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PHYSIOLOGY RESEARCH ARTICLE

A study of respiratory disorders among the Sawmill workers in Kalyani city, Nadia

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Abstract: Respiratory disorders (chronic obstructive pulmonary disorders (COPD) and asthmatic disorders) are common among various health related disorders of Sawmill workers. Daily basis they get exposed to wood dusts, which is an organic dust of vegetable origin composed of cellulose, hemi celluloses, lignin and hundreds of compounds. Wood dust also may contain many microorganisms (including fungi), toxins and chemical substances and they may significantly affect human health, inhalation of such toxins and chemical substances causes various respiratory disorder among sawmill workers. Among different industries those deals with wood dust, sawmill workers are more prone to the respiratory disorders caused by wood dust, because they exposed to the wood dust at workplace.

The objective of the study is to evaluate the adverse effects of wood dust on respiratory function and sputum analysis of sawmill workers within the area of Kalyani city, Nadia, West Bengal varies parameters were taken. A comparative cross-sectional study was carried out among a total of 50 randomly selected male person. A measurement of physical parameters, respiratory questionnaire, Work environment study, Pulmonary function test (PET), and sputum analysis was performed on the study subjects.

The study demonstrated that pulmonary function significantly reduced in sawmill workers compared with control subjects, and such impairment was poorly correlated with the duration of exposure. The mean PEF rate was also significantly ($p < 0.001$) lower among sawmill workers (336.37 ± 64.45) than the control (448.80 ± 42.38), and % of O_2 Saturation also lower among sawmill workers (79.30 ± 9.06) than the control (97.29 ± 1.76), Results also indicate significantly ($p < 0.001$) lower level of viable alveolar macrophages (AMs) among sawmill workers (46.79 ± 15.68) than control (81.74 ± 8.25) and significantly ($p < 0.001$) higher level of non-viable alveolar macrophages among sawmill workers (53.21 ± 15.68) than control (18.26 ± 8.28).

Sawmill workers in Kalyani city showed reduced pulmonary functions and higher prevalence of pulmonary related symptoms compared with nonexposed subjects alongside Sputum cytology also indicates there was high risk in alveolar sacs and lower respiratory tracts.

Keywords: Sawmill workers; Wood dust; Lung function; Respiratory symptoms

1. Introduction

Wood dust is created when machines are used to cut or shape wood materials. Industries that have a high risk of wood-dust exposure include sawmills, dimension mills, furniture industries, cabinet makers, and carpenters. Negative health effects have been associated with professions that

shape, cut, or work wood [1]. The respiratory tract is vulnerable to occupational hazards, which include exposure to organic and inorganic dusts generated from various industries. Sawdust is a byproduct of wood processing and an occupational hazard of workers. Sawmill is one of the industries, where workers are daily exposed with saw dust. Wood dust is created when machines are used to cut or shape wood materials.

Wood dust is an organic dust of vegetable origin composed of cellulose, hemi celluloses, lignin and hundreds of compounds known as "wood extractive" [2]. Wood contains many microorganisms (including fungi), toxins and chemical substances and they may significantly affect human health.

It is estimated that at least 2 million people are exposed to wood dusts every day around the world. In general, wood dust exposure deteriorates pulmonary functions, increases the prevalence of respiratory diseases, exacerbates existing illnesses, increases cancer incidence and deaths. Wood dust also contain some agents which may cause irritation of oral cavity and throat, tight- ness of the chest, irritant dermatitis, urticaria, alveolitis, deterioration of pulmonary functions, and a reduction of FEV1.

Breathing wood dust can cause a variety of health problems. One of the most serious is occupational asthma. Asthma is a lung condition that causes chest tightness, breathing difficulty, cough, and wheezing. It can be disabling and, on rare occasions, fatal. When caused by conditions on your job, it's called occupational asthma.

Besides occupational asthma, wood dust also has other hazards which are not covered here. Dust from woods such as oak, mahogany, or ash can cause nasal cancer as well as irritate your skin and eyes. Wood dust is also combustible and may explode if exposed to heat or flames.

Pulmonary function test has become the best way for assessing the respiratory health in human subjects.

Workers can be exposed to wood dust at all stages of wood processing. For many years, wood dust was considered to be a nuisance dust that irritated the nose, eyes, or throat, but did not cause permanent health problems. Numerous recent studies, however, have shown that exposure to wood dust can cause health problems [3].

According to the Occupational Safety and Health Act 1985 the union's proposed standard for wood dust set exposure limits at 1 mg/m3 for hardwoods and 5 mg/m3 for softwoods.

2. Review of literature

According to reports, wood dust is an organic dust of vegetable origin composed of cellulose, hemicelluloses, lignin, and hundreds of compounds known as "wood extractive" [2]. The result from the work of Akinyeye *et al*. [4] shows that exposure to sawdust has significant effect on respiratory irritation and mild effect on skin irritation among sawmill workers in Okada Edo state.

Workers below 18 (children) should not be allowed to work in sawmill industries as they are more susceptible to respiratory and skin irritation with exposure to sawdust. This may be because of their developing immune system not being able to cope with the microbial load in such environment and the phytochemical components of the logs. The older people are also at a greater risk of being affected by sawdust probably because of their degenerating physiological mechanism, thus cannot protect them from the hazards associated with the sawmill environment. Workers should be discouraged from smoking, as this increases their risk rate of susceptibility to respiratory irritation. Occupational exposure to wood dust leads to increased risk of chronic bronchitis (cough and phlegm production) being more pronounced in smokers [5]. Chronic bronchitis is more prevalent among smokers than non-smokers [6].

This work showed that most of the chronic and the acute respiratory manifestations and irritations were significantly higher among sawmill workers compared with the control [4]. These results were consistent with El-Far *et al*. (1999) who reported that wood workers experienced higher rates of chest manifestations (symptoms and signs) and manifestations of rhinitis (catarrh) than control group. Majority of the workers have respiratory irritation with symptoms like running nose, cough, sneezing while some complained of skin irritation like rashes, and continuous itching. The most frequent pulmonary symptoms among sawmill workers are running nose, and sneezing due to exposure to sawdust [7]. Occupational risk rate by year experience per 100 among sawmill workers is likened to prolonged and repeated exposure to sawdust which leads to symptoms like fever, headache, weakness, catarrh after working hours. Year experience within 0 to 1 year was 75%and above 2 years was 77.8%. A South African study reported that the prevalence of nasal symptoms was 49%, cough 43%, and phlegm 15% among furniture workers [8]. In contrast to the previous South Australian study, the South African study reported that the prevalence of cough and nasal symptoms increased with increase in the number of years of employment. According to Sosman *et al*. [9], respiratory disease resulting from prolonged exposure to wood dust may be due to hypersensitivity reaction in addition to nonspecific toxic or mechanical irritant effects of the inhaled materials. Answers from the questionnaires given revealed that majority of workers have respiratory disease with symptoms like running nose, sneezing and cough. Workers complained that this happens mostly when a particular hard wood with the local name Ekimi is being processed into planks. According to the workers, Ekimi wood has a dusty and spicy pepper like smell which causes the running nose and sneezing especially when the wood is very dry.

Another similar wood working study reported chronic bronchitis among 33% of smokers and 17% of non- smokers [6]. Mandryk *et al*. [10] found that exposure to wood dust and biohazards associated with among sawmill workers lead to high prevalence of regular cough, chronic bronchitis and sinus problems.

According to Gold smith *et al.* [11] the inhalation of organic dust contaminated with microbes has been recognized as an occupational hazard for persons who work with decomposing

vegetable matter (1-6). An outbreak of illness caused by such inhalation occurred in Ohio in 1983. The investigation that followed is described below.

Ugheoke *et al*. [3] conclude after studied with two hundred and twenty-eight sawmill workers and 371 controls with mean ages of 33.1±7.3 and 32.9±7.2 years, respectively. The 2 groups were generally comparable in their socio-demographic characteristics. This is shown in the sawmill workers had a significantly higher prevalence of pulmonary symptoms compared to the control group viz: Cough (35.1 vs 8.6%), sputum production (51.8 vs 1.6%), breathlessness (8.3 vs 0%), wheeze (3.1 vs 0%). Among the sawmill workers, 179 (78.5%) reported at least one respiratory symptom compared to 45 (12.1%) of the controls ($p<0.05$).

The results of their study, showed that sawmill workers in Benin City had a higher prevalence of respiratory symptoms compared with controls. This is in agreement with earlier works on the same subject [7, 12]. However, the prevalence figures for respiratory symptoms reported in this study are somewhat different from those reported elsewhere in this country [7,12]. While the prevalence of cough among the sawmill workers in this study is comparable to the 34.4% reported by Ige and Onadeko [7], it is lower than the 45.8% reported by Fatusi and Erhabor [12]. Also, sputum production prevalence rate of 51.8% among the sawmill workers in this study is comparable to the 50.8% reported in the study by Fatusi and Erhabor (1996) but <34.4% reported by Ige and Onadeko [7]. Similarly, while the prevalence rate of breathlessness among the sawmill workers in this study was found to be 8.3 and 4.1% was reported by Ige and Onadeko [7] while, Fatusi and Erhabor [12] reported 25.4%.

As there were no material differences in the structural design of the sawmills used in this study and those of these other workers on the same subject, these differences are likely to relate, not only to the quantity of sawdust in the research environment, but also sawdust control measures put in place and utilized at the different sawmills.

It is estimated that at least 2 million people are exposed to wood dusts every day around the world. In general, wood dust exposure deteriorates pulmonary functions, increases the prevalence of respiratory diseases, exacerbates existing illnesses, increases cancer incidence and deaths. International Agency for Research on Cancer (IARC) reports that wood dust causes cancer and included it in 1995 into Group 1 carcinogens. Besides, wood contains many microorganisms (including fungi), toxins and chemical substances and they may significantly affect human health It is recognised that those agents may cause irritation of oral cavity and throat, tight- ness of the chest, irritant dermatitis, urticaria, alveolitis, deterioration of pulmonary functions, and a reduction of FEV1. Basic tools for evaluating the effect of exposure on respiratory system include pulmonary function test [13].

Exposure to wood dust caused decreases in pulmonary functions of the workers. In comparing of smokers and non-smokers for FEV1 and FVC, we found decreases in FEV1, FVC and FEF25–75 for the smokers. Milanowski *et al*. [14] found decreases in FEV1 and FVC values

for both smokers and non-smokers in their study. Liou *et al*. [6] found lower FEF25–75 values for both smoker and non-smokers exposed to wood dust compare with the control group in their study con- ducted in Taiwan.

Shamssain [8] conclude Exposure to wood dust can cause a variety of lung problems, including chronic airflow obstruction.

3. Aim & objectives

The study is planned to achieve the following goals:

i. To assess the effect of wood dust exposure on respiratory symptoms.
ii. Evaluation of effect of wood dust exposure on respiratory health of the workers.
iii. To assess the knowledge of sawmill workers regarding existing health problems in sawmill industry.
iv. Formulating some interventional policies to minimize the prevalence of the respiratory damage due to environmental dust exposure and thereby improving the lung status of sawmill workers.

4. Methods and materials

4.1. Study population

A total of 50 male persons were randomly selected for the present study, around kalyani, Nadia, West Bengal. Among them 33 are directly exposed to wood dust (called exposed group) and rest 17 persons (who are mill owner, businessmen and some office stuff) are not directly exposed to the wood dust called reference group. The subjects are earlier informed about the study.

4.2. Measurement of physical parameters

Height of each subject was measured by using standard Martin anthropometric rods and weight was measured by digital weighing machine and during both measurement subjects were asked to stand erect on the machine and the reading was noted. From the above readings body mass index (BMI) and Body Surface Area (BSA) of individual subjects was calculated in [15] and [16] respectively.

$$BMI\ \left(\frac{Kg}{m^2}\right) = \frac{Weight}{Height}\left(\frac{Kg}{m^2}\right)$$

$$BSA\ (m^2) = Height^{0.725} \times Weight^{0.425} \times 0.007466$$

4.3. Questionnaire study

A general questionnaire was asked to subjects to gather information about their job type, food habit, educational status, marital status, job experience, family status etc. And then a slightly modified version of European Community Respiratory Health Survey II (ECRHS II) questionnaire was asked to the subjects to collect the information about the respiratory symptoms. The questions were asked to the workers in their native language (Bengali).

4.4. Working environment study

Wood dusts are generated during sawing and re-sawing the wooden logs and it contaminates to surrounding environment. The workers are worked in that environment without any safety or mask. So, the environmental wood dust was measured by handy sampler (Enviro. Tech. AMP- 821). The collected sample was weighted and calculated using following formula:

$$C = \frac{W1 - W2}{Tx\frac{[R1 - R2]}{2}} \times 100$$

Where, W1=Preliminary weight of the filter paper (mg); W2= Final weight of filter paper (with dust sample) (mg); Tx= Operation time (min); R1= Preliminary air suction flow rate (L/ min); R2= Final air suction flow rate (L/ min).

4.5. Pulmonary function test (PFT)

Pulmonary function tests such as Force expiratory volume in the first second (FEV1), Peak expiratory flow rate (PEFR), Peak inspiratory flow rate (PIFR) was performed by the instruments portable spirometer (Micro medial ltd. Mod-CE 0120) and PEFR & PIFR was measured by Mini-Bell Peak flow meter (made in Spain, Mod-CE0319) & portable inspiratory flow meter (Clement Clarke International Ltd., Mod-CE 0120) respectively. FVC was calculated from the value FEV1and percent predicted FVC and FEV1 using spirometry calculator (www.patient.co.uk). Oxygen saturation in the blood of the subjects was measured by Pulse Oximeter. Each subject was asked to perform thrice, and the best value was taken to consideration. The PFT tests were performed in standing posture during the resting time or end of the work. The percentage predicted values of each of indices were judged for analysis.

5. Sputum processing and screening of viability

5.1. Sputum processing

Exfoliated sputum was collected from each subject by deep cough method into a sterile polypropylene tube (Tarsons Ltd., India). Then equal volume of phosphate buffer saline (PBS) (PH-7.4) was mixed and was shaken vigorously. The tubes containing sputum was then centrifuged at 3000 rpm for 10 minutes. After two successive washing and centrifuging, 500 µl from the

precipitant was collected to another micro-centrifuge and it was made up to 1 ml with adding PBS. From that, 80 µl was taken into another micro-centrifuge and 200 µl PBS was added to it.

5.2. Screening of viability

1% Trypan blue was made by dissolving the dye into the PBS. From that stock solution 20 µl was taken diluted up to 1ml by adding PBS. 10 µl from that dye was added to the diluted sample. 100 µl of that mixture was charged to haemocytometer and the cells were counted. The number of viable macrophages, non- viable macrophages, viable alveolar epithelial cells and non-viable alveolar epithelial cells were counted.

5.3. Statistical aanalysis

Data of the respiratory symptoms were analysed using adjusted Chi-square (X2) test with 95% confidence interval. Pulmonary function variables and sputum cell counts were analysed by Students' t test. Level of significance was considered as $p<0.05$. The responses were adjusted with subjects' age, smoking status and year of experiences.

6. Results and discussion

The physical parameters are presented in the Table 1. The table shows the parameters did not alter much in the reference to the exposed subjects to wood dust.

Table 1: Presentation of physical parameters of reference and exposed subjects

Parameters	**Referent (N=17)**	**Exposed (N=33)**
Age (Years)	32 ± 3.7	43.09 ± 10.7
Height (cm)	167.41 ± 7.73	160.43 ± 5.09
Weight (kg)	64.64 ± 9.14	54.87 ± 8.44
BMI (kg/m^2)	21.72 ± 2.61	21.48 ± 3.13
Exposure time (Years)	14.56 ± 5.20	15.04 ± 12.46

**Data are presented as Mean and SD*

The comparison of each respiratory symptom of reference subjects and exposed subjects are shown in the Table 2. data are presented as their positive outcome, its percentage value.

Table 2: Presentation of Adjusted chi-square test of each respiratory symptom between reference and exposed subjects

Respiratory Symptoms	Referent (N=17)	Exposed (N=33)	Chi-square (X^2)	P Value
Wheezing or whistling	3 (17.64)	16 (48.48)	19.02	< 0.001
Tightness in chest	2 (11.76)	13 (39.39)	17.79	< 0.001
Shortness of breathing	2 (11.76)	12 (36.36)	14.50	< 0.001
Attack of coughing	5 (29.41)	24 (72.72)	36.99	< 0.001
Cough in the morning in the winter	7 (41.17)	26 (78.78)	21.36	< 0.001
Cough during day/ night in the winter	4 (23.53)	23 (69.69)	40.64	< 0.001
Phlegm in chest	6 (35.29)	24 (72.72)	27.56	< 0.001
Breathing trouble	2 (11.76)	9 (27.27)	6.24	< 0.012
Asthma ever	1 (5.88))	2 (6.06)	0.096	< 0.756
Respiratory problem after work	1 (5.88)	5 (15.15)	3.40	< 0.065

It is clear that the respiratory symptoms like wheezing/ whistling, attack of coughing, cough in the morning and day/night in the winter, phlegm production, breathing trouble are much higher in the exposed personnel compared to reference personnel.

As, the respiratory disturbances are influenced by age, height, exposure duration and smoking status, the best way to analysis the data adjusted chi-square test and compare with reference subjects. The chi-square values are significantly higher for all the respiratory symptoms of the workers personnel compared to reference personnel. It means the prevalence of all respiratory symptoms of the worker group is high than the reference group but age, height, exposure duration, smoking status could have some additional role in these results.

Some environmental and physiological factors can influence the respiratory disturbance. It was informed that the workers do not wear or unable to wear sufficient clothes in winter season. This is why the personnel compliance the cough in morning, day/ night in winter.

Use of mask, clothes, and any protective measures may protect or minimize the direct inhalation of wood dust. So, therefore, the inhalation of wood dust may be another big reason of respiratory disturbances of the sawmill workers.

Beside these exposure duration and smoking or tobacco addiction are the other causes of occurrence of respiratory disturbances of the exposed personnel. Exposure to wood dust for a long time also affects the respiratory health. For log time exposure, wood dust deposit in the alveolar sacs and lower respiratory tracts and obstruct the air exchange between lung and environment.

Environmental wood dust was measured and that was too high (8mg/ m^3) from any International recommended permissible limits. OSHA permits 5 mg/m^3, NIOSH- 1 mg/m^3 and ACGIH- 0.5 mg/m^3.

Table 3: Comparison of pulmonary function test between reference and exposed people

Parameters	Referent (N= 17)	Exposed (N= 33)	t value	P value
FVC (L)	2.67 ± 0.22	2.40 ± 0.29	3.36	<0.001
FVC (% predicted)	54 ± 5.66	55.48 ± 7.95	6.68	<0.498
FEV_1 (L)	2.48 ± 0.46	1.60 ± 0.24	8.93	<0.001
FEV_1 (% predicted)	58.12 ± 6.77	47.12 ± 7.68	4.98	<0.001
FEV1/FVC	0.85 ± 0.06	0.67 ± 0.11	6.26	<0.001
PIF (L/min)	323.92 ± 27.18	236.06 ± 55.59	6.12	<0.001
PEF (L/ min)	448.80 ± 42.38	336.37 ± 64.45	6.48	<0.001
% of O_2 Saturation	97.29 ± 1.76	79.30 ± 9.06	8.07	<0.001

Table 3 shows the comparison of pulmonary function test between the reference subjects and exposure subjects. It was observed that the almost all indices altered and decreased among the exposed group compared to reference group. From, Table 3, It is clear that forced vital capacity (FVC) and forced expiratory volume in 1st second (FEV1) altered significantly among the sawmill workers. It means the lung volumes deteriorated among the worker who are regularly exposed to the wood dust. But percent predicted values of FVC did not alter significantly, that means there is age some other factors that deteriorate those values. If look at the table-1, there is only one variable that is significantly different between the two groups and that is the reason [17]. The value of percent predicted FEV1 is significantly lower among the workers than reference subjects. That concludes that there is some obstruction in the air ways of the subjects who are getting exposed to wood dust. Here another two indices that significantly decreased among the worker group compared to reference group that are PIF &PEF which suggest that there was some obstruction in the air ways of exposed group. The value O_2 saturation in blood also got significantly lowered among workers personnel compared to reference personnel, which denotes the chronic obstructive pulmonary disorders (COPD) and asthmatic disorders.

Table 4: Percentage of pulmonary disorders (Obstructive/ restrictive/combined)

Total Subjects	Affected	Obstructive	Restrictive	Combined
33	23(69.70)	22(66.66%)	0(0%)	1(3.03%)

Table 4 represent the percentage of pulmonary disorders of sawmill workers. From this table it was observed that most of the workers are affected, among them most of were obstructive in nature. This was categorized by using Millard Quardent Chart. The cytological patterns of viability and non- viability of alveolar macrophages (AMs) and alveolar epithelial cells (AECs) collected from sputum have been presented in Table 5.

Table 5: Comparison of Sputum cytology between reference and exposed personnel

Sputum Cytology	Referent (N= 17)	Exposed (N= 33)	t value	P value
Alveolar Macrophage (AM) Non-Viable	18.26 ± 8.28	53.21 ± 15.68	8.57	<0.001
Viable	81.74 ± 8.25	46.79 ± 15.68	8.57	<0.001
Non-Viable/ Viable	22.86 ± 9.37	118.52 ± 39.14	9.88	<0.001
Alveolar Epithelial Cells (AEC) Non-Viable	23.54 ± 7.69	57.90 ± 3.71	21.41	<0.001
Viable	76.46 ± 7.69	42.10 ± 3.71	21.41	<0.001
Non- Viable/ Viable	32.52 ± 19.46	139.53 ± 23.61	17.74	<0.001

**Data are presented as percentage value of the sample*

It was observed that the viable cells of alveolar macrophages markedly decreased and non-viable AMs were markedly increased. Likewise, viable of AECs was lowered and non-viable AECs were significantly higher among exposed group compared to reference group. Macrophages are modified monocytes and alveolar macrophages provide the first line defence to the lung tissue against external particles and pathogenic organisms. Generally, AMs reside within the alveolar sacs to provide defence by engulfing the harmful external factors or pathogens. So, the viability of AMs is more important for that kind of activity. But when lungs are getting more threat, AMs fail to provide sufficient defence against that adverse condition and AMs getting dead.

It was observed that the percentage of alive AMs were significantly lower in the exposed subjects compared to reference subjects. In case of an acute attract of hazardous substances, the number of AMs increases to defence the inflammation. But when this event becomes chronic, the AMs fail to provide sufficient barrier against it. Chronic exposure to wood dust as well as various other factors like fibres, moulds, etc. affects the lung by deposition and having large size, and the AMs fail to engulf them. Although, the first line of defence is always active in human being normal condition, the infiltrated particles generate superoxide free radicals, which destroy the cellular cyto-architecture of the AMs and the cells become non-viable [18] It was also clear from the result of percentage of viable alveolar epithelial cells were significantly lower among the exposed workers.

This indicates the lining of alveolar parenchyma was significantly damaged among the exposed workers.

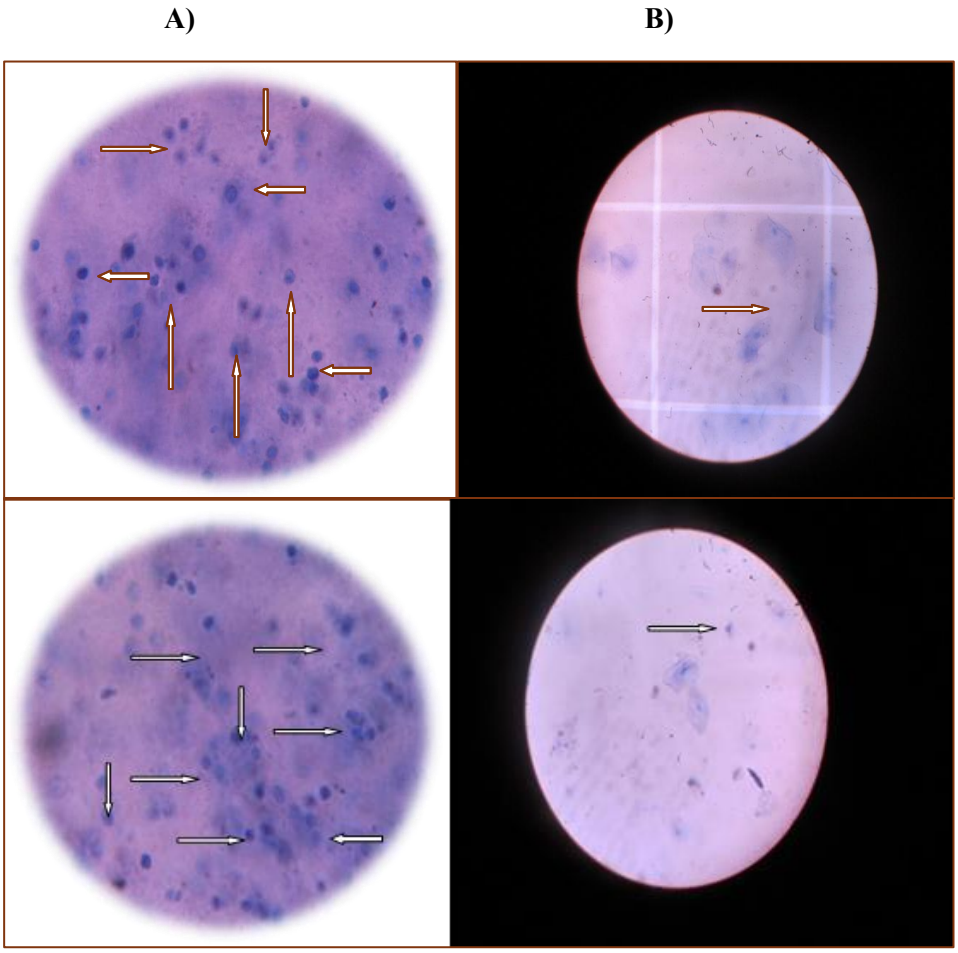

Figure 1: Arrows indicating Macrophage of exposed group (A) and (B) sputum

7. Conclusion

From the present study it can be concluded that the people who are getting regularly exposed to wood dust, are at high threat of having obstructive type of pulmonary disorders. The workers are working high dusty environment and they had experienced of prevalence of higher respiratory symptoms and lower lung function. Sputum cytology also indicates there was high risk in alveolar sacs and lower respiratory tracts among sawmill workers.

8. Interventional policies

Regarding the improvement of health condition of sawmill workers, to avoid or minimize wood dust induced respiratory disorders, some policies should be implemented. Below are some

recommendations/ implementations which can prevent adversed heath of sawmill workers due to occupational exposure.

i. The workers should use mask or towel/ cloths to prevent/ minimize the inhalation of wood dust.

ii. The worker should wear full sleeve shirts or dress and proper safety devices to avoid dermal contact of wood dust.

iii. Clearing of dust lying on floor.

iv. Cheque up the pulmonary function test minimum twice in a year.

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