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Assessment of Indoor Particulate Matter During Dusting by Household Women and Associated Health Impacts

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Abstract: The present study describes the monitoring of Particulate Matter (PM) concentration during broom dusting by house hold women and their associated health impacts. Monitoring was carried out at nine sampling stations with variable flour structures. Before, during and after dusting PM1.0, PM2.5, PM4.0 and PM10 fractions of the particulate matter were estimated. On the average basis PM1.0, PM2.5, PM4.0 & PM10 concentration ranged from 214.3-289.0, 248.3-360.3, 294.7-412.6 and 439-517 $\mu g/m^3$, before dusting; 420.2 -644.3, 496.0 – 695.0, 550.7-717.0 and 609.7 – 752.3 $\mu g/m^3$ during dusting and 253.0-353.7, 315.7-421.4, 373.3-509.6 and 405.3-551.0 $\mu g/m^3$, respectively, after dusting. Analysis of Variance (ANOVA) depicted that on average basis the PM concentrations differ significantly with p-value < 0.05. Furthermore, it was found that before and after dusting the PM concentrations differ non significantly with reference to the sampling points with p-value $0.1 > 0.05$, whereas significant difference was depicted for PM concentrations with reference to defined sampling points on the average basis with p-value <0.05. The associated socio-epidemiological impacts were also assessed and it was found that during dusting majority of the respondents do not use mouth covers, consequently they are facing cough related problems.

Key words: Indoor pollution · Particulate matter · Socio-epidemiological impacts · Correlation

INTRODUCTION

Although healthy air consists mainly of mixture of gases yet it is becoming polluted day by day with the addition of air pollutants. Currently, air pollution has become a topic of great debate because of the enhanced anthropogenic activities which add substances like particulate matter that causes severe epidemiological impacts on human being along with many other living organisms [1-4]. The levels of particulate matter and gaseous pollutants in air usually determine the quality of air [5]. The particulate matter usually consists of many heterogeneous substances varying in source, size, composition and surface area etc. The environmentalists give much emphasis on the PM10 and PM2.5 with particle diameter lesser than 10 and 2.5 micron, respectively [6-8]. The particulate matter originates from different sources and affects human health and in turn standard of social life [9]. A number of epidemiological impacts of the particulate matter pollution include asthma, headache, breathing problem, itching and cough [10]. The reactive oxygen radicals may originate from dust particles and can cause different acute and chronic toxic effects on the respiratory system [11]. It has been established that the fine particulate matter has strong association with many serious health effects. Beyond certain levels PM2.5 may cause severe diseases like respiratory infections, heart attack, asthma and immature death [12]. Children and elders are depicted to be most vulnerable to the diseases caused by PM2.5 [13-18]. Different respiratory diseases are the most common and may results because of the accumulation of particulate matter with different size fraction in different parts of the respiratory track [19-21]. At least 4 to 5 million cases of chronic bronchitis and

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500,000 premature deaths are being reported each year [22]. Furthermore, it is ascertained that 4-8% premature deaths on the global scale are because of the interaction with high levels of particulate matter in ambient air [23].

Since most of the house hold women, their babies and elders of middle and lower middle class spend most of their time inside their homes and they are more vulnerable to the indoor particulate matter pollution [24]. Studies have been performed to assess the health effects of indoor air pollutants on infants and children [25-30], but little information is available regarding the impact of indoor PM pollution on the health of household women. Although, mounting evidence is available regarding the significant association between indoor particulate matter pollution and severe epidemiological impacts yet the policy makers are paying little attention to it [31-33].

There is dire need to have comprehensive monitoring of particulate matter pollution originating from various sources to evaluate their possible health implications and then to suggest suitable recommendations based on the findings. Present study was therefore designed with the objective to estimate particulate matter concentration during dusting with brooms by the house hold women and focus was solely on the houses of middle and lower middle class families with variable floor structures. The idea was to monitor the particulate matter that pollute the indoor atmosphere and may pose severe socio epidemiological impacts on to the working women and even to the other family members (most importantly the children); as a result of broom dusting.

MATERIALS AND METHODS

The Whole Study Was Carried out in Following Steps

Selection of Sampling Points: In order to meet with the defined objectives of the study and to estimate levels of particulate matter sampling points were identified based on careful survey in district Gujranwala, Punjab, Pakistan. Three types of sampling points were selected with different floor structure. Each type covered three houses and focus was toward the houses of middle and lower middle class families. First, second and third type of sampling point was characterized by houses with floor structure made up of marble, bricks and clay, respectively. Particulate matter estimations were then carried out at defined sampling points.

Particulate Matter Monitoring: Dust Track ™ ii Aerosol Monitor (model 8530), a light scattering laser photometer was employed to monitor the concentration of different particulate matters like PM1.0, PM2.5, PM4.0 and PM10.0 [34]. The monitoring of particulate matter was carried out at all the selected sampling stations using iso-kinetic conditions. All the estimations were carried out thrice, before, during and after dusting.

Assessment of Socio-epidemiological Impacts: For the socio-epidemiological impacts' assessment, the respondents (house hold women) were thoroughly interviewed randomly based on a comprehensive questioner to extract the maximum information regarding the socio-epidemiology upon interaction with the particulate matter. The findings about the socio-epidemiological impacts of indoor particulate matter pollution during broom dusting were then reported based on the information provided by more than 170 respondents during a comprehensive survey.

Statistical Analysis: All the findings of the research were analyzed by ANOVA, multiple comparisons, correlation studies along with other descriptive statistics using statistical software (SPSS).

RESULTS AND DISCUSSIONS

During present study PM concentrations were estimated before dusting, during and after dusting at defined sampling points and results are described as mean values along with standard deviations.

Particulate Matter Levels: Before dusting, PM1.0, PM2.5, PM4.0 and PM10 concentration at the sampling points SP1-SP9 were found in the range 214.3-289.0 μg/m^3, 248.3-360.3 μg/m^3, 294.7-412.6 μg/m^3 and 439-517 μg/m^3, respectively. The PM1.0 concentrations at various sampling point SP1, SP2, SP3, SP4, SP5, SP6, SP7, SP8, SP9 were depicted to be 214.3±2.5, 257.0±9.8, 230.7±3.1, 273.3±6.1, 260.5±2.5, 284.0±6.0, 221.7±2.5, 250.3±5.5 and 289.0±3.6 μg/m^3, respectively, whereas, PM2.5 concentrations were found to be 249.0±2.0, 291.7±4.2, 260.7±3.5, 302.0±5.7, 286.0±9.2, 360.3±10.0, 248.3±3.1, 277.7±2.5 and 311.6±2.5 μg/m^3 respectively. On the other hand estimated levels of particulate matter at same sampling points before dusting were 350.7±5.5, 348.6±3.5, 294.7±4.9, 412.6±2.1, 346.3±3.2, 391.3±9.9, 354.2±8.1, 302.0±2.0 and 382.0±7.2 μg/m^3 respectively, for PM4.0 and 449.0±7.8, 454.0±3.1, 499.1±1.5, 517.0±4.5, 487.0±6.2, 508.0±3.2, 479.2±4.7, 504.0±1.5 and 439.0±4.5 μg/m^3, respectively for PM10. Before dusting, the orders of PM1.0, PM2.5, PM4.0 & PM10 concentrations at different

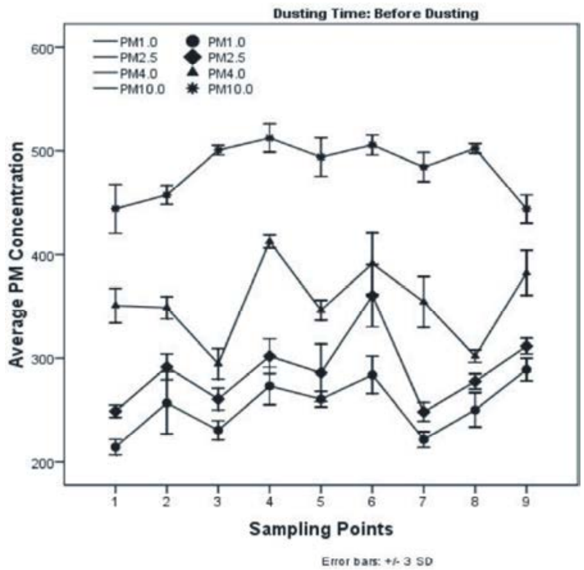

Fig. 1: Particulate Matter Concentration (µg/m^3) at selected sampling points before dusting

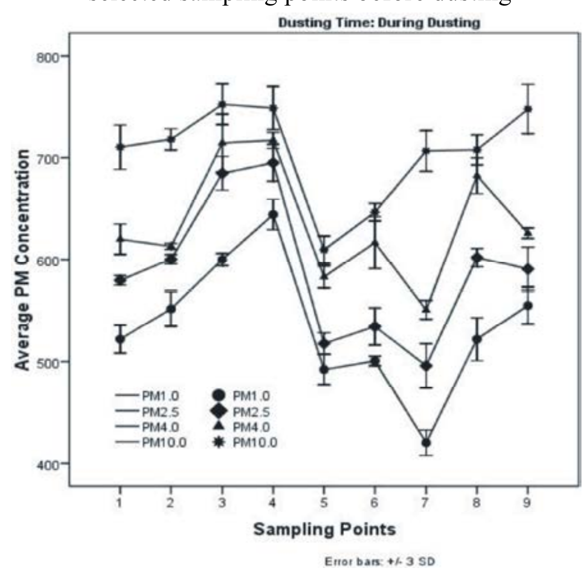

Fig. 2: Particulate Matter Concentration (µg/m^3) at selected sampling points during dusting

sampling point were SP9› SP6› SP4› SP5› SP2 ›SP8› SP3› SP7› SP1, SP6› SP9› SP4› SP2› SP5› SP8› SP3› SP1› SP7, SP4› SP6› SP9› SP7› SP1› SP2› SP5› SP8› SP3 and SP4› SP6› SP8 ›SP3 ›SP5› SP7 ›SP2› SP1 ›SP9, respectively (Fig 1).

The levels of PM with different size fractions were also evaluated during dusting at all the sampling points i.e. SP1, SP2, SP3, SP4, SP5, SP6, SP7, SP8, SP9 and found to be 522.0±4.6, 551.7±5.7, 600.0±2.0, 644.3±4.9, 492.2±4.8, 500.6±1.5, 420.4±4.1, 522.0±7.0 and 555.0±6.0, µg/m^3 respectively, ranging from 420.2 -644.3 µg/m^{3}for PM1.0 with order SP4 ›SP3 ›SP9› SP2› SP1› SP8 ›SP6› SP5 ›SP7; 579.6±1.5, 600.3±1.5, 684.7±5.5, 695.0±6.0, 517.7±3.5, 534.3±6.0, 496.0±7.2, 602.0±3.0,590.7±7.2 µg/m^3, respectively ranging from 496.0–695.0 µg/m^3 for PM2.5 with order SP4›SP3› SP8› SP2› SP9› SP1› SP6› SP5› SP7; 620.0±5.0, 613.0±1.0, 714.3±9.5, 717.0±2.6, 583.0±3.6, 616.7±8.5, 550.7±3.1, 682.3±5.8,626.0±1.7 µg/m^3 respectively ranging from 550.7-717.0 for PM4.0 with order SP4› SP3› SP8› SP9› SP1› SP6› SP2› SP5› SP7 and 710.3±7.2, 718.0±3.5, 752.3±6.6, 748.6±7.0, 609.7±4.5, 646.7±2.9, 706.6±6.6, 707.7±4.9, 747.5±8.0 µg/m^3 respectively ranging from 609.7 – 752.3 µg/m^3 for PM10 and with order of SP3› SP4› SP9› SP2› SP1› SP8 › SP7› SP6 (Fig. 2).

Comparative to PM concentration before and during dusting the estimated ranges for PM1.0, PM2.5, PM4.0 and PM10 for all the sampling points after dusting were depicted to be 253.0-353.7 µg/m^3, 315.7-421.4 µg/m^3, 373.3-509.6 µg/m^3 and 405.3-551.0 µg/m^3, respectively. The depicted levels of PM1.0 at SP1, SP2, SP3, SP4, SP5, SP6, SP7, SP8, SP9 after dusting were 306.3±5.1, 253.0±9.8, 318.7±3.2, 292.0±5.3, 309.7±5.1, 297.3±3.2, 353.7±7.8, 331.7±7.6 and 339.0±1.7 µg/m^3, respectively with the concentration order at different sampling points SP7› SP9› SP8› SP3› SP1 ›SP5› SP6› SP4› SP2, for PM2.5 401.3±3.2, 383.2±5.0, 376.0± 6.2, 315.7± 3.5, 412.0± 3.0, 353.3±3.0, 421.3±1.5, 391.0±2.6, 386.3±3.2 µg/m^3 respectively with sampling point wise concentration order SP7› SP5› SP1› SP8› SP9› SP2› SP3› SP6› SP4, for PM4.0; 473.7±5.1, 399.0±1.0, 419.0±1.7, 373.3±3.8, 456.3±3.8, 395.0±4.6, 509.7±8.7, 419.7±2.1 and 437.0±2.6 µg/m^3 respectively with order of concentration SP7› SP1› SP5› SP9› SP8› SP3› SP2› SP6› SP4 and for PM10 506.7±6.1, 464.3±5.1, 405.3±4.7, 498.4±2.1, 503.0±2.6, 544.7±1.5, 546.7±2.9, 475.7±5.9, 484.7±6.1 µg/m^3, respectively, whereas the order of concentration with respect to defined sampling points for PM was found to be SP7› SP6› SP5 ›SP1 ›SP4› SP9 ›SP8› SP2 ›SP3 (Fig 3).

Statistics Evaluation: The estimated PM levels before, during and after dusting were subjected to the Analysis of Variance (ANOVA) and it was found that on average basis the PM concentrations differ significantly with p-value<0.05. Furthermore, multiple comparisons were also checked for the PM levels on average basis and it was found that for PM1.0, PM2.5, PM4.0 and PM10 levels, the mean difference was significant at the 0.05 level during all sampling conditions i.e., before, during and after dusting (Table 1).

Table 1: ANOVA for PM concentration (A) before dusting (B) during dusting & (C) after dusting

(A)

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	829612.620	3	276537.540	280.177	.000
Within Groups	102649.037	104	987.010		
Total	932261.657	107			

(B)

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	426165.741	3	142055.247	42.316	.000
Within Groups	349131.333	104	3357.032		
Total	775297.074	107			

(C)

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	473296.102	3	157765.367	120.687	.000
Within Groups	135951.556	104	1307.226		
Total	609247.657	107			

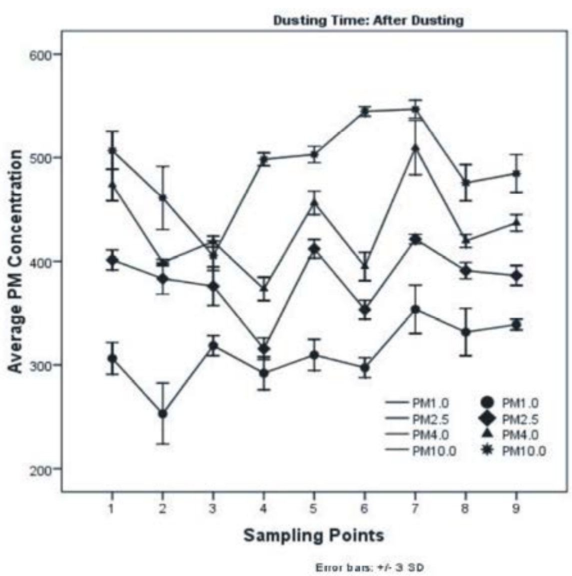

Fig. 3: Particulate Matter Concentration (μg/m^3) at selected sampling points after dusting

Analysis of variance was also performed for the estimated results regarding PM concentrations to find their significant difference with reference to the sampling points and it was observed that before and after dusting the PM concentration differs non significantly with reference to the sapling points with p-value 0.1>0.05, whereas significant difference was found for PM concentrations with reference to defined sampling points on the average basis with p-value <0.05 (Table 2).

Before dusting, sampling point wise multiple comparisons showed a non significant difference at all the sampling points for PM levels with different size fractions with p-values >0.05 on average basis. Similarly, non significant difference was depicted for PM concentrations.

The comparison of PM concentrations at sampling point 1 during dusting, with those estimated at sampling points 2, 6, 8 and 9 show non significant difference for those of PM concentrations with p-values 0.657, 0.245, 0.475 and 0.447 >0.05 respectively, whereas, significance difference among PM concentrations estimated at sampling point1 was noted when compared with PM concentrations at sampling point 3, 4, 5 and 7 with p values 0.006, 0.002, 0.048 and 0.026<0.05, respectively. Likewise the PM concentrations showed significance difference at sampling point 2 when compared with those estimated at sampling point 3, 4, 5 and 7 with p values 0.021, 0.006, 0.016 and 0.008<0.05, respectively. However, at other sampling points the difference was non significant with p value>0.05. PM concentration at sampling point 3 showed significance difference when compared with PM concentration at all other sampling points except sampling point 4 with p values <0.05. Similarly PM concentration depicted at sampling point 4 showed significant differences comparative to their levels at sampling point 5-9. PM levels at sampling point 5 differ significantly with respect to sampling point 8 and 9 with p-values <0.05, whereas, a non significant difference was found when compared with the PM concentration at sampling point 6 and7 with p values i.e., 0.405, 0.800 >0.05. Non significant difference was also depicted for PM concentration at sampling point 6 compared to these estimated at sampling point 7, 8 and 9 with p-values i.e., 0.279, 0.062 and 0.056 >0.05. On the other hand PM concentration was significantly different with p values

Table 2: ANOVA for PM concentration with reference to sampling points (A) before dusting (B) during dusting & (C) after dusting

(A)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	55700.241	8	6962.530	.786	.616
Within Groups	876561.417	99	8854.156		
Total	932261.657	107			

(B)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	289365.741	8	36170.718	7.369	.000
Within Groups	485931.333	99	4908.397		
Total	775297.074	107			

(C)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	74852.741	8	9356.593	1.733	.100
Within Groups	534394.917	99	5397.928		
Total	609247.657	107			

0.004 and 0.003<0.05 when compared with those found at sampling point 8 and 9, whereas, a non significant difference was observed for PM concentration at sampling point 8 compared to the PM concentration at sampling point 9 with p value 0.963>0.05 during dusting on the average basis. The multiple comparisons of the PM concentration after dusting at 9 sampling points was also carried out and it was depicted that PM concentration at sampling point 7 differ significantly with those estimated at sampling points 2, 3, 4 and 6 with p values 0.006, 0.011, 0.004 and 0.047 <0.05, respectively, after dusting on average basis. A non significant difference was observed for PM concentration at different sampling points with p-values > 0.05 level when compared to that at all other sampling points.

To check the interrelation between different size fractions of PM correlation estimated before, during and after dusting, the data was subjected for Pearson Correlation and on average basis significant correlation was found for PM1.0 concentration during dusting and after dusting with p-value 0.027<0.05. Significant correlation was also depicted for PM2.5 concentration estimated before and during dusting with those estimated after dusting with p-values 0.002 and 0.000<0.05, respectively. The only significant difference for PM4.0 and PM10 concentration was depicted during and after dusting with p-value 0.000 and 0.007<0.05, respectively.

Socio-Epidemiological Impacts: According to Simoni *et al*. (2003) and Books *et al*. (1991) the levels of several indoor pollutants may even be greater than those present in outdoor environment. Same may be the case with the indoor particulate matter pollution and as the residents

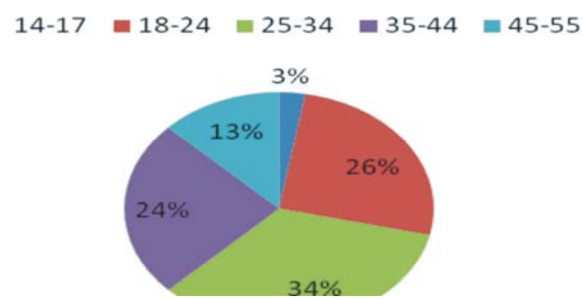

Fig. 4 : Percentage of Age Groups

spend most of their time inside their homes, therefore, even very low concentrations of indoor particulate matter may pose severe epidemiological impacts due to long exposure periods [25-30]. The percentage of the respondent regarding their socio-epidemiological impacts of dust were found to be 2.7, 26.0, 34, 24.7 and 12.7% with the age groups 14-17, 18-24, 25-34, 35-44 and 45-55 years, respectively (Fig 4). The percentage of respondent during survey was 63.35 and 36.7% married and unmarried respectively.

Among the women respondents 4.7, 5.3, 8.0, 20.7, 20.7, 18.7, 17.3, 2.0, 1.3, 0.7 and 0.6% have 2, 3, 4, 5, 6, 7, 8, 9, 10, 12 and 15 family members respectively (Fig 5). Furthermore, the education level of the respondent women was such that, 20.0% women were illiterate, 12.7% got education at elementary level, 10.7% up to middle level, 24% at high school, 23.3% at college level and 9.3% at university level.

It was assessed during the study that only 29.3% respondent women were aware about the protective mouth covers and their functions and they were using protective mouth covers during dusting hours, whereas,

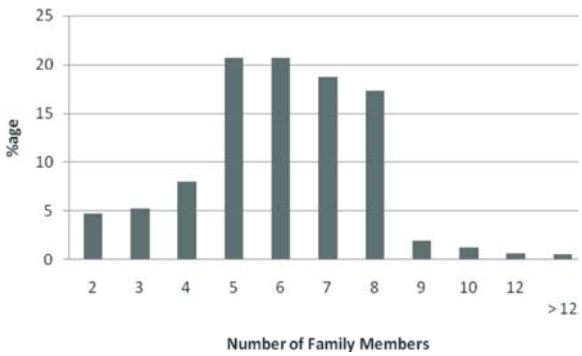

Fig. 5: Percentage of Number of family Members

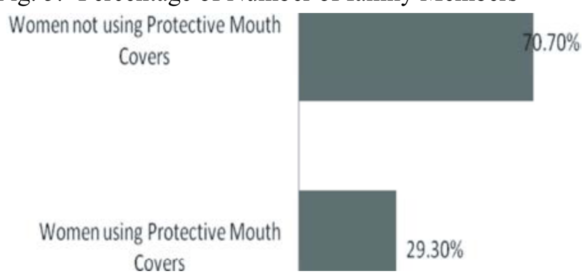

Fig. 6: Percentage of Respondents using Protective Mouth Covers during Dusting

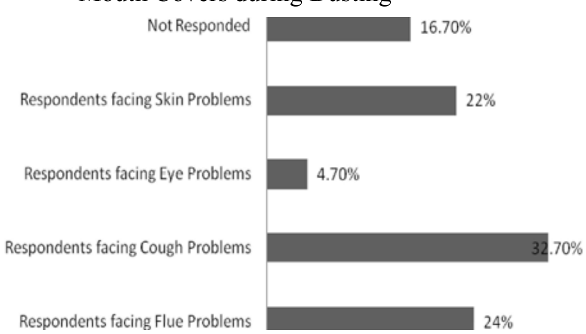

Fig. 7: %age of the Respondents facing different Epidemiological Impacts

70.7% respondent were lacking such knowledge. Furthermore, they were not practicing such care because of their illiteracy or primary level education (Fig 6).

It was found that the 58.0% women respondents were facing physiological difficulty before dusting, whereas, 42.0% did not have such problem. Most of the respondents (32.7%) facing physiological difficulty had cough (pulmonary disease), 24% flue infections, 22% skin and 4.7% eye diseases, whereas, 16.7% did not responded in this regards (Fig 7).

CONCLUSION

It was concluded that during dusting the levels of different size fractions of particulate matter were considerable and close association was also evaluated between the particulate matter concentrations depicted in indoor ambient air with various socio-epidemiological impacts. Most common epidemiological impacts of the particulate matter were cough, flue and skin and eye irritation. Most of the respondents were not using the protective mouth covers during dusting and even they were not aware of the possible health impact of indoor particulate matter pollution.

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