$PM_{2.5}$ mass concentrations and lung functioning of factory workers

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Indoor air quality in work place environments is critical for workers' health. Exposure for extended periods to high concentration of $PM_{2.5}$ is strongly associated with the cardiovascular mortality and morbidity and lungs malfunctioning.

The present study investigated $PM_{2.5}$ (24 hours) indoor/outdoor and lung function among workers at three sites (Site A: Quetta Textile Mills Pvt. Limited. Site B: Century Paper & Board Mills Limited. Site C: Ittehad Oil Ghee and General Industries Pvt. Limited) in Lahore, Pakistan. In the indoor environment $PM_{2.5}$ was monitored by a DustTrak DRX Aerosol Monitor (Model 8533, TSI Inc.) while in ambient air $PM_{2.5}$ was assessed parallel to indoor monitoring using a real time monitor (DustTrak, Model 8520, TSI Inc.). Pulmonary function was determined by spirometry (Newspirolab).

The ambient $PM_{2.5}$ levels were found to be elevated as compared to indoor levels. Peaks indoors and outdoors were observed simultaneously which suggest similar sources. Hourly mean values of $PM_{2.5}$ were at their peak when there was maximum working in all sections (table 1).

Table 1. Comparison of hourly means of $PM_{2.5}$ and spirometry

Sections (Sites)	$PM_{2.5}$ (In)	$PM_{2.5}$ (Out)	FVC	FEV1	FEV1	PEF
	Hourly Mean ± S.D	Hourly Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D
Warping (A)	468 ±224	675 ±188	87 ±05	100 ±08	120 ±04	88 ±09
Sizing (A)	190 ±109	673 ±114	75 ±10	90 ±10	123 ±02	72 ±04
Weaving (A)	399 ±218	587 ±69	80 ±16	92 ±15	121 ±07	89 ±26
Folding (A)	220 ±73	557 ±28	89 ±14	103 ±15	121 ±04	79 ±20
Paper mill (B)	300 ±203	657 ±167	74 ± 16	87 ±14	122 ±9	63 ±22
Oil mill (C)	459 ±198	621 ±55	88 ±21	98 ±20	116 ±10	73 ±15

When the mean values of FVC, FEV1, FEV1% and PEF were compared with the indoor $PM_{2.5}$ fractions it was observed that there was not a specific order of change in spirometry values with increase in $PM_{2.5}$. The lowest values of FVC, FEV1 and PEF were observed in paper mill workers. There was significant change in FEV, FEV1 and FEV in textile industry workers. The lowest value of FEV1 was observed in the sizing and weaving section than in the folding and warping section. Glindmeyer et al. (1991) observed FEV1 values in different sections of cotton mills and found a higher decline in cotton yarn workers than in the weaving and slashing section. During dusting a large amount of cotton dust was removed by the exhaust systems causing possible elevations in ambient PM levels. The decline in lung capacity was steeper in smokers than nonsmokers.

All machines generated maximum PM pollution in form of cotton dust. Minimum levels were observed during non-working hours. Maximum hourly means of all size fractions were observed during the warping step which ends with knitting (Muezzinoglu, 1998) and so less PM was in the folding section.

A decline in lung function with exposure duration and age was observed. A similar decline was reported by Glindmeyer (1994). . They also concluded that smokers should not be allowed to work in the yarn manufacturing unit of textiles. The ambient $PM_{2.5}$ fraction was a minimum in folding section as there were no synthetic processes taking place. There was only quality checking and packing of cloth in bundles for exportation. In ambient air there were higher levels of PM during dust storms.

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