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Byssinosis among Jute Mill Workers

Bhaskar P. CHATTOPADHYAY[1]*, Habibullah N. SAIYED[2] and Ashit K. MUKHERJEE[1]

[1] Regional Occupational Health Centre (Eastern), Indian Council of Medical Research, Salt lake City, Kolkata-700 091, India
[2] National Institute of Occupational Health, Indian Council of Medical Research, Meghani Nagar, Ahmedabad-380 016, India

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Abstract: Although byssinosis in jute mill workers remains controversial, studies in a few jute mills in West-Bengal, India, revealed typical byssinotic syndrome associated with acute changes in FEV_1 on the first working day after rest. The present study on 148 jute mill workers is reported to confirm the occurrence of byssinosis in jute mill workers. Work related respiratory symptoms; acute and chronic pulmonary function changes among exposed workers were studied on the basis of standard questionnaire and spirometric method along with dust level, particle mass size distributions and gram- negative bacterial endotoxins. The pulmonary function test (PFT) changes were defined as per the recommendation of World Health Organization and of Bouhys et al. Total dust in jute mill air were monitored by high volume sampling, technique (Staplex, USA), Andersen cascade impactor was used for particle size distribution and personal exposure level was determined by personal sampler (Casella, London). Endotoxin in airborne jute dust was analysed by Lymulus Amebocyte Lysate (LAL) "Gel Clot" technique. Batching is the dustiest process in the mill. Size distribution showed that about 70–80% dust in diameter of <10 μm, 40–50%, <5 μm and 10–20%, <2 μm. Mean endotoxin levels found in batching, spinning and weaving, and beaming were 2.319 $\mu g/m^3$, 0.956 $\mu g/m^3$, 0.041 $\mu g/m^3$ respectively and are comparable to the values obtained up to date in Indian cotton mills. Respiratory morbidity study reported typical byssinotic symptoms along with acute post shift FEV_1 changes (31.8%) and chronic changes in FEV_1 (43.2%) among exposed workers. The group with higher exposure showed significantly lower FVC, FEV_1, PEFR and $FEF_{25-75\%}$ values. The study confirmed the findings of the earlier studies and clearly indicated that the Indian jute mill workers are also suffering from byssinosis as observed in cotton, flask and hemp workers.

Key words: Jute mill, Byssinosis, Pulmonary Function Test, Post shift, Acute changes, Chronic Changes, Endotoxins

Background Information and Introduction

Regional Occupational Health Centre (Eastern) has been carried out a number of epidemiological and environmental studies in different jute mills and their workers (NIOH, ROHC [E] Annual Report 1985–86, 1986–87, 1987–88[1]). Earlier some scientists evidenced in favour of the occurrence of byssinosis in jute mill workers and some others were inconclusive and against of the occurrence of the disease.

The evaluation of the occurrence of byssinosis by clinical symptomatic (work related) study and the pattern of changes of pre-shift and post-shift ventilatory pulmonary function tests were made recently. The etiological factors responsible for the onset of the disease was also studied and the results of both the studies were reported[2, 3]. The prevalence of obstructive, restrictive and mixed type of functional impairment of the lung was found to have direct relation with the dust concentrations and duration of exposure[1, 4, 5]. The evidence of byssinosis like syndromes and the ventilatory

*To whom correspondence should be addressed.

pulmonary function test results at the pre-shift and post-shift period amongst the Indian jute mill workers found to be prominent in the recent studies[2, 3]. Chattopadhyay *et al.*[2] showed the byssinosis like symptoms in 8 (22.8%) workers, and the acute and chronic changes of ventilatory pulmonary function in 9 (25.7%) and 7 (20.0%) workers, respectively. In another study the same author, Chattopadhyay *et al.*[3] noticed the evidence of byssinosis in 18 (8.7%) workers and acute and chronic changes of ventilatory pulmonary function in 70 (35.7%) and 62 (31.6%) workers respectively. The prevalence of the disease was more in highly dust exposed group of workers in comparison to low dust exposed group[3].

The etiological factors responsible for the occurrence of the disease in cotton textile workers is believed to be the endotoxins derived from the gram-negative bacteria. Because of the similarity of the disease in jute mill workers it is speculated that the etiological factor(s) may be the same in both. It has been found that the gram-negative bacterial endotoxins are present in the jute mill dust (Annual Report 1994–95[5]) and level was higher than the reported value of Rylander and Morey[15] in jute mill dust. Level of endotoxins of the jute mill dust in that study was almost similar to that of the study of Gokani *et al.*[16] reported in Indian cotton textile mills. However there are reports available in support of the view as well as against it and others are inconclusive[6, 13].

The present paper reports the clinical symptoms and pre and post shift ventilatory pulmonary function changes among the jute mill workers. According to dust concentrations in mill environment and endotoxin content of the jute dusts it has been established that jute dust exposure may cause byssinosis and the etilogical factors are same as observed in case of cotton dust[3]. The present study was undertaken to confirm the occurrence of byssinosis and the etiological factors causing byssinosis in jute mill workers.

Materials and Methods

The study was carried out in 1995–1996 in a jute mill manufacturing jute cloth, jute bags, etc. The mill works in three shifts. The mill environment is comprised of two distinct dust zones: high (softening, carding, and preparing, collectively known as batching area) and low (spinning, winding, beaming, weaving, and finishing)[17]. Multiple numbers of area samples were taken by high volume sampler (Staplex, U.S.A) on glass fiber (GF) filter paper (GF/A, 20 $\times$ 25 cms, Whatman, UK) for 1 h at a rate of 1.5 m^3/min. Over loading of filters by very long fibers (called fly) was avoided by using a 2 $\times$ 2 mm wire mesh at the entry point. Workers' personal exposures were measured by personal sampler (AFC 123, Casella, London) by drawing air 2 l/min for the work shift. Open type, cone and cyclone heads were used for total and respirable dusts, respectively. For particle size distribution eight-stage, one actual cubic feet per minute (1ACFM) cascade impactor (Andersen, USA) was used to collect the size fractioned particles of different size range up to 10 μm on GF collection substrates for 8 hours. Weight differences of filter papers were used to compute the results of the size distribution.

It has to be noted that no threshold limit value (TLV) has been suggested for jute dust. The TLV for nuisance dust is 5 mg/m^3 .The dust level of different work processes were measured and divided into two groups: the 'high dust zone' with a mean dust level of above 5 mg/m, and a 'low dust zone' with a mean dust level below 5 mg/m^3.

Endotoxin estimation was done in the collected total dust samples of 2 to 3 numbers of each process on pyrogen free GF filter papers. The samples were extracted in 5 ml pyrogen free water. Endotoxin was estimated in the water extract by following the standard lymulus amebocyte lysate (LAL) Gel clot technique as per US pharmacopia guidelines[18]. LAL test kit, and all pyrogen free glass and plastic wares were supplied by Endo safe Inc. USA. LAL test were performed by mixing equal parts (0.1 ml) of LAL reagent and test samples in serial dilutions and quickly incubating the mixture in a heating block, undisturbed for 60 minutes at 37°C (± 1°C). The formation of firm gel gave positive reaction and absence of gel negative. The last positive test in the series of dilutions was the end point. The sensitivity of LAL, divided by the total dilution of sample at the end point, gave the concentration of endotoxin in the original extract. Endotoxin level was first computed into ng/ml and then expressed in μg/m^3.

The study was carried out in a jute mill employing about 1500 workers including administrative, accounts, securities, and sweepers etc . The workers work in three shifts as follows:

Shift A—	6 A.M. to 11 A.M. and 2 P.M. to 5 P.M.
n=396	(Recess between 11 A.M. to 2 P.M.)
Shift B—	11 A.M. to 2 P.M. and 5 P.M. to 10 P.M.
n=387	(Recess between 2 P.M. to 5 P.M.)
Shift C—	10 P.M. to 6 A.M.
n=337	

Every week the shift of the workers is changed from Shift C to shift B, Shift B to Shift A, and shift A to shift-C. Therefore by rotation all workers will come in Shift A in every twentyone days. The workers of shift-A only were included in the study. The time was suitable for the investigating team of conducting the study in comparison to the other shifts and the continuous exposure into the jute mill environment of the shift-A workers were more in duration. The pulmonary function tests were carried out at 5:30 A.M before the shift and then during the recess just after 11:00 A.M

One hundred forty eight (n=148) randomly selected male workers of the said jute mill participated in the study. After collecting the master list from the jute mill authority, we made a list of workers who have at least 7 years of duration of work. Then they were categorically divided as high dust exposure group (selection, softening, carding, and preparing broadly known as batching) and low dust exposure group (spinning, winding , beaming, weaving, and finishing). From the list of high dust exposure group (n=395) and in low dust exposure group (n=725), we select randomly every 5th worker. But, some selected 5th workers did not agreed to do the tests (clinical and pulmonary function). They were unwilling and avoid testing by raising different reasons. Because of the non co-opertion of those workers the number has become reduced. In selection of subjects smoking habit was not considered because a number of studies have established that there is no association of smoking habits and prevalence of byssinosis[19, 20]. It has been noticed that byssinosis did occur in jute mill workers particularly those who are exposed to high concentration of dusts for a long time than other factors[3].

All subjects were interviewed by using a standard questionnaire based mainly on the inquiry on byssinosis by Schilling[21]. The emphasis was on inquiry regarding occurrence of chest tightness, cough, sputum and breathlessness, other type of occurrences, day of occurrence, duration and relationship with work. They were interviewed using a standard questionnaire on detailed occupational and medical history.

Ventilatory pulmonay function tests comprised mainly of recording the vital capacity (VC) and forced vital capacity (FVC) using a Vitalograph- S-Model Spirometer (Vitalograph Ltd., Buckingham, UK). Each individual performed the tests at three times at pre-shift and post shift examination. The best of the three performances was taken into account. From the FVC curve, the forced expiratory volume in one second (FEV_1) was measured .The standardization of equipment was carried out every day and calibrated with the instrument at regular interval during the investigation. For the evaluation of chronic effect in ventilatory functions, the predicted equation for FEV_1 of Chatterjee *et al.*[22]—(FEV_1=–0.028 age + 0.047 height –3.737. SEE=0.38, R=0.78, R^2=0.61) was used.

The level of significance was presented in the footnote of the respective table only in those comparisons, which were statistically significant. The statistical analysis of the data (t-test and chi-square test) was done for total workers, smokers and non-smokers in the high dust and low dust exposure groups and also the non-smokers and smokers in the same exposure group. We considered $P < 0.05$ to be a significant level.

The definition of acute and chronic changes in lung function (FEV_1) from exposure to vegetable dusts causing byssinosis as recommend by the WHO study group[23] is as follows:

Change	Category	Definition
Acute	No effect	A consistent decline in FEV_1 up to 5% or an increase in FEV_1 during the work shift.
	Mild effect	A consistent decline of FEV_1 between 5–10% during the work shift.
	Moderate	A consistent decline of FEV_1 effect between 10–20% during the work shift.
	Severe effect	A decline of FEV_1 of more than 20% during the work shift.
Chronic	No effect	FEV_1—80% predicted value.
	Mild to moderate effect	FEV_1—60–79% of predicted value.
	Severe effect	FEV_1—less than 60% of predicted value.

Bouhys, Gilson and Schilling[24] have recommended another classification with the following grading of acute and permanent changes in ventilatory capacity. The acute effect in terms of fall in FEV_1 are classified as:

No acute effect — Less than 0.06 litres
Slight acute effect — 0.06–0.20 litres
Definite acute effect — Over 0.20 litres

Chronic effects are classified as percentage of predicted normal FEV_1.

No chronic ventilatory impairment
—Over 80% of predicted normal FEV_1
Moderate chronic ventilatory impairment
—60–80% of predicted normal FEV_1
Severe chronic ventilatory impairment
—Less than 60% of predicted normal FEV_1

Results

Total and respirable dust concentrations in the jute mill in high dust and low dust zone are given in Table 1. The process of selection, softening, carding, and preparing, broadly known as batching, had the mean dust concentration of 6.58 ± 3.22 mg/m^3, which was found higher than 5 mg/m^3. Therefore it was classified as 'high dust zone'. On the other hand spinning, winding, beaming, weaving, and finishing had the mean dust concentration of 1.39 ± 0.86 mg/m^3) was classified as low dust zone[15].

Table 1. Dust concentrations in a jute mill environment

Dust zone	Dust level in general work-environment (mg/m^3) Total dust[a)] n[c)]	Mean ± SD	Respirable[b)] (<10 μm) n[c)]	Mean ± SD
High dust zone	17	6.58 ± 3.22	8	4.21 ± 3.02
Low dust zone	10	1.39 ± 0.86	9	1.29 ± 0.42

a) Determined with High Volume Sampler, Staplex, USA, b) Determined with Anderson eight stages cascade impactor. c) Number of samples.

Table 2. Personal dust exposure levels in different processes of a jute mill

Process	n[a)]	Personal exposure level (mg/m^3) Total Mean	n[a)]	Respirable Mean
Batching	5	9.38	10	2.20
Spinning	3	2.15	3	0.63
Winding and Beaming	2	2.96	4	0.65
Weaving	3	1.80	3	0.58

a) Number of samples.

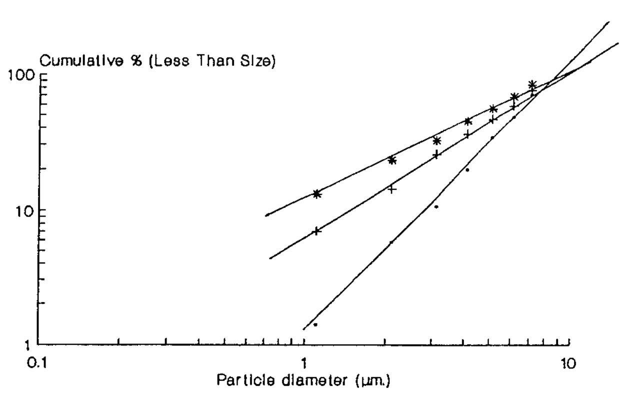

Fig. 1. Cumulative distribution of particle mass in different size ranges of the jute mill air.

Personal exposures of workers in different processes of the mill are shown in the Table 2. The cumulative distribution of respirable particle mass in mill is presented in Fig. 1. by plotting the effective cut off diameter (ECD) against cumulative percentage on log probability paper. The mass median diameter (MMD) as 50% particle mass and geometric standard deviation (GSD) as ratio of particle diameter of 84 and 50% particle mass were computed from the graph. Fig. 1 shows the log normal distribution pattern of particles below 10 mm. The MMD of particles in the mill of batching, spinning and winding and weaving were 6.2, 5.2, 4.4 mm, respectively and the GSD were 1.29, 1.42 and 1.54, respectively. The overall distribution of respirable dust (<10 μm) particle size shows about 70–80% . The bacterial endotoxin levels in total dust collected from the processing areas of jute mill is processed in Table 3. Batching area (high dust zone) had higher mean endotoxin concentration, compared to spinning and weaving (low dust zone).Table 4 shows the distribution of jute mill workers according to age groups and degree of dust exposure. More than 83% workers in the high dust exposure group and 74% workers in the low dust exposure group were above the age of 40 years. Mean age of the high dust (46.61 ± 1.18 years) and the low dust (43.91 ± 1.24 years) exposure group were highly comparable. The age range of high dust exposure group was 27 years to 57 years and low dust exposure group 20 years to 57 years respectively. Distribution of workers according to different age ranges by decade showed more

Table 3. Air borne endotoxin levels in a jute mill

Process	n[a)]	Endotoxin concentration (μg/m^3) Mean	Range
Batching	3	2.32	0.22–4.42
Spinning	2	0.96	0.44–1.49
Weaving	2	0.041	0.0071– 0.075

a) Number of samples.

Table 4. Distribution of jute mill workers according to age groups and dust exposure group

Age groups (Yr)	High dust exposure n=59	Low dust exposure n=89
Less than 30	2 (4)[a)]	6 (7)
30–39	8 (14)	17 (19)
40–49	22 (37)	41 (46)
50 and above	27 (46)	25 (28)

n=Number of subjects. [a)]Figures in the parenthesis are percentages.

workers in 50 and above years age range (45.8%) in high dust exposure group and 40 to 49 years age range (46.1%) in low dust exposure group.

Table 5 shows the distribution of workers according to the duration of work and dust concentrations. More than 81% workers of the high dust exposed group and 64% in the low dust exposed group had more than 20 years of working exposure. 54.2% workers of the high dust exposure group and 52.8% workers of the low dust exposure group had 20–29 years of exposure history.

Table 6 depicts the comparison of mean and standard error of age, duration of exposure and ventilatory function test results in the jute mill workers according to dust exposure group. FVC, FEV_1 and PEFR were significantly ($p<0.001$, $p<0.01$ and $p<0.05$) lower in high dust exposure group in comparison to low dust exposure group. FEV_1% and $FEF_{25–75}$% showed lower mean values in high dust exposure group than the low dust exposure group but the changes were statistically non-significant.

Table 7 shows the prevalence of byssinosis like symptoms in those jute millworkers. 21 (14.2%) workers had byssinotic type respiratory symptoms like chest tightness, cough, breathlessness and difficulty in breathing after the weekend break on Monday. Amongst them, 13 (22.0%) workers belonged to high dust exposure group and 8 (9.0%) workers

Table 5. Distribution of jute mill workers according to duration of work and dust exposure group

Duration of work (Yrs)	High dust exposure n=59	Low dust exposure n=89
Less than 10	3 (5)[a]	5 (6)
10–19	8 (14)	27 (30)
20–29	32 (54)	47 (53)
30 and above	16 (27)	10 (11)

n=Number of subjects. a) Figures in the parenthesis are percentages.

Table 6. Pulmonary function test results (Mean and SEM) of the jute mill workers according to dust exposure group

Parameters	High dust exposure (n=59)	Low dust exposure (n=89)
Age (Yr)	46.61 ± 1.18	43.91 ± 1.24
Duration of exposure (Yr)	24.81 ± 1.13*	21.64 ± 0.82
FVC (l)	2.37 ± 0.11***	2.83 ± 0.08
FEV_1 (l)	2.00 ± 0.09**	2.36 ± 0.07
FEV_1%	84.42 ± 1.22	83.43 ± 0.89
$FEF_{25–75\%}$ (l/sec)	2.19 ± 0.16	2.45 ± 10.12
PEFR (l/min)	387 ± 14.42*	423 ± 11.41

n=Number of subjects. *$P<0.05$, **$P<0.01$and ***$P<0.001$ as compared to low dust exposure group.

Table 7. Prevalence of byssinosis like symptoms in Jute mill workers

Clinical symptoms	High dust n=59	Low dust n=89	Total n=148
Byssinosis like symptoms present on Monday	13* (22.03)	8 (8.99)	21 (14.19)
Byssinosis like symptoms present on days other than Monday	14[@] (23.73)	16 (17.97)	30 (20.27)
No Byssinosis like symptoms	32 (54.24)	65 (73.03)	97 (65.54)

n=Number of subjects. Figures in the parenthesis are percentages.
[@]Insignificant as compared to low dust exposure. *$P<0.05$ as compared to low dust exposure group.

Table 8. Acute changes in FEV_1 in the jute mill workers according to duration of exposure

Duration of exposure	Fall in FEV_1[a)] across the shift				No effect FEV_1 increased or decreased up to 5%
	5–10%	0–20%	>20%	Total	
Up to 10	–	–	2	2	6
n=8			(25.0)	(25.0)	(75.0)
10–19	7	3	2	12	23
n=35	(20.0)	(8.6)	(5.7)	(34.3)	(65.7)
20–29	12	10	1	23	56
n=79	(15.2)	(12.7)	(1.3)	(29.1)	(70.9)
30 and above	7	1	2	10	16
n=26	(26.9)	(3.9)	(7.7)	(38.5)	(61.5)
Total	26	14	7	47	101
n=148	(17.6)	(9.5)	(4.7)	(31.8)	(68.2)

Figures in the parenthesis are percentages. [a)] Calculated by taking pre-shift FEV_1 value as 100%.

Table 9. Acute changes in FEV_1 during work on Monday according to dust exposure group

Dust exposure	Fall in FEV_1[b] across the shift			
	5–10%	10–20%	>20%	Total
High dust exposure group n=59[a]	11 (18.6)	12 (20.3)	2 (3.4)	25 (42.4)*
Low dust exposure group n=89	15 (16.8)	2 (2.2)	5 (5.6)	22 (24.7)

[a]n= number of subjects. [b]Calculated by taking pre-shift FEV_1 value as 100%. *P<0.05 as compared to low dust. Figures in parenthesis are percentages.

Table 10. Chronic changes in FEV_1 according to the dust exposure group and smoking habit

Exposure group	Mild to moderate, effect, 60 to 79% of predicted value	Severe effect, 60% of predicted value	Total
High dust n=59[a]	14 (23.73)	15 (25.42)	29 (14.29)
Smoker n=38	11 (28.94)	13 (34.21)	24 (63.16)*
Non-Smoker n=21	3 (14.29)	2 (9.52)	5 (23.81)
Low dust n=89	21 (23.59)	14 (15.73)	35 (39.33)
Smoker n=35	6 (17.14)	5 (14.29)	11 (31.43)
Non-Smoker n=54	15 (27.78)	9 (16.67)	24 (44.44)

[a]n=Number of subjects. Figures in parenthesis are percentages.
*P<0.01 When high dust exposure group smokers compared to low dust exposure group Smokers. Other comparisons of high dust exposure group as a whole with the low dust exposure group and Non-smokers of high dust exposure group with low dust exposure group are insignificant.

in the low dust exposure group. In other 30 (20.3%) workers, 14 (23.7%) from high dust group and 16 (18.0%) from low dust exposure group, these work related symptoms were present on any day of the working week and did not necessarily occurs following weekend break. These symptoms complex, which closely resemble byssinosis, is not typical of byssinosis in which the symptom start on the first day of the week after break. Each workers' clinical study in the morning before starting their work as pre-shift and post-shift was done throughout the week starting from the first working day. The prevalence of byssinotic like

Table 11. Acute and chronic ventilatory impairment of FEV_1 before shift and after shift of work on the first day after a weekend rest (Bouhys *et al.*, 1970[24]))

	Ventilatory impairment	Number (%)
Acute effect[a]	No effect (<60 ml)	86 (58.1)
	Slight to moderate (60–200 ml)	44 (29.7)
	Definite acute (>200 ml)	18 (12.1)
Chronic effect[b]	No effect (>80% of predicted)	84 (56.7)
	Moderate (60–<80% predicted)	35 (23.6)
	Severe (<60% of predicted)	29 (19.6)

[a]In terms of fall in FEV_1 (Before and after shift), [b]As percentage from predicted values (S.Chatterjee *et al.*, 1988). Figures in parenthesis are percentages.

symptoms was significantly higher (p<0.05) in high dust exposure group as compared to low dust exposure group. 97 (65.5%) workers were found to have no byssinosis like symptoms. Their number was significantly higher than in low dust group.

Table 8 shows acute changes in FEV_1 according to duration of exposure. It has been found that only 43 (29.1%) workers had working exposure of less than 20 years, others had more than 20 years.Totally 47 (31.8%) jute mill workers showed 5% or more fall in FEV_1 across the shift on first working day of the week that was on Monday. Amongst them 26 (17.6%) workers had 5–10% decrement, 14 (9.5%) had 10–20% and 7 (4.7%) workers had >20% decrement of FEV_1. Remaining 101 (68.2%) of workers had no change in FEV_1, which was FEV_1 increased or decreased by less than 5%. The percentage of workers having FEV_1 decrease was more in 10–19 years exposure group than the 20–29 years exposure group. However the statistical test showed no significant difference between the two groups. Table 9 shows the acute changes in FEV_1 on Monday according to dust exposure group. In the high dust exposure group 25 (42.4%) workers had acute changes of more than 5%, and in low dust exposure group that figure was 22 (24.7%). The number of workers having acute changes in high dust exposure group was significantly (p<0.05) higher in comparison to low dust exposure group.

Table 10 shows the chronic changes of FEV_1 according to the dust exposure group. In high dust exposure group 49.2% workers had chronic changes of FEV_1 and that figure in low dust exposure was 39.3%. The difference between two groups was statistically non-significant. However the chronic changes between the smokers of high dust exposure group and low dust exposure group were statistically significant but in non-smokers the chronic changes between these two groups were non-significant.

Table 11 shows the acute and chronic ventilatory impairment of FEV_1 according to the classification of Bouhys *et al.*[24]. This lung function grading system based on changes in FEV_1 has been used in addition to clinical grading system. In this table the fall of FEV_1 is expressed in terms of millilitre. When the fall in FEV_1 was <60 ml it was considered as no acute effect.

Slight to moderate acute effect was a fall of 60–200 ml and definite fall >200 ml in post-shift FEV_1. In high dust exposure group 20 (33.9%) workers had slight to moderate effect and 10 (16.9%) workers had definite acute effect. These figures in low dust exposure group were 24 (26.7%) and 8 (9.0%), respectively. Similarly the chronic changes were found more in high dust exposure group of workers (moderate: 23.7% and severe: 25.4%) in comparison to low dust exposed group (moderate: 23.59% and severe: 19.59%). It has been found in the present study that the acute ventilatory changes were more prevalent (41.9%) with the Bouhys classification than with the WHO classification (31.8%). However the chronic changes were found to be prevalent in almost same figures (43.2%) within both the classifications.

Discussion

It is evident from Table 1 that the dust level in the high dust zone was much higher than the low dust zone. The proportion of respirable dust (<10 μm) was much more in low dust zone compared to the high dust zone. In the case of personal exposure the workers of batching area had the highest dust exposure compared to the workers of other processes. It has been noticed that byssinosis does exist particularly those who were exposed to high concentration of dusts for a longer time than other factors. However, there is no threshold limit value (TLV) available for jute dust.

The mean highest concentration of endotoxin was obtained in the batching area (2.319 $\mu g/m^3$) and the values decreased subsequently in spinning (0.956 $\mu g/m^3$) and weaving (0.041 $\mu g/m^3$). The control area, outside the mill, showed endotoxin level lower than the inside of the jute mill.

The present study clearly indicated the presence of symptoms and acute ventilatory function changes of byssinosis amongst jute mill workers. This study also supports the findings of the earlier studies[2, 3, 24].

Roy[7] also reported the byssinosis like symptoms in jute mill workers. In China, Zhou *et al.*[13] reported higher prevalence of chest tightness and cough in jute mill workers compared to control. Bacterial endotoxins, which are thought to be associated with byssinosis in cotton workers[15, 25] may have the similar role in jute mill workers. Moreover for the extraction of the fibres jute plants are subjected to deliberate microbial decaying process called “retting”. It is therefore very likely that the gram-negative bracterial endotoxins may be present in the jute fibre. Besides these jute fibre has been undergone cure process at 25°C for 48 hours after treating with oil and water. There are ample scopes for bacterial contamination during these processes that may be the reason for higher endotoxin levels in jute dust. Except these the hot and humid Indian climate of this region is quite favorable for the bacterial growth. The concentrations of bacterial endotoxins in the airborne jute mill dust are comparable to the concentration in the card room and blow room of cotton textile mills[16]. Significantly higher prevalences of byssinotic symptoms and acute ventilatory function changes were found in high dust exposed group with high endotoxin levels, which can confirms the relation of level of dust exposure and endotoxin concentration with the occurrence of byssinosis.

Fall in FEV_1 across the shift on Monday was found in 47 (31.76%) workers. This fall in FEV_1 was observed amongst jute mill workers both with and without the symptoms of byssinosis also. The present findings are in agreement with the findings of Gandevia and Milne[26] and two studies of our earlier findings[2, 3]. Temporary fall in FEV_1 in non bysinotic workers indicate the effect of jute dust on smooth muscles of the airways resulting in their constriction[29]

Chronic changes of PFT in jute mill workers were established by Zhou *et al.*[13]. They reported low FEV_1 in jute workers, which they attributed to exposure to jute dust. Zenlin and Zhou[28] also reported the fall in FVC and FEV_1 in a longitudinal study of jute mill workers.

It is concluded on the basis of the study that the byssinosis occurs in jute mill workers particularly in those who are exposed to high concentrations of dust for a longer period. The exposure to jute dust leads to fall in FEV_1 on Monday (first working day of the week) and this fall may occur in the jute workers in the absence of symptoms of byssinosis. The etiological factor for the occurrence of the disease in cotton workers is the gram-negative bacterial endotoxins. In jute mill workers, the factors are likely to be the same.

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