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ASSESSMENT OF SUSPENDED PARTICULATE MATTER (SPM) LEVEL IN THE HOUSEHOLDS OF OLD JAMMU CITY, J&K

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ABSTRACT

The paper deals with assessment of indoor SPM levels in various households located in different areas of old Jammu city. Within each household indoor SPM in bedrooms, drawing rooms and kitchens was evaluated. From the above study, it can be concluded that kitchens of the study area have higher values of SPM (715.65 ± 233.71 µg/m^3) followed by drawing rooms (612.79 ± 213.20 µg/m^3) and bedrooms (608.59 ± 219.15 µg/m^3). The overall average of the ambient indoor SPM level in the studied households is 645.68 ± 221.78 µg/m^3.

INTRODUCTION

All the self-balanced natural ecosystems are affected by man induced environmental changes. Man is responsible for deteriorating quality and standard of natural environment leading to its pollution.

Air pollutants can pollute both, the indoor and outdoor environment. Indoor air pollution can be traced to prehistoric times when man first moved to temperate climate and used fire for cooking, warming and lighting. Indoor air pollution, a major health problem in industries, has now been recognized as a significant problem in homes and offices in urban areas. A large number of people spend more than 90% of their time indoors particularly women who spend a considerable amount of time in kitchens, which are high-risk zone in most of the homes so far as indoor air pollution is concerned. Depending upon the type of fuel and burning conditions various inorganic gases, particulates and hydrocarbons are produced. Gas stoves burn at a temperature ranging from 800 to 1200°C. Air reacts with flame to produce a variety of gases such as nitrogen oxides, CO, SO_2 and respirable suspended particulate matter (PM_{10} and $PM_{2.5}$). It has been reported that 30 % of urban households and 90 % of rural households in developing countries use biomass fuels for cooking (Hughart 1979).

Any solid or liquid droplet with diameter between ~0.002µm and ~100µm is termed as particulate matter. But nowadays in the age of modernization and industrialization, its everincreasing concentration and changing chemical composition makes it responsible for collapsing public health (Perkins 1974). Particulate matter is produced by natural as well as anthropogenic sources. Among the many pollutants highlighted for adverse health effects, particular attention has been focused recently on fine particulate matter (Schwartz 1994, Dockery & Pope 1994, Pope et al. 1995). Dockery and Pope (1994) reported that for every 10µg/m^3 increase in concentration of particulate matter of < 10 µm in diameter, there is an estimated increase in mortality of 0.6-1.6%.

MATERIALS AND METHODS

The study was conducted in the households located in different areas of old Jammu city. The specific study area was divided into five sites- (I) households located on ground floor in residential areas, (II) households located on first floor in residential areas, (III) households located on ground floor in commercial areas, (IV) households located on first floor in commercial areas, and (V) households

located on second floor in residential areas. At each site five households were sampled to assess the indoor SPM levels in kitchen, drawing room and bedroom. Sampling of air for collecting SPM was done with the help of Handy Air Sampler Envirotech APM-821, using millipore filter paper with diameter of 25 mm., type AA and pore size 0.8 µ. Precisa balance XB 120A with sensitivity of 0.01 g to 120 g with LCD display was used for weighing the filter paper before and after sampling. Sampling was done for 8 hours at each site and level of indoor SPM was calculated and expressed in µg/m^3 by using following formula:

$$\text{SPM } (\mu g/m^{3)} = \frac{W_2 - W_1 \times 10^3}{T\,(R_2 + R_1)/2}$$

Where, W_1 = Initial weight of the filter paper in mg, W_2 = Final weight of the filter paper in mg, R_1 = Initial flow rate of the sampler, R_2 = Final flow rate of sampler, T = Time of sampling in minutes. Flow rate of the air was read in units of LPM from the instrument which was converted to m^3/min before calculation by using conversion formula.

RESULTS AND DISCUSSION

The analysis of collected data revealed that kitchens in the households, irrespective of their location, exhibited higher levels of indoor SPM of 715.65 ± 233.71 µg/m^3 as compared to that of bedrooms and drawing rooms (Table 1). Long et al. (2000) also demonstrated that indoor fine particle concentration in nine homes of Boston area was significantly elevated during cooking and other general indoor activities involving combustion. The analysis further revealed that bedrooms of the study area have average indoor SPM of 608.59 ± 219.15 µg/m^3, and drawing rooms 612.79 ± 213.20 µg/m^3.

Critical analysis of the collected data further revealed that kitchens without exhaust fan exhibited higher (772.88 ± 309.81 µg/m^3) indoor SPM as compared with that of kitchens with exhaust fan

Table 1: Indoor SPM level in households located in different areas of the old Jammu city.

Sites	SPM µg/m^3			Average SPM in Households (µg/m^3)
	Bedroom	Drawing Room	Kitchen	
Households located in ground floor of residential areas	718.25 ± 37.85 (683.06-757.50)	704.28 ± 63.43 (631.31-746.26)	781.70 ± 24.45 757.50-806.40)	734.75 ± 52.75 (631.31-806.4)
Households located in first floor of residential area	693.19 ± 124.53 (595.2-833.33)	587.84 ± 29.30 (555.55-612.74)	595.35 ± 115.12 (462.98-672.04)	625.46 ± 99.98 (462.98-833.33)
Households located in ground floor of commercial area	853.90 ± 45.61 (806.45-897.43)	871.33 ± 130.25 (735.29-994.90)	1059.42 ± 207.75 (870.64-1282.0)	928.22 ± 159.03 (735.29-1282.02)
Households located in first floor of commercial area	404.99 ± 188.43 (245.09-612.74)	622.14 ± 97.05 (520.83-714.28)	675.56 ± 33.92 (651.04-14.28)	567.76 ± 164.08 (245.09-714.28)
Households located in second floor of residential area	372.59 ± 130.05 (245.09-505.05)	278.38 ± 72.70 (234.74-362.31)	466.19 ± 151.38 (378.79-641.0)	372.38 ± 133.76 (234.74-641.0)
Average household in the study area	608.59 ± 219.15 (245.09-897.43)	612.79 ± 213.20 (234.74-994.90)	715.65 ± 233.71 (378.79-1282.0)	645.68 ± 221.78 (234.74-1282.0)

Table 2: Indoor SPM in kitchens of households of old Jammu city.

	Site	SPM (μg/m^3)
1a	Kitchens with LPG gas and exhaust fan	590.29 ± 168.25
1b	Kitchens with LPG gas and without exhaust fan	772.88 ± 309.81
2a	Kitchens in residential areas	688.53 ± 126.33
2b	Kitchens in commercial areas	733.72 ± 291.03
3a	Kitchens on ground floor	920.57 ± 201.59
3b	Kitchens on first floor	635.46 ± 87.70
3c	Kitchens on second floor	466.19 ± 151.38

Table 3: Indoor SPM in drawing rooms of old Jammu city.

	Site	SPM (μg/m^3)
1a	Drawing rooms located towards the street	600.63 ± 210.06
1b	Drawing rooms located away from the street	626.70 ± 232.72
2a	Drawing rooms in residential areas	523.50 ± 197.19
2b	Drawing rooms in commercial areas	746.73 ± 170.83
3a	Drawing rooms on ground floor	787.81 ± 129.49
3b	Drawing rooms on first floor	604.99 ± 66.81
3c	Drawing rooms on second floor	278.38 ± 72.70
4a	Drawing rooms installed with fan	528.18 ± 217.21
4b	Drawing rooms installed with fan and cooler	688.68 ± 70.15

(590.29 ± 168.25 μg/m^3). Data further revealed that kitchens in commercial areas have higher values of indoor SPM of 733.72 ± 291.03 μg/m^3 as compared to indoor SPM of 688.53 ± 126.33 μg/m^3 in kitchens located in residential areas. The indoor SPM level in the kitchens was observed to decrease with location of kitchens on higher floors as revealed by the fact that the kitchens on the ground floor have an average indoor SPM level of 920.57 ± 201.59 μg/m^3, kitchens on the first floor 635.46 ± 87.70 μg/m^3, and kitchens on second floor 466.19 ± 151.38 μg/m^3 (Table 2).

Critical analysis of the indoor SPM level of drawing rooms of the study area revealed that the rooms located away from the street exhibited higher indoor SPM than that of drawing rooms located towards the street. Drawing rooms of the households located in commercial areas exhibited higher indoor SPM of 746.73 ± 170.83 μg/m^3 whereas drawing rooms of the households located in residential areas exhibited lower level of 523.50 ± 197.19 μg/m^3. Drawing rooms also exhibited decreasing values of indoor SPM with increasing floors of the households. The average indoor SPM level was observed to have higher value of 688.68 ± 70.15 μg/m^3 in the drawing rooms installed with fan and cooler, and lower values of 528.18 ± 217.21 μg/m^3 in the drawing rooms installed with only fan (Table 3).

Critical analysis of indoor SPM level of bedrooms of study area revealed the trends similar to that of drawing room i.e., bedrooms of the households located away from street exhibited higher values as compared with that of bedrooms in households located near the street. The bedrooms of the households located in commercial area exhibited higher value of 629.45 ± 274.76 μg/m^3 whereas bedrooms of the households located in residential areas exhibited lower value of 594.68 ± 190.57 μg/m^3. Bedrooms also exhibited decreasing level of indoor SPM with increasing floors. Bedrooms of households installed with fan and cooler were observed to have higher value of 644.12 ± 72.75 μg/m^3 as compared with indoor SPM level of bedrooms installed with only fan. The bedrooms of the

Table 4: Indoor SPM in bedrooms of old Jammu city.

	Site	SPM (μg/m^3)
1a	Bedrooms located towards the street	377.21 ± 191.47
1b	Bedrooms located away from the street	697.72 ± 164.43
2a	Bedrooms in residential areas	594.68 ± 190.57
2b	Bedrooms in commercial areas	629.45 ± 274.76
3a	Bedrooms on ground floor	786.08 ± 831.14
3b	Bedrooms on first floor	549.15 ± 212.93
3c	Bedrooms on second floor	372.59 ± 130.05
4a	Bedrooms installed with fan	656.68 ± 232.38
4b	Bedrooms installed with fan and cooler	654.12 ± 72.75
4c	Bedrooms installed with air conditioners	301.11 ± 79.23

households installed with air conditioners exhibited least value of SPM, 301.11 ± 79.29 μg/m^3 (Table 4).

The analysis of data further revealed that sources of indoor SPM were both external and internal e.g., the bedrooms located towards the street exhibited lower values of SPM as compared with bedrooms located away from the street. From the above study, it can be concluded that kitchens of the study area exhibit higher values of SPM (715.65 ± 233.71 μg/m^3) followed by drawing rooms (612.79 ± 213.20 μg/m^3) and bedrooms (608.59 ± 219.15 μg/m^3). The data also show that average ambient indoor SPM level in the studied households is 645.68 ± 221.78 μg/m^3 with a range of 234.74 - 1282.0 μg/m^3.

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