

EFFECTS OF AIRBORNE DUST ON LUNG FUNCTION OF THE EXPOSED SUBJECTS

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Background: The roadside dust is one of the most important contributors towards overall atmospheric pollution. This problem becomes even more significant when we consider it in relation to the poorly maintained roads loaded with ever increasing motor vehicle traffic, especially in urban areas. This results in many adverse effects especially to the respiratory health of the persons exposed to this dust either because of their residence or occupation in these areas.

Methods: The roadside dust levels were determined by using 'High volume portable dust sampler' at nine sites/busy road-crossings of Lahore. These were then, categorized into three groups (each consisting of 3 areas) as; low, medium and high pollution areas. One hundred and five subjects residing/ working in these areas for >10 years were subjected to Vitalography for measurement of their Forced vital capacity, Forced expiratory volume in first second and Forced mid-expiratory flow rate, as part of assessment of their lung function. **Results:** The mean \pm SD values of dust in low, medium and high pollution areas were 1.231 ± 0.409 mg/m³, 3.365 ± 0.272 mg/m³ and 4.697 ± 0.3 mg/m³. The results of Vitalography showed statistically significant impairment of lung function parameter values of the exposed residents/workers of these areas, proportionate to the extent of exposure to the roadside dust. **Conclusion:** The inter-group comparison of lung function parameters in groups I, IIa and IIb showed association of impairment with the extent of exposure to roadside dust levels.

Keywords: Roadside dust, Forced vital capacity, Forced mid-expiratory flow rate, Vitalography

INTRODUCTION

The airborne dust plays a major part in the overall atmospheric pollution and the motor vehicle emissions constitute the most significant source of ultrafine particles in an urban environment.¹ The smoke emitted by these vehicles is a mixture of particles and gaseous chemicals of varying physical and chemical properties. When inhaled, these cause damage to the airways and the lungs. The particles increase the toxicity of the chemicals present in the smoke.² The potential association between long-term exposure to air pollution and histopathologic evidence of damage to human lungs was evaluated by Souza and his associates and the results of his study suggested that long-term exposure to air pollutants may contribute to the pathogenesis of airway disease and the urban levels of air pollution have adverse effects on respiratory tract.³ Pope and colleagues found that respirable particulate air pollution is likely an important contributing factor to respiratory diseases.⁴ Pinkerton et al evidenced visible particle accumulation in peri-bronchial lymphoid and connective tissues along with varying degrees of wall thickening and remodelling in terminal and respiratory bronchioles arising from each pathway. Bronchiolar walls with marked thickening contained moderate to heavy amounts of carbon and mineral dust; and wall thickening is associated with increase in collagen and interstitial inflammatory cells, including dust-laden macrophages.⁵

The spirometric parameters estimated in subjects exposed to ambient levels of particulate matter/dust in Germany showed dose-response relationships more pronounced for forced vital capacity (FVC) compared to forced expiratory volume in first second (FEV₁).⁶ FVC decreases in restrictive lung diseases.⁴ Forced expiratory volume in first second (FEV₁) is the volume of air (expressed in litres) exhaled in the first second of the FVC manoeuvre, and it is decreased in obstructive lung diseases and restrictive lung diseases which decrease FVC.^{7,8} Forced mid-expiratory flow rate (FMEF or FEF_{25-75%}) is the rate of flow of air between 25% and 75% of the FVC. It is a sensitive measurement and its value is determined from forced expiratory spirogram. It is reduced in early obstruction involving the smaller airways, which are the primary site of deposition of inhaled pollutants.⁹

A study of traffic-related ambient concentrations of air pollution as a risk factor in the work environment of a group of street-cleaners in Copenhagen emphasized that traffic-related air pollution is an occupational health hazard to individuals who perform physical labour close to traffic. Moreover, the general public can also be affected in areas of high traffic density.¹⁰

In another study,¹¹ positive association was found between particulate matter less than 10 μ m size (PM₁₀) and development of symptoms of chronic productive cough and increased severity of airway obstructive disease and asthma. These associations

were stronger for those who were exposed occupationally to dust and fumes.

The traffic policemen are among the subjects maximally exposed to traffic related pollution. The respiratory health status of non-smoker policemen working in Thonburi, Bangkok was assessed. When the results were compared with the normal Thai population, showed statistically significant reduction in FVC and FEV₁ along with increased cough and rhinitis.¹² Wang *et al* found similar trend of FVC and FEV₁ decrement in the subjects of Chongqing city of China exposed to particulate matter in both urban and suburb areas.¹³ The subjects living in areas with high levels of air pollution, because of traffic density and thereby particulate matter pollution from automobile exhaust, showed higher prevalence of respiratory symptoms and decreased FEV₁ values compared with those living in areas with low levels of air pollution.¹⁴

A study to assess the lung function status of the shopkeepers of Ahmedabad, India, stationed near six traffic junctions exposed to low, medium and high levels of auto exhaust pollutants, revealed significant reduction in vital capacity and FEF_{25-75%} values in subjects of high pollution areas as compared to those of medium or low pollution areas.⁹

The present study was designed to investigate the different levels of airborne dust pollution and their effect on different parameters of lung function (FVC, FEV₁ and FEF_{25-75%}) of the exposed subjects.

MATERIALS AND METHODS

Airborne dust concentration was estimated by using 'Static high volume pump'¹⁵ (Model: L 30, MK III No.3374, 230V, 0.8 A, Rathore & Mitchell Ltd. Middlesex), Glass fibre filtration discs 6.0 Cm diameter (WCN type Cat. No: 7184003, Whatman Ltd., Maidstone, England) and analytical microbalance (Chyo, JL-900, measuring range: 0.1 mg-200 g).

Biological sampling comprised of pulmonary function testing of the subjects by Vitalograph[®] spirometer (Buckingham, England), 6.0 seconds vitalographic papers and Vitalograph[®] calibration syringe (1.0 L).

A 'walk through survey' of busy road-crossings of Lahore was carried out and based on traffic density in different areas (vehicle count & smoke density) 9 road-crossings were selected for assessment of dust levels by using 'high volume dust sampler' which has a suction rate of 40 L/min. placed at a height of 5 feet in the breathing zone of the

subjects residing/working there. These 9 areas were then grouped into 3 (Group I, IIa and IIb), consisting of 3 areas in each group. The filtration discs used for collection of dust were weighed before and after sampling for 2 hrs and the average dust concentration in the area tested was determined by using the formula:¹⁵

$$\text{Dust conc. (mg/m}^3\text{)} = \frac{W_2 - W_1 \times 1000}{R_f \times t}$$

W₁ and W₂ are pre-sampling and post-sampling weights (mg) of the filtration discs, R_f is average flow rate (L/min) and t is the duration of sampling in minutes.

Based on the concentration estimates obtained, the 9 areas/busy road-crossings sampled for dust were categorized into 3 groups; low, medium and high pollution areas.

The subjects were selected according to the following criteria: Healthy male subjects aged 19-48 years, body mass index less than 25 kg/m², residing/working in that polluted area for >10 years with daily exposure to roadside dust for 8-10 hours were included in the study. Smokers and subjects with chronic cardio-respiratory illness were excluded from the study. The body mass index (BMI or Quetelet's index) was calculated as body weight divided by height squared.¹⁶

The subjects thus selected were grouped into 'Reference group (I)', 35 subjects from the low pollution areas for comparison with 'Exposed groups IIa & IIb' (35 subjects in each) from medium and high pollution areas. All the subjects underwent forced expiratory spirometry by using 'Vitalograph[®]', a dry bellows spirometer, and the FVC, FEV₁ and FEF_{25-75%} values were determined from the graphic record obtained.

RESULTS

The concentrations of the roadside dust obtained at 9 busy road-crossings, grouped into I, IIa and IIb are presented in Table-1.

Pulmonary function testing of total 105 subjects was done by using Vitalograph[®]. Forced vital capacity (FVC), Forced expiratory volume in first second (FEV₁) and forced mid-expiratory flow rate (FEF_{25-75%}) values of all the subjects were determined from their vitalograms, which showed significant and highly significant decrements in group IIa and IIb as compared to the 'Reference group-I' depending upon the extent of exposure to roadside dust in the three groups, as shown in Table-2.

Table-1: Roadside dust levels at different road-crossings of Lahore

Pollution Category	Group I (Low pollution)			Group IIa (Medium pollution)			Group IIb (High pollution)		
	Sites	Lahore Hotel Chowk	Muslim Town More	Qartaba Chowk	General Bus stand	Lohari Gate	Yateem Khana Chowk	Naulakha Chowk	Mochi Gate
Dust levels	0.760	1.428	1.505	3.070	3.420	3.607	4.515	4.532	5.044
Mean ± SD	1.231±0.409			3.365±0.272			4.697±0.300		

Table-2: Comparison of Pulmonary Function Parameters' values in Groups I, IIa & IIb

Groups	I	IIa	IIb	p value		
				I vs IIa	IIa vs IIb	I vs IIb
No. of subjects	35	35	35			
FVC (L)	3.94±0.30	3.37±0.14	2.80±0.28	p<0.001	p<0.001	p<0.001
FEV ₁ (L)	3.18±0.37	2.80±0.27	2.29±0.26	p<0.001	p<0.001	p<0.001
FEF _{25-75%} (L/min.)	210.80±40.81	185.57±56.20	153.74±46.21	p<0.05	p<0.05	p<0.001

Data expressed as Mean ± SD, p<0.00 = Highly significant, p<0.05= Significant, Group I (Low), IIa (Medium), IIb (High)

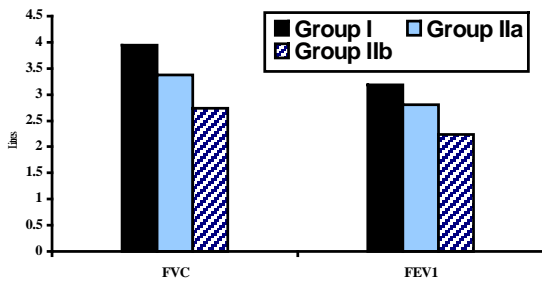


Fig-1: Values of FVC and FEV₁ in Groups I, IIa & IIb.

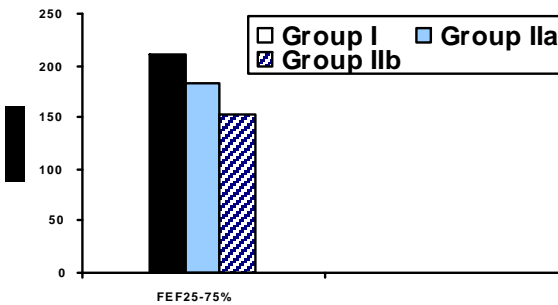


Fig-2: Values of FEF_{25-75%} in Groups I, IIa and IIb.

DISCUSSION

The dust concentrations in our study ranged from 0.760-5.044 mg/m³. The mean (±SD) values in low, medium and high pollution areas were 1.231±0.409 mg/m³, 3.365±0.272 mg/m³ and 4.697±0.300 mg/m³. The Threshold limit value (TLV) for mixed organic dust is 5.0 mg/m³.¹⁷ The mixed dust consists of soil dust (organic carbon, chlorides and sulphates), roadside dust (organic carbon and iron), solid waste, animal excreta, fossil fuel combustion products and tyre wear.¹⁸

Different studies,^{4,19} provide further evidence that long-term exposure to air pollution of

rather low levels (even below TLV for particulate air pollution) are associated with higher prevalence of respiratory symptoms in adults.

The dust levels reported by other national and international studies²⁰⁻²⁶ are comparable to those obtained in our study as shown in Table-3. The levels recorded in our study are higher and it is also a notable fact that the health effects of airborne dust do occur at levels even less than the TLVs or ambient air quality standards.

Table-3: Comparison of Roadside dust levels in different studies

Studies	Roadside dust levels (mg/m ³)
Xu <i>et al</i> (1995) ²⁰	0.388-1.255
Najeeba and Saleem (1997) ²¹	0.147-1.293
Peters <i>et al</i> (1997) ²²	0.098
Xu and Wang (1998) ²³	0.261-0.449
Meijer <i>et al</i> (1998) ²⁴	2.000
Raza <i>et al</i> (1999) ²⁵	1.980
Savrin <i>et al</i> (1999) ²⁶	0.120-0.390
The Present study (2002)	0.760-5.044

The standard values of FVC, FEV₁ and FEF_{25-75%} differ with different population groups but those narrated by Cotes²⁷ in healthy adult males, depending upon their age and body size are; 3.8-4.8 litres, 1.2-5.7 litres and 12.0-444.0 litres/min., respectively.

The FVC values obtained in different groups of our study are 3.94±0.3 litres in group I, 3.37±0.14 litres in group IIa and 2.80±0.28 litres in group IIb. These values are similar to or lesser than those of Nadeem *et al*²⁸ (3.90±0.50 litres) but far less than those reported by Siddiq *et al*²⁹ (4.76±0.78 litres).

The FEV₁ values in 'Reference group I' of our study and studies by Nadeem *et al*²⁸ and Siddiq *et al*²⁹ are; 3.18±0.37 litres, 3.50±0.50 litres and 3.96±0.85 litres, respectively. This shows a

downward trend in lung function in our study than the ones compared with.

The inter-group comparison of FVC, FEV₁ and FEF_{25-75%} values also reveals a sharp decline in these values in groups IIa and IIb in comparison with the reference group I as already shown in Table-2.

It is notable from this table that the decline in FVC in group IIa from reference group I is, 0.57±0.16 litres; and this even further increases with increasing exposure to pollutants in group IIb to 1.14±0.02 litres, which clearly associates this decline to the increasing extent of exposure.

Similar trend is seen for FEV₁, a decline of 0.38±0.1 litre in group IIa and 0.89±0.11 litre in group IIb, as compared to group I. The reductions in FEF_{25-75%} values are around 26.0±15.0 litres/min. in group IIa and 58.0±10.0 litres/min. in group IIb, in comparison to group I, which again documents progressive decrement in FEF_{25-75%} values in relation to the extent of exposure to air pollutants.

The above findings strongly show positive association between the extent of exposure to roadside dust and decrements in lung function.

CONCLUSION

The results of the present study have shown that marked rise in roadside dust above 'WHO defined threshold limit value' (TLV) has resulted in statistically significant impairment in lung function parameters (esp. FVC, FEV₁ and FEF_{25-75%}) of the exposed residents of Lahore. The impairment in lung functions is proportionate to the extent of exposure to the roadside dust.

RECOMMENDATIONS

Mass media should play its role to invoke people for a cleaner environment and increase public awareness regarding its importance in their lives and for generations to come. Proper cleaning, widening and maintenance of the roads, removal of encroachments, making pavements of sidewalks and effective sewerage system for smooth traffic flow and impounding of smoky vehicles is another essential step. Plantation, green belts and water bodies alongside roads act as natural filters/barriers to dust and gaseous pollution.

The nature and size distribution of the dust particles may further be investigated for determining their sources/origin, thus helping to target them for an effective approach towards a better, healthy and cleaner environment. Health education of the people at risk & provision of facemasks can help prevent the devastating effects of air pollution on respiratory system.

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