measured using psychrometer.

SPM Sampling

SPM was quantified by trapping it on pre-weighed glass millipore microfiber filter paper (Diameter 25mm, Type AA and poresize 0.8µ) attached to the tube assembly of the Handy Air Sampler APM 821. Air Sampling was done for two hours at a flow rate of 1.5 L min-1 (LPM). The filters were dessicated prior to pre-sampling weighing and post-sampling weighing by Precisa balance B (120 A sensitivity of 0.01g to 120 g)).The concentration of SPM was calculated in µg m-3.

Bacterial sampling

Air using Handy Air Sampler APM 821 was made to pass through known volume of sterile water for 10 minutes. This impinged water was inoculated into the petriplates (diameter 10 cm) containing Nutrient Agar, MacConkey Agar and BTB

Lactose Agar media. Three different media were used so that maximum possible bacteria in air can be quantified. Quantitative evaluation of bacteria (CFU (Colony forming unit) m-3) was done using these media. Bacterial cultures were incubated at 37°C for 24-48 hr. Cycloheximide was added as fungicide at the concentration of 100 μg ml-1.

A control set for each culture media was prepared to detect contamination (if any). Moreover, the autoclaved distilled water before inoculation was also poured in petriplates to detect any kind of contamination.

Bacteria were stained using Gram's staining technique.

Socio-personal survey

The socio-personal survey was conducted to evaluate the general state of house by Questionnaire/interviewed method. During the survey, one individual in each household was interviewed. The questions asked were status of cigarette smoking, health condition of different members of family etc. Data was interpreted by using percentage basis.

Data of SPM and bacteria was compiled to calculate average values with standard deviation using Microsoft Excel. Reported comparisons and correlation coefficients (r) were considered significant when $p<0.05$ and it was calculated using statistical packages of SPSS 10.0.

3 Results and Discussion

3.1 Average indoor SPM in households of urban and area of Jammu

The analysis of data of average indoor SPM in the households located at different sites of the urban area of Jammu during two year study period revealed that all the households exhibited significantly higher values ($p<0.05$) during second year study period as compared with that of first year study period. On the contrary, Gupta et al. (2003) while studying SPM in Jamshedpur city reported the highest values during first year study period (1995) and lower values during second year study period (1997-1998). Similarly, Chelani and Devotta (2007) observed decrease in SPM in Delhi from 2000 to 2003 due to shift to Compressed Natural Gas in vehicles.

Indoor SPM in urban area revealed that the households of urban Residential area (UZII) exhibited minimum (584.53±58.5 μg m-3) value of indoor SPM during first year study period whereas, the household located near National Highway I-A (UZIV) exhibited the maximum (1700.16±506.95 μg m-3) value of indoor SPM during second year study period (Table I).

Two room Accommodation Households located in/near	Average indoor SPM (μg m-3) during							
	I Year study period in (2008-2009)				II Year study period in (2009-2010)			
	Living Room	Kitchen	Bedroom	Household	Living Room	Kitchen	Bedroom	Household
Residential Area (UZI)	[illegible]	[illegible]	[illegible]	584.53±58.5	[illegible]	[illegible]	[illegible]	[illegible]
Commercial Area (UZII)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Crossings (UZIII)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
National Highway I-A (UZIV)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1700.16±506.95
Average One room Accommodation Household (UZV)	-	-	-	[illegible]	-	-	-	[illegible]
Average two room Accommodation Household(I)	[illegible]	1141.96±240.4	[illegible]	[illegible]	[illegible]	1524.34±457.39	[illegible]	[illegible]
Average Household of Study Area(I)	-	-	-	[illegible]	-	-	-	[illegible]
Average Household of Study Area(II)	-	-	-	[illegible]	-	-	-	[illegible]

The average value of indoor SPM in the average kitchen in the household of urban area exhibited highest value in both first year (1141.96±240.4 μg m-3) as well as second year (1524.34±457.39 μg m-3) study period. (Table I). Similarly to present study, Cheng et al. (2006) also reported higher concentrations of PM10 in kitchens as compared to that of living rooms and bedrooms in homes of Guiyang City, People's Republic of China. Rampal and Abrol (2007) found that kitchen exhibited highest level of SPM followed by drawing room and bed room in the households located in the older part of Jammu city. Likewise, Ahuja et al. (1985) reported alarmingly high concentration of pollutants in Indian kitchens.

On the comparative basis, the average one room accommodation household exhibited higher value of indoor SPM as compared with that of average two room accommodation household in the urban area during both first as well as second year study period (Table I). These findings indicated that biomass burning for cooking contributed significantly to indoor particulate (Jiang and Bell, 2008).

All the households in the urban area exhibited value of indoor SPM above the permissible limits as prescribed by the Central Pollution Control Board (CPCB), India. Mohan et al. (1992) while studying indoor air quality of Pune and Ghose et al. (2005) while assessing ambient air quality of kolkata also reported SPM levels above permissible limits. Chattopadhyay et al. (2007) found that mean concentration of particulate matter of size ≤10 μm ranged from 535.9 to 1114.5 μg m^{-3} were above permissible limit set by CPCB in Kolkata. Joshi and Mishra (1998) also observed that annual average concentration of SPM exceeded the prescribed limit set by CPCB in commercial and residential areas of the Indore town. But Dutta and Meena (2008) in their study of air quality of Ajmer city observed that concentration of SPM was below air quality standards at residential and industrial zones where as at traffic, commercial and sensitive zones it exceeded the prescribed standards.

In the present study, higher indoor SPM values, which were above the permissible limits in households of urban area were credited to high traffic rate, constructional and renovational activities at regular intervals, surrounding environment and type of fuel for cooking. (Jiang et al., 2004; Chattopadhyay et al., 2007).

3.2 Analysis of bacterial count in households of urban area of Jammu

Indoor bacterial count in households of urban area revealed that two room accommodation households located in commercial area (UZII) exhibited highest value (6285±1351.99 CFU m^{-3}) during first year study period and household located near National highway I-A (UZIV) exhibited highest value (9478.5±3711.6 CFU m^{-3}) during second year study period (Table II).

Annual variations in Average number of Bacteria (CFU m^{-3}) in the Indoor air of the Households located in Urban Area of Jammu during the two year study period

Two room Accommodation Households located in/near	Average number of Bacteria (CFU m-3) during							
	I Year study period in (2008-2009)				II Year study period in (2009-2010)			
	Living Room	Kitchen	Bedroom	Household	Living Room	Kitchen	Bedroom	Household
Residential Area (UZI)	4171.5±1348.39	4408.5±1718.2	4282.5±7700.4 (?)	5091.5±181.75	5876±909.34	7373.5±1796.25	6781±982.78	6664±518.64
Commercial Area (UZII)	6181.5±1351.28	6230.5±1455.34	6440±1349.37	6285±1351.99	8379±974.39	7399±2520.15	6571.5±1003.2	7621±815.77
Crossings (UZIII)	3438±2182.33	6376±1404.82	2181±680.73	2724±981.24	8702±417.19	7849.5±4282.77	8435±1797.47	8284±2163.36
National Highway I-A (UZIV)	3764.5±1882.92	4768.5±1274.91	1652±171.94	4042±931.97	11005±3744.34	8081±1276.85	9331±2003.89	9478.5±3711.6
Average One room Accommodation Household (UZV)	-	-	-	10209.17±1407.35 (?)	-	-	-	11771.33±1207.61
Average two room Accommodation Household(I)	[illegible]	6094.38±1272.51	2889.38±787.87	7790.63±8723.3 (?)	8488.25±2964.11	7656.25±2098.47	7777.13±2337.49	7936.88±1992.31 (?)
Average Household of Study Area(II)	-	-	-	6074.4 ±2085.79 (?)	-	-	-	9120.2±3232.26 (?)

All Households showing significant annual difference (p<0.05) at same site, between different sites and between sub-sites

In the average household in urban area kitchen exhibited highest value (6094.38±1272.51CFU m-3) during first year study period and living room exhibited highest value (8488.25±2964.11 CFUm-3) during second year study period (Table II). Colbeck et al. (2008) observed higher CFU m^{-3} inside living rooms than kitchens while studying indoor air quality at rural and urban sites in Pakistan. Yassin and Almouqatea (2010) concluded that higher the number of residents confined to small space, higher would be the build up of airborne microbes shed by human body. Moreover, kitchens have more nutrients available for bacteria to exist naturally, therefore, resulting in higher concentration of organisms in kitchens.

The average one room accommodation household exhibited higher value of bacterial count as compared with that of two room accommodation household during both first as well as second year study period. (Table II). Nasir and Colbeck (2010) also reported bacterial and fungal aerosol concentration higher in housing type III (Two room or three room bed roomed houses) as compared with that of type I (Single room in shared accommodation).

The value of relative humidity varied between 69 to 76% during the two year study period.

3.3 Socio-personal survey of the respondents

65% of households had individuals who smoke and 60% of respondents reported headache, sore throat, nausea, sneezing to occur when they spent long periods of time indoors. Crespin (1994) studied that the high levels of certain ambient air contaminants, tobacco smoke, indoor allergens and agricultural pesticides can aggravate asthmatic symptoms. Gupta et al. (2007) observed 78% subjects in study group had symptoms like redness, watering, irritation strain or photophobia due to exposure to high level of air pollution on ocular surface. Lac[asana et al.] (2005) concluded that an increase of 10 μg m-3 of particle concentration (measured in PM10) was associated with 22% for post neonatal mortality for respiratory diseases.

3.4 Statistical analysis of data of SPM and bacterial count

The critical statistical analysis of data of SPM in all households showed significant annual difference ($p<0.05$) between different sites whereas, bacteria showed significant annual difference ($p<0.05$) at same site, between different sites and between subsites. The two room accommodation households in urban area showed irregular trends of correlation between SPM and bacterial count at different sites during two year study period which implies that SPM cannot be considered as a single factor determining the bacterial concentration (Table III).

Correlation of SPM with Bacteria (CFU m^{-3}) in the Households located in Urban Area of Jammu during the two year study period.

Two room Accommodation Households located in/near	I^{st} Year study period in (2008-2009)	II^{nd} Year study period in (2009-2010)
Residential Area (UZ_I)	0.33	0.82
Commercial Area (UZ_{II})	-0.94	0.89
Crossings (UZ_{III})	1.0	0.16
National Highway I-A (UZ_{IV})	0.78	-0.99
Average One room Accommodation Household (UZ_V)	-0.92	0.41

Bacterial concentrations may vary due to changes in occupant dress and activities as well as ventilation patterns during cooling and heating seasons (Tsai et al., 2002). Moreover, the source of SPM, environmental factors and stresses also influence the bacterial numbers (Franzetti et al., 2011).

The average one room accommodation household exhibited significant higher values of SPM and bacterial count as compared with that of two room accommodation household in the urban area during both first as well as second year study period. One room accomodation exhibited significant positive correlation between SPM and bacteria. Subramanyam et al. (1999) observed definite positive correlations of occurrence of different microbes with PM10 in Chennai City. Mancinelli and Shulls (1978),too while analysing the bacteriological quality of urban air, calculated statistically significant correlations between the number of viable bacteria isolated and suspended particulate pollutants (+0.56). besides them, Wu et al. (2012) also observed statistically significant relationships between ambient bacteria and PM10 in Taipei.

4 Conclusions

All the households exhibited significantly higher values during second year study period as compared with that of first year study period were due to increase in traffic rate, constructional and renovational activities at regular intervals.

Cooking was most important source of indoor SPM in the average kitchen in the household of urban area. Smoke generation from combustion of biomass fuels contributed significantly to higher level of indoor particulate in the average one room accommodation household.

The households selected during the present study had differences in number of occupants, their eating habits and various outdoor sources which should be the reasons for irregular trends of correlation between SPM and bacteria. Everyday activities result in significant changes in number and types of bacteria. The indoor environments in the households may contain dead or dormant bacteria but this study reveals only those culturable bacteria which can grow on above mentioned culture medias. Although dead bacterial forms cannot cause any disease but they are potential source of allergic reactions. Presence of pathogenic bacteria and bacterial endotoxins can cause harmful effects on human health. They are likely to be of significance for health implication.

In the present study an attempt has been made to assess the SPM and bacteria in households of urban area, so that suggestive measures regarding abatement strategies can be framed. The data presented may be helpful in terms of ecology and prevention of health problems. This study has provided baseline information on urban households in northern India. This may be useful for making comparisons in future studies between indoor air and outdoor air, urban and suburban areas.

Acknowledgment
We would like to express our sincere gratitude to UGC fellowship provided by Govt. of India.

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