Biochemical Profile and Pulmonary Function in Ginning Factory Women Labourers Exposed to Cotton Dust Pollution at Tirupur

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A Thesis submitted to Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, In partial fulfilment of the requirement for the degree of **Doctor of Philosophy**

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CERTIFICATE

This is to certify that this thesis entitled ***"BIOCHEMICAL PROFILE AND PULMONARY FUNCTION IN GINNING FACTORY WOMEN LABOURERS EXPOSED TO COTTON DUST POLLUTION AT TIRUPUR"*** *submitted to the Avinashiligam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for the award of the degree of Doctor of Philosophy in* ***BIOCHEMISTRY*** *is a record of original research work done by* ***JANNET VENNILA, J*** *during the period of her study in the Department of Biochemistry, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, under my supervision and guidance and the thesis has not formed the basis of the award of any Degree/ Diploma / Associateship / Fellowship or similar title to any candidate of any University*

M. P. Jayanthi.
5/10/2001

Signature of the Guide

DECLARATION

I hereby declare that the matter embodied in this thesis is the result of investigations carried out by me in the Department of Biochemistry, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, under the supervision of ***Dr.G.P. JEYANTHI M.Sc., M.Phil, Ph.D.,*** *Reader in Biochemistry, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, and it has not been submitted for the award of any degree, diploma, associateship, fellowship etc., of any other University or Institute*

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This thing hath proceedeth from Lord

Genesis 24:50

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Introduction

1.0 INTRODUCTION

Air pollution is the presence of one or more contaminants, such as dusts, fumes, gas, mist, odour, smoke or vapour in quantities with characteristics in the out door atmospheric air and of durations such as to be injurious to human, plant or animal life or which unreasonably interfere with the comfortable enjoyment of life and property (Trivedy and Raj, 1992).

Air pollution is one of the greatest environmental evils. The air we breathe has not only life-supporting properties .An average man breathes 22,000 times a day and takes in 16 kg of air each day. Depending upon the chemical nature of the air pollutants, some may be harmful when present in the air in small concentration and others only if they are present in high concentrations (Shukla and Srivastava,1992).

The prime factors affecting human health are nature of pollutants, duration of exposure, state of health and age of target individual (Mowli and Subhaya, 1989). Particulate matters play a major role in air pollution. It includes aerosol, dust, fog, fume, mist, smog and smoke. Of all these, dust is an important air pollutant released mainly during industrial operations. It refers to solid particles predominantly larger than colloids and capable of temporary suspension of air or other gases (Mallette,1991).

Occupational hazards among industrial workers are known to man for a long time. Since the Second World War, there has been a rapid growth in occupational health studies on a world - wide scale. Occupational lung diseases among the industrial workers are very common due to inhalation of various types of dusts. Dusts of organic nature encountered in various occupations include the

dusts of bagasse, cotton, flax, flour, grains, hay, hemp, jute, linseed, malt, nuts, straw, seed, tea, tobacco and wood. Byssinosis and other related respiratory abnormalities are well known occupational respiratory diseases in textile mill workers caused by cotton dust pollution (Gokani,1985).

National Institute of Occupational Safety and Health (NIOSH) has defined cotton dust as a dust which is generated into the atmosphere as a result of processing of cotton fibres combined with any naturally occurring materials such as stems, leaves, bracts, inorganic matter, fungi and bacteria which may have accumulated on the cotton fibres during growing and harvesting period.

The respiratory system includes nasal cavity, larynx, trachea and lungs. Particles larger than 10 mm in diameter would be completely removed in the passage of air stream through the nose and upper airways and the particles between 5 – 10 mm get deposited primarily in upper airway by mucociliary system. Only the particles in the range of 1 – 2 mm would be likely to penetrate into the deeper portions of the lungs (Spencer,1977). Cotton dusts being fibrous materials and having a size of approximately 50 – 200 mm find some way to enter the nasal system and evoke many respiratory disorders like byssinosis, asthma, bronchitis and wheezing.

In a textile industry which involves large amount of cotton dust, the air pollution is serious. Cotton textile industry is the single largest organised industry having largest number of employment with the risk of exposure to cotton dust leading to the respiratory disease,byssinosis. The industry accounts for roughly 20% of India's total industrial production and is one of the leading foreign exchange earners (International Textile Review, 1999). There are 661 textile mills in India, of which 370 are spinning and 291 are composite mills. India occupies second position in terms of spindles after China and fourth in terms of

cotton consumption. The Pocket Book of Labour Statistics (1982) quoted that there were 11,47,000 cotton textile workers in India. India has the largest area in the world under cultivation of cotton, which accounts for 1/4th of the total world area. Next to USA and Japan, India is the biggest textile producer in the world.

Coimbatore district in Tamil Nadu ranks first in India where a total of 80 textile mills and 40 ginning factories are situated. The first mechanical process following cotton harvesting is ginning, the primary aim of which is to separate the fibre or lint from seed. Gin workers have much higher exposure to cotton dust than textile workers.

Cotton ginning and pressing have been identified as traditional industries under the unorganized sector which functions on a seasonal basis. The season begins with maturing of cotton crop which varies with the geographical distribution and ends shortly after the cotton harvesting ends. In Coimbatore district, it starts in October and ends in March every year. The employees in ginning factories do not get registered under the Employees Security Insurance (ESI) Act.

Work carried at gin suggests that exposure to cotton dust inside the gin leads to the development of acute effects and decline in pulmonary function among the exposed subjects comparable to byssinosis among cotton textile workers, although the work environment and the work pattern in both the places are different, (Ghosh *et al.*,1997).

Although a number of epidemiological studies were undertaken in the past to study the cotton dust exposure and prevalence of cotton dust exposed diseases in textiles mills in various parts of the country, no attempt has been

made to evaluate the impact of the cotton dust exposure on the health status of the textile workers in Coimbatore district.

Till date in India, only a limited number of studies have been conducted to highlight the occupational hazards in ginning factories and there are hardly any studies conducted on the employees of ginning factories in Coimbatore district. Tirupur, a textile city in Coimbatore district, is the major exporter in cotton garments and ranks second to Coimbatore city where 18 ginning factories are situated employing 1500 labourers. Women are the major employees in these ginning factories. Although the textile industry in India has a large population for many years, health hazards in the women labourers in these ginning factories have been overlooked. Moreover all the studies conducted so far, were in late 1980s and there is no recent study, which portray clearly the health status of ginning workers especially in Tirupur.

Working women have multiple roles to play as a wife, a mother and an employee. Being subject to dual demands of home and workplace, they are liable to face crisis of adjustment which may cause stress and strain (Kaila, 1995).

According to many recent reports, raw cotton contains large number of microorganisms, especially gram negative bacteria (GNB). A causal relationship has been suggested to exist between pulmonary symptoms on cotton workers and the GNB and their membrane lipopolysaccharide (LPS) endotoxin (Gokani *et al.*, 1988). Moreover, endotoxins have been reported in animal experiments and human exposure to produce effects that relates closely to clinical effects in man (Rylander *et al.*, 1985) Histamine is an important mediator of cotton dust and endotoxin which induces bronchoconstriction in man (Bhatt *et al.*,1989) .

Chronic lung diseases associated with exposure to cotton dust can be attributed to passive smoking (Schachter, 1998). It was indicated that passive smoking is much harmful, if not more in some cases, than direct smoking. It is now revealed that an equal number of non-smokers, many of them women, suffer from a host of respiratory diseases. Patel *et al.* (1984) have mentioned that women using traditional fuels like firewood and cow dung are at a greater risk of developing pulmonary disorders compared to those using modern fuels like liquid petroleum gas (LPG).

The present study was undertaken to assess the pulmonary function and biochemical profile in the selected ginning factory women labourers at Tirupur.

The objectives of the study were

- to find the prevalence of respiratory morbidities among textile workers in Coimbatore district
- to assess pulmonary function and selected biochemical parameters in women labourers of a selected ginning factory located at Tirupur
- to correlate the findings of pulmonary function parameters with the selected biochemical parameters, age and duration of exposure to cotton dust
- to assess the effect of passive smoking and fuel used for cooking on chronic pulmonary function parameter changes in ginning factory women labourers
- to study the impact of cotton dust exposure on pulmonary functions based on the proximity of the work area
- to analyse the cotton dust in different sections of the ginning factory with respect to size, respirable dust, endotoxin and gram negative bacteria

A ginning factory located at Tirupur was chosen for the study. 104 women labourers working in different sections of the selected ginning factory namely the

gin house, gutter and sorting sections formed the experimental group. They were grouped according to their age, duration of exposure to cotton dust, clinical symptoms, fuel they used for cooking and chances for exposure to passive smoking. Forty age and sex matched control women of similar economic status were selected for the study. Both the experimental and control group participants were subjected to pulmonary function test and analysis of selected biochemical parameters.

Review of Literature

2.0 REVIEW OF LITERATURE

The review of literature pertaining to the present study **"BIOCHEMICAL PROFILE AND PULMONARY FUNCTION IN GINNING FACTORY WOMEN LABOURERS EXPOSED TO COTTON DUST POLLUTION AT TIRUPUR"** is presented under the following headings:

2.1 AIR POLLUTION

2.2 CLASSIFICATION OF AIR POLLUTANTS

2.3 SOURCES OF AIR POLLUTION

2.4 AIR POLLUTION AND HEALTH HAZARDS

2.4.1 Hematological system

2.4.2 Cardiovascular system

2.4.3 Nervous system

2.4.4 Gastro intestinal system

2.4.5 Immunological system

2.4.6 Respiratory system

2.5 EFFECT OF AIR POLLUTION ON RESPIRATORY SYSTEM

2.5.1 Anatomy of respiratory system

2.5.2 Functions of the respiratory system

2.5.2.1 Respiratory functions of the lungs

2.5.2.2 Defencing against environmental agents

2.5.2.3 Effect of dust on lungs

2.5.2.4 Occupational lung hazards caused by dust

2.5.2.4.1 Occupational asthma

2.5.2.4.2 Pneumoconiosis

2.5.2.4.3 Chronic bronchitis

2.5.2.4.4 Lung Cancer

2.6 OCCUPATIONAL LUNG HAZARDS IN TEXTILE INDUSTRY

2.6.1 Cotton textile industry

2.6.2 Analysis of cotton dust

2.6.3 Pulmonary effects of cotton dust

2.6.4 Cotton dust in ginning factory

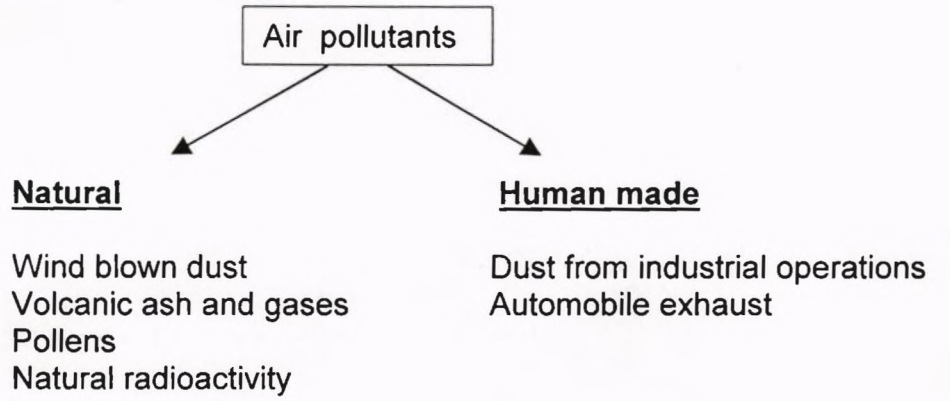
2.1 AIR POLLUTION

Air pollution is considered to be one of the most dangerous and common kinds of environmental pollution that has been reported in most industrial towns and metropolitans of India and abroad (Katyal and Satake, 1989).

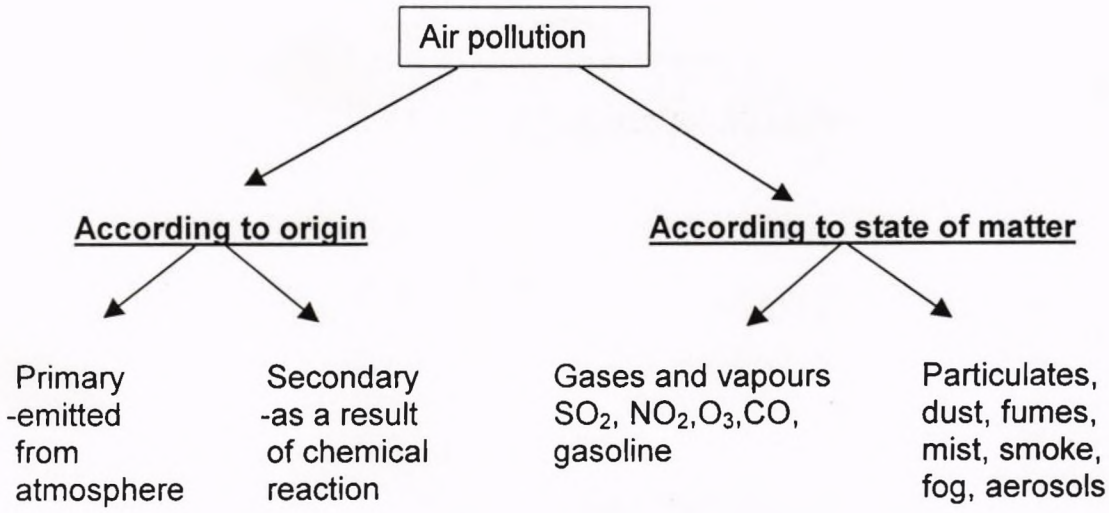
According to World Health Organisation (WHO), an air pollutant is defined as "a substance put into air by the activity of mankind into concentration sufficient to cause harmful effect to his health and property or to interfere with the enjoyment of his property".

2.2 CLASSIFICATION OF AIR POLLUTANTS

Air pollutants are classified in different aspects:



(Theodore and Buonicore,1988)



(Wellburn,1994)

2.3 SOURCES OF AIR POLLUTION

The sources of air pollution are presented in Table 1.

TABLE - 1

SOURCES OF AIR POLLUTION
(Trivedy and Raj, 1992)

No.	Class	Aerosols	Gases and Vapours
1.	Combustion process (domestic burning, thermal power plants, cars, trucks, aeroplanes and railways)	Dust, fume and smoke	SO_2, NO_2, CO, odours
2.	Chemical processes (paper mills, cement, fertilizer, textile mills)	Dust, fume and mist	Process dependent (SO_2, CO, NH_3, NO_2, organic vapours, odours)
3.	Petroleum operations	Dust, mist	SO_2, H_2S, NH_3, CO, hydrocarbons, mercaptens
4.	Metallurgical processes	Dust, fume	SO_2, CO, fluorides, organic vapours.
5.	Mineral processing	Dust, fume	Processes dependent
6.	Food and feed operations	Dust, mist	Odourous materials
7.	Agricultural activities		
a)	Crop spraying	Dust, mist	Chlorinated hydrocarbons
b)	Field burning	Smoke, fly-ash	Sulphur oxides, organic vapour
8.	Nuclear energy programs Fuel fabrication, ore operations	Dust	I^{131} and A^{41} radio active gases (Sr^{90}, C^{137}, C^{14} etc.)

2.4 AIR POLLUTION AND HEALTH HAZARDS

Air pollution is an important problem in industrial areas, which has an adverse effect on the health of the population (Park and Park, 1985). Air pollution studies reveal that it may cause reduced vision, eye irritation, respiratory irritation and discomfort to normal life. Other medical studies link air pollution with lung cancer, chronic bronchitis, emphysema and chronic cardiac diseases (Smolensky, 1982).

According to Insel and Roth (1988), air pollution can cause illness and death if pollutants become concentrated for a period of several days or weeks.

2.4.1 Hematological system

Occupational factors especially work in textile mills could be implicated in the pathogenesis of pernicious anemia(Roman *et al.*, 1991).Turk and Turk (1990) found that carbonmonoxide interferes with oxygen transport function of the blood.

2.4.2 Cardiovascular system

Chronic respiratory disease, particularly where extensive fibrosis or loss of lung tissue occurs, was found to be associated with heart disease. The mechanism by which air pollution affects cardiovascular system might be a longterm basis (Kudesia, 1987). Ultrafine particles less than 10 μm in diameter caused alveolar damage and in turn caused acute changes in blood coagulation. These blood changes might increase the susceptability to cardiovascular diseases, providing a possible explanation for their apparent link to air pollution (Seaton, 1995).

2.4.3 Nervous system

Split *et al.* (1989), analysed the conditions of nervous system in female workers in cotton industry and showed the existence of cervical pains, lumbo sacral pains and headaches in them. Stern (1977) established a change in the amount of time needed to produce an eye sensation after exposure to an air pollutant.

2.4.4 Gastrointestinal system

Asbestos fibres were found to frequently enter and reside in the wall of the colon and were often associated with tumor tissue at the site of colon in asbestos workers (Ehrlich *et al.*, 1991).

2.4.5 Immunological System

According to Perkins (1974), air pollutants especially nitrogen dioxide were known to increase the susceptibility to bacterial infection.

2.4.6 Respiratory system

Air pollutants attack human health primarily through respiratory system (Moran *et al.*, 1980). Over 75 million children and adults suffered from some form of respiratory diseases like asthma, bronchitis and occupational lung diseases caused by the inhalation of air pollutants like smoke, pollens, dust and fumes (Greenberg and Dintiman, 1992). Noninfectious diseases of the respiratory system include chronic bronchitis and emphysema, which are highly related to air pollution (Hales, 1994). According to Bruess and Richardson (1992), aggrevation and/or causation of chronic bronchitis, asthma and pulmonary emphysema have all been considered in association with community air pollution.

2.5 EFFECT OF AIR POLLUTION ON RESPIRATORY SYSTEM

2.5.1 Anatomy of respiratory system

The upper respiratory tract consists of nasal cavity, pharynx and trachea. In the lower respiratory tract, the trachea branches out into two bronchi. These bronchi further subdivide into smaller bronchioles. At the end of the bronchioles are the alveoli, which are arranged in clusters, with each cluster connected to bronchiole by an alveolar duct. The alveoli are very minute sac like structures surrounded by blood capillaries. The final divisions of the respiratory tract into alveoli increase the surface area for gaseous exchange. The two lungs with a volume less than 1 cubic foot have a surface area of well above 600 square feet. The inside of the whole respiratory passage is covered by the lining of mucus and cilia (Connellan, 1993).

2.5.2 Functions of the respiratory system

2.5.2.1 Respiratory functions of the lungs

The function of respiratory system is to bring the air into close contact with a large number of blood capillaries, so as to facilitate the diffusion of atmospheric oxygen into the blood and carbondioxide out from the impure blood (Sabiston and Spencer, 1983).

2.5.2.2 Defencing against environmental agents

Among the organs of the body, the respiratory system has the most intimate contact with the environment because of its large surface area and the volume of air exchanged with the external environment. Clean air contains

suspended bacteria, fungi, spores and a small amount of dust. Therefore, the lungs are the major portal entry for myriad infectious agent (Huang, 1985)

The upper respiratory tract (nose, pharynx and larynx) and airways (trachea and bronchi) have an efficient method of removing particulate inhalants from the inspired air, thus preventing them from reaching the lung parenchyma where they may cause tissue injury. The gaseous toxic materials adsorbed onto particulate inhalants are also removed with the particles. The toxic chemicals remaining in the gaseous phase are removed by an entirely different mechanism, which is generally much less effective (Gillett and Ford, 1978)

Particles larger than 10 μm in diameter would be removed completely in the passage of the air stream through the nose and upper airways and particles between 5 and 10μm would be deposited primarily in the upper airways on the mucociliary escalator. Only the particles in the range of 1 to 2 μm would be likely to penetrate into the deeper portions of the lung, where deposition in the alveoli could occur by gravity and diffusion (Morgan and Seaton,1984).

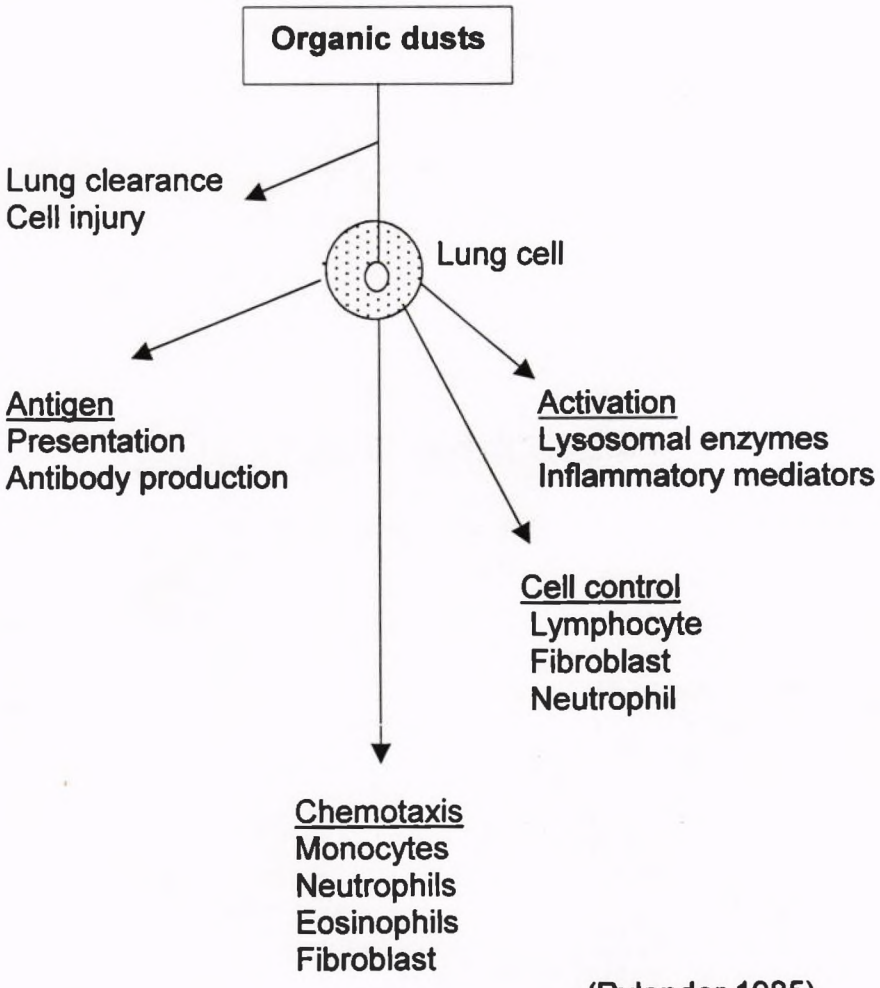
The basic concepts of lung cell reactions after organic dust exposure is shown in figure 1.

2.5.2.3 Effect of dust on lungs

The most significant effect of dusts on lungs is the excessive production of elastic like material called collagen, which causes tissue damage and dilation of air sacs. This seriously disrupts the lungs ability to perform exchange of oxygen and carbondioxide across the alveolus blood barrier. Other effects include inflammatory reactions and allergic phenomena (Harrington, 1981).

Figure – 1

BASIC CONCEPTS OF LUNG CELL REACTIONS AFTER ORGANIC DUST EXPOSURE



(Rylander, 1985)

2.5.2.4 Occupational lung hazards caused by dust

Occupational lung diseases are the disorders of the lungs that are caused by the air pollutants in one's working environment (Hendrick *et al.*, 1980). Certain highly toxic products, including gases, metallic fumes and a few dusts may be inhaled accidentally by workers engaged in their commercial production, or may incidentally contaminate the environment of a worker occupied in a task. The effect of inhaling such substances depends mainly on the concentration and nature of inhaled poison (Cole, 1977). According to a survey conducted by Meredith *et al.* (1991), out of 2101 cases reported to have occupational respiratory disorders, 26% had asthma, 16% had mesothelioma, 15% pneumoconiosis, 11% benign pleural disease and 6% allergic alveolitis. Occupational exposure to specific agents and work processes might be independent markers of obstructive lung disease in general population (Per *et al.*, 1991).

2.5.2.4.1 Occupational asthma

Occupational asthma may be defined as a respiratory disorder by inhalation of airborne dusts, vapours or fumes encountered in work place and characterized clinically by shortness of breath, wheezing and cough (Taylor, 1980). According to Brody and Snider (1985), asthma and dust go together. Dust was found to induce inflammatory reaction in lungs and result in allergic asthma (Harrington, 1981). The respiratory reaction to the inhaled particles such as cellular proliferation and fibrosis leads to chronic lung disease. Early sensitization to environmental allergens has been reported to account for the recent worldwide increase of bronchial occupational asthma (Hsieh, 1996).

Asthma forms the largest group of patients in an allergic clinic. Pulmonary function tests are important in assessing a worker with occupational asthma (Oxman, 1996).

Bronchial asthma with its distressing wheeze is a very common respiratory disorder affecting a large number of people all over the world (Wright, 1996). The relationship between dust sensitization and asthma was studied by Gupta (1991).

Dust, fumes, vapours or highly sensitizing substances in a working environment increased the rate of occupational asthma (Hirshaw and Murray, 1980).

Occupational asthma is a variable airflow obstruction, which is increased as a cause of work related exposure. In Norway, 20% of asthma cases among adults were found to be occupational who were exposed to dusts and gases (Kongerud, 1992). Occupational asthma may resemble classical intrinsic asthma, but delayed reactions may be present. This symptomatology is sometimes similar to that encountered in byssinosis, a cotton dust induced lung disorder, but the symptoms are not confined to exposure on Mondays (Rylander, 1985). It is a type I reaction involving sensitization to immunoglobulin E antibodies.

A worker can be diagnosed to have occupational asthma if the worker has chest complaints with reversible air flow obstruction. A relationship exists between occupational exposure and the occurrence of respiratory symptoms and a specific airways senstiser present in the workplace to provoke asthma (Awad, 1999).

The lung responses to work place hazards and the prescribed occupational lung diseases are shown in Table 2 and 3.

TABLE – 2

LUNG RESPONSES TO WORK PLACE HAZARDS (Seaton *et al.*, 1989)

Type of diseases	Postulated Mechanism	Examples of Occupational Exposure
Diffuse fibrosis	Macrophage damage Type IV hypersensitivity	asbestos, beryllium
Nodular fibrosis	Macrophage damage	silica, coal
Emphysema	Neutrophil enzymes	coal
Bronchitis	Mucosal irritation	general dust
Chest tightness	Endotoxin, complement activation	cotton, hemp, humidifier
Allergic alveolitis	Cell mediated and type III hypersensitivity	fungi in hay, malt
Bronchial carcinoma	DNA damage	asbestos, radon
Mesothelioma	DNA damage	asbestos

TABLE - 3

PRESCRIBED OCCUPATIONAL LUNG DISEASES (Seaton *et al.*, 1989)

Diseases	Prescribed Occupation
Anthrax	Contact with animals or their products
Tuberculosis	Medical or laboratory contact
Extrinsic allergic alveolitis	Agriculture, malt work, mushroom growing, bird handling, bagasse handling
Asthma	Exposure to isocyanates, platinum salts, epoxy resin hardeners, proteolytic enzymes, animals, grain dusts, antibiotics, wood dust, cotton dust, castor bean dust
Byssinosis	Contact with cotton or flax dust
Various poisonings	Exposure to mercury, cadmium, nickel, carbonyl, beryllium, nitrogen oxides
Pneumoconiosis	Mining, quarrying, ceramics, foundry work, asbestos handling etc.
Mesothelioma	Asbestos handling
Lung cancer	Nickel refining, asbestos handling
Nasal cancer	Nickel refining, wood work, shoe manufacture
Pleural fibrosis	Asbestos handling

2.5.2.4.2 Pneumoconiosis

The term pneumoconiosis was coined by Zenker to define a group of diseases caused by the inhalation of dust (Spencer, 1977).

Asbestosis

Correlation between respiratory symptoms and pulmonary function in asbestos exposed workers was found by Brodkin (1993). Asbestosis is a clinical disease observed in workers employed in the manufacture of asbestos products (Craighead and Mossman, 1982). Sebastein *et al.* (1982) found out that small numbers of asbestos fibers that deposited on alveolar surface caused low grade but sustained alveolar injury, resulting in fibrosis of alveolar septa called asbestosis. Increasing use of asbestos was related to pulmonary fibrosis – asbestosis (Becklake *et al.*, 1980). Harrington (1981) conducted a study to diagnose, prevent and control asbestosis.

Silicosis

Silicosis is a lung injury caused by silica which extends from acute alveolar injury with pulmonary edema on one extreme to chronic fibroic process developed over decades on the other (Khanna, 1994).

Coal worker's Pneumoconiosis

Coal worker's Pneumoconiosis is a complicated form of tissue change caused by coal dust in mining workers. The dust laden macrophages migrate and converge on the peribronchiolar space of the last two generations of respiratory bronchioles and cause weakening and dilation of bronchioles and also fibrosis of the lungs (Spencer, 1977).

Berylliosis

Beryllium is a metal highly toxic to respiratory system. Fibrosis and sarcoid like granulomas are the hall marks of chronic berylliosis (Huang, 1985).

Farmer's lung

Farmer's lung is an example of organic dust lung disease, caused by massive exposure to fungi, fungal spores and other fungal derivatives in moldy hay in farmer's lung. X-ray examination often showed pulmonary edema (Perry and Sellors, 1983).

Other Occupational Pneumoconiosis

Bagassosis (allergic alveolitis seen in workers employed in the manufacturing of cardboard, insulation board who use Bagasse), saw mill worker's lung (fibrosis of lungs in saw mill workers which is induced by *Cryptostroma corticale* fungi in redwood), Bird Fancier's lung (allergic alveolitis seen in persons employed in animal husbandries which is a reaction of bird droppings) and Byssinosis (bronchitis caused by cotton dust in mill workers) are some of the other occupational Pneumoconiosis (Spencer, 1977).

2.5.2.4.3 Chronic bronchitis

Pollution of the common air is strongly suspected as a factor in the aetiology of chronic bronchitis and there is no doubt that it can kill patients with established disease. Chronic bronchitis results from chronic inflammation in the bronchi of the lungs, which causes mucus formation, with resultant coughing. In many incidences, this disease is due to occupational exposure to dust (Bruess and Richardson, 1992). It is characterized by an increase in the goblet cell number, an increase in mucus production and a change in the characteristics of the mucus toward a more sticky consistency. Airway obstruction develops next. The patients complain persistent cough and the condition is often aggravated by repeated upper respiratory infections, particularly in winter time. The endotoxins

may play a role in the development of this effect (Rylander, 1985). Kennedy *et al.* (1987) have defined chronic bronchitis as cough or sputum for atleast 3 months per year for two or more consecutive years.

According to Greenberg and Dintiman (1992), chronic bronchitis is always nearly associated with heavy cigarette smoking and air pollution. A study was conducted by Oxman *et al.* (1993) to assess the relationship between occupational dust exposure and chronic bronchitis and the results showed a significant association between loss of lung function and cumulative respiratory dust exposure. Dusty conditions in work place caused or aggravated existing chronic bronchitis (Auerbach *et al.*, 1990). The effect of occupational dust exposure on chronic lung bronchitis was studied by Muir *et al.* (1989).

2.5.2.4.4 Lung cancer

Lung cancer is one of the few malignant neoplasms associated with environmental pollution. Occupational exposures to radioactive materials in mining industries, chromium, nickel, vanadium, molybdenum, beryllium and asbestos contributed to carcinogenesis in selected segments of the population (Huang, 1985). The related exposure to coal mining dust and cigarette smoking increased the rate of lung cancer (Morgan and Seaton, 1984).

2.6 OCCUPATIONAL LUNG HAZARDS IN TEXTILE INDUSTRY

Textile industry is one of the oldest and profitable industries of India (Behnke, 1996). In a textile industry, yarn is prepared, woven or knitted and processed. The basic raw materials are cotton, synthetic fibre and wool (Agarwal, 1996).

2.6.1 Cotton textile industry

The flow chart indicating the processes carried out in a textile industry is illustrated in figure 2.

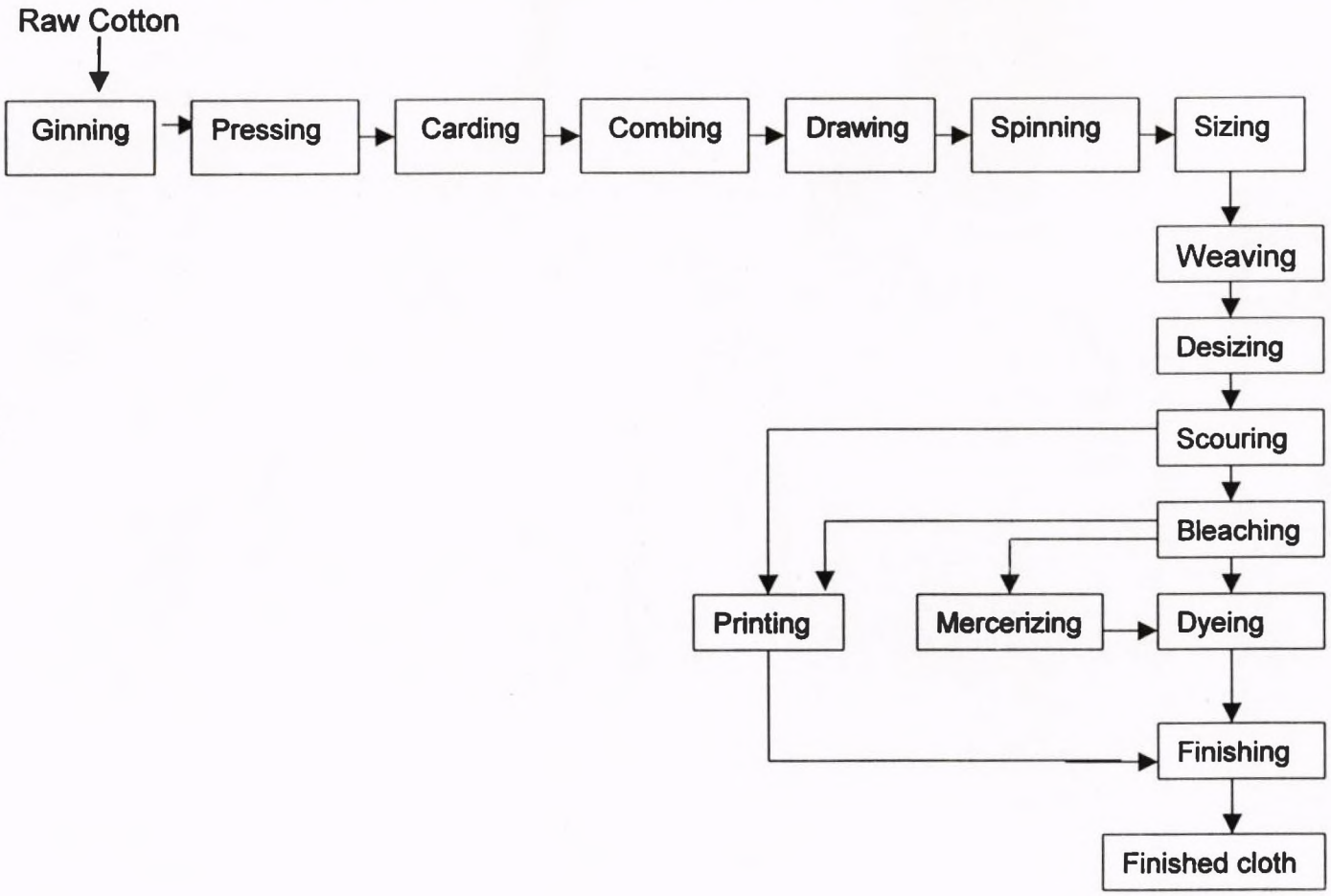
Textile mills produce about 33,000 – 35,000 tonnes of cotton dust in blow rooms (Pathe *et al.*, 1982). Pandit *et al.* (1972) analysed the concentration of airborne cotton particles from coarse and fine cloth mills and recorded an average particle count of 176, 274 and 763 mg/100 m^3 from fine mills, coarse mills and ginning processes respectively. Gokani *et al.*(1993) have also observed high dust concentration in blowing and carding sections of textile mills at Ahmedabad. Kennedy *et al.*(1987) have mentioned that the range of cotton dust concentration of two Chinese textile mills were 0.15 – 2.34 mg/m^3 in plant 1 and 0.19 – 2.5 mg/ m^3 in plant 2. Dust fly component of the total dust is a better indicator of cotton dust levels in textile mills (Bhagia *et al.*, 1985).

2.6.2 Analysis of cotton dust

Cotton dust is a mixture of cotton fibres and trash. Trash consists of plant debris which come along with cotton from harvesting stage and is expressed as percentage by weight. There are 3 varieties of cotton-coarse, medium and fine. According to British Occupational Hygiene Society (BOHS), relative fineness of the spun yarn is expressed in length per unit pound. The English system is based upon the 'count'. One count is equivalent to 840 yards in length and higher the count, finer is the yarn. Coarse cotton has 6 –12 counts and its trash content varies from 4 – 15%. Medium cotton has 12 – 44 counts with its trash content 1.5 – 5%. Fine cotton has 40 – 120 counts, with its trash content less than 2%. The threshold limit value (TLV) for cotton dust (less fly) concentration was found to be 0.5mg/m^3 (Bhagia *et al.*, 1996).

Figure - 2

FLOW CHART INDICATING THE PROCESSES CARRIED OUT IN A TEXTILE INDUSTRY



(Agarwal, 1996)

As per Neefus *et al.* (1977), cotton dust is a complex organic dust which contains a respirable portion and a nonrespirable portion including fibrous material. The term organic dust includes dusts of vegetable and animal origin (Rylander, 1985). Exposure to cotton dust is aetiologically important in several diseases-occupational asthma, byssinosis, chronic airflow limitation and chronic bronchitis (Simpson *et al.*, 1998).

Chemical analysis of Cotton dust (Kudesia, 1987)

Components	Percent by weight
Total nitrogen	1.22
Hemicellulose	9.80
Carbon	44.05
Cellulose	38.35
Pectin	6.58

2.6.3 Pulmonary effects of cotton dust

Textile includes a woven fabric made of fibres or yarns. In textile industry, yarn manufacturing, opening and picking machinery, carding, drawing, combing, roving, spinning, all prove to be sources of cotton dust air pollution (Suess *et al.*, 1985).

Continuous exposure to cotton dust caused increased airway reactivity which resulted in fixed airways obstruction (Bouhuys *et al.*, 1977). The aerodynamic diameter cut off for dust entering the trachea and bronchi was found to be 15 μ (Neefus *et al.*, 1977). World Health Organisation (1983) has recommended that the cotton dust levels as measured by vertical elutriator (having cut off size 15 μ) should not exceed 0.5 mg/m^3. Both the total and respirable cotton dust were found to be correlated with the prevalence of respiratory disorders (Pangtey *et al.*, 1993).

Cotton dust is a potent respiratory irritant and the workers were occupationally exposed to pulmonary hazards in their work environment (Berry *et al.*, 1973).

Exposure to cotton dust seemed to cause both acute and chronic illness (Christiani *et al.*, 1993). Exposure to cotton dust for more than 10 years might induce a permanent and irreversible impairment of lung function. There was a correlation between dust concentration and the severity of disease (Douglas *et al.*, 1984). Workers chronically exposed to cotton dust were at risk of developing chronic airflow obstruction (Christiani *et al.*,1994).

Cumulative inhalable cotton dust was the cause of byssinotic symptoms, acute lung function decrements, cough , phlegm and chronic bronchitis (Jiang *et al.*, 1995).

Byssinosis is an occupational lung disease of textile workers caused by excessive inhalation of cotton dust (Balmes *et al.*, 1983). The symptoms include chest tightness, dyspnea, asthmatic wheezing and cough which were noticed when the worker returned to work on Monday after being away from the mill for the weekend (Spencer,1977). These symptoms might resemble chronic bronchitis and chronic obstructive lung diseases. The lung parenchyma showed fibrotic nodules containing calcified fibres surrounded by degenerating macrophages (Huang, 1985). One characteristic of the acute pulmonary response to cotton dust exposure was a drop in forced expiratory volume in one second (FEV_1) during the Monday workshift or the first day back at work after atleast a two days lay off (Christiani and Wegman,2000). A significant reduction in FEV_1 and peak expiratory flow (PEF) in acute byssinotic reaction was also reported by Valic and Zuskin (1973). Fox *et al.* (1973) have predicted that approximately 10% of subjects exposed to 0.5mg/m^3 of dust for 40 years had the

symptoms of byssinosis. In byssinosis, there was complete absence of specific radiographic changes in the lung, as well as pathology on autopsy (Rylander,1985)

A cross sectional study was carried out by Mishra *et al.* (1997) in different departments of a textile mill of Baroda city and in healthy controls for assessment of acute and chronic changes in ventilatory functions and prevalence of byssinosis due to exposure to cotton dust. Their study revealed that 16.15% had byssinosis. Both chronic and acute changes in pulmonary function were observed in cotton dust exposed workers.

The clinical and functional grades of byssinosis were suggested by Schilling *et al.* (1963). British Occupational Hygiene Society (BOHS) committee on hygiene standards (1972) have concluded that at dust levels below $0.5mg/m^3$, the prevalence of Grade 2 byssinosis was less than 4%. At this level, byssinosis occurred only in workers with more than 10 years of exposure. Dust levels in excess of 1.0 mg/ m^3 might produce a higher prevalence of byssinosis and the disease might occur in susceptible individuals within first four years of exposure.

The acute decrements in lung function after several hours of exposure to cotton dust was demonstrated by Castellan *et al.* (1984).

Jacobs *et al.* (1993) found significant decline in ventilatory function in young healthy nonsmokers after an exposure of 1 mg/m^3 respirable cotton dust. Jones *et al.* (1980) showed an association between atopy and drop in forced expiratory volume in one second (FEV_1) over a work shift in cotton textile workers.

About 50,000 workers suffered from byssinosis caused by cotton dust according to Harsh Jaitley, the ChairPerson of a survey conducted by Occupational Health and Safety Commission of Delhi based society for Participatory Research in Asia (Khanna, 1994).

An epidemiological study was conducted by Parikh *et al.* (1991) in textile workers, Ahmedabad, which showed that byssinosis behaved distinctly and showed maximum acute and chronic changes in pulmonary functions and the effect was more predominant than that of smoking.

Woldeyohannes *et al.* (1991) investigated the prevalence of respiratory problems in textile workers in Ethiopia. The result showed that the prevalence of byssinosis was 43.2% among blowers, 37.5%, in carders and 24% in other sections. The prevalence of chronic bronchitis was 17.6 – 47.7% and bronchial asthma was 8.5%- 20.5%. A significant dose response relationship for pulmonary function and respiratory illness was found.

A follow up study of ventilatory capacity and respiratory symptoms in cotton workers for a period of 5 years was done by Zuskin *et al.* (1991) in females and males. The results showed an increase in byssinosis from 22.9 to 42.9% in females and 25.8 to 51.6% in males . This demonstrated an association between exposure to cotton dust and increasing prevalence of respiratory symptoms and progressive impairment of ventilatory capacity.

A study was conducted by Rastogi *et al.* (1990) to assess the ventilatory obstruction in textile mill workers exposed to cotton dust. The results portrayed that the healthy cotton workers and byssinotics engaged in carding, blowing and waste plant rooms, showed an insignificant high prevalence of bronchial obstruction (11.3 and 24.4%) than among workers in spinning, reeling and winding section of mill.

The clinical picture, classification, therapy and diagnostic criteria of byssinosis were put forward by Frantisek and Lek (1988).

Glindmeyer *et al.* (1991) established a longitudinal study on large multimill population of cotton textile and synthetic process workers in USA. The results suggested that in short term, smoking should be restricted from working in yarn manufacturing areas, and in long term, the feasibility of lowering respirable dust levels to provide protection for all yarn manufacturing workers should be evaluated.

Holness *et al.* (1983) have reported that the prevalence of mill fever and byssinosis was 31% and 5% respectively in cotton-felt industry located at Ontario. The results of their study also showed a dose - response relationship between vertical elutriator dust measurements and change in FEV_1 over the work shift.

Mohan rao *et al.* (1991b) investigated the workers employed in different departments of a textile mill at Ahmedabad. Their investigation revealed chronic pulmonary dysfunction of moderate to severe category in 71.4% byssinotics and 40.1% in nonbyssinotics. Smoking had an additive effect over dust exposure in causing decline in ventilatory function.

Shah and Rajagopal (1985) have observed in a study that the effect of cotton dust on bronchoconstriction was more than woolen dust.

Studies of Fox *et al.* (1973) have shown that the prevalence of byssinosis increased with exposure to cotton dust and was affected by smoking.

Bhatt *et al.* (1990) have suggested that measurement of forced expiratory flow at middle half of forced vital capacity ($FEF_{25-75\%}$) could be used as an early indicator of small airway obstruction in byssinotics.

Reports on pathology studies conducted by Schachter (1998) have shown that the pattern of diseases caused by cotton dust involved the larger airways.

Airway inflammation caused by cotton dust increased with increasing exposure time and the changes were more notable in workers with reactivity to cotton dust extract (Jiang *et al.*, 1995).

A survey was conducted by Fishwick *et al.* (1996) to investigate the lung function levels in workers employed in cotton and man made fibres. The results showed that work related symptoms and lower forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) levels were significantly higher in cotton mill operatives.

Christiani *et al.* (1986) undertook a study to investigate the respiratory disease in cotton textile workers in China. They have reported that the prevalence of byssinosis was substantially higher among nonsmoking women than nonsmoking men.

According to Parkes (1982), byssinosis was associated apparently more with women. He has also mentioned that the prevalence of byssinosis in cotton workers varied according to the quality and quantity of cotton dust in the work environment.

The pulmonary function tests in different grades of byssinosis were studied by Mohan rao *et al.* (1992). Their study revealed that ventilatory dysfunction increased with increasing grades of byssinosis.

High prevalence of byssinosis and chronic bronchitis was also reported in Tanzanian cotton mill workers by Mustafa *et al.* (1978).

The prevalence of byssinosis in Swedish cotton mills was studied by Haglind *et al.* (1981). They observed that the prevalence of byssinosis was related to the number of airborne viable gram negative bacteria and cotton dust levels.

The studies of Cinkotai and Whitaker (1978) on the textile mill workers in Lancashire portrayed a significant excess of symptoms of chronic bronchitis and asthma in byssinotics when compared to nonbyssinotics.

High prevalence of byssinosis (67% in blowers and 40% in carders) was also reported by Karim *et al.* (1986) among textile workers in Sudan.

Cotton dust induced acute bronchoconstriction by one or more mechanisms and a number of factors were suggested to cause bronchoconstriction among textile workers (Mundie and Ainsworth,1986).

Microbial contamination is an important factor determining the biological reaction involving cotton dust induced lung diseases. The dusts are contaminated with bacteria, fungi and molds. Gram negative bacteria contain a compound known as endotoxin in their outer cell wall. This is a lipopolysaccharide, which is present between the protein molecules of cell wall and causes a series of biological effects (Rylander, 1985). Endotoxin is a potent inflammatory and adjuvant substance related to occupational asthma syndromes and chronic airflow obstruction (Milton *et al.*, 1997).

The inhalation of bacterial endotoxins may be one of the responsible factors for the induction of bronchoconstriction in byssinotics (Gokani *et al.*, 1993).

Controlled exposure of humans to endotoxin laden cotton dust have led to a definite association between decrease in acute pulmonary function and the level of airborne endotoxin (Olenchock *et al.*, 1989).

Endotoxin appears to be an important determinant in acute pulmonary effects of cotton dust (Kennedy *et al.*, 1987). The same result was also reported by Castellan *et al.* (1984) who have observed that acute drop in FEV_1 was correlated highly with endotoxin level, when they subjected volunteers to cotton dust with high endotoxin content.

The results of Gokani *et al.* (1993) have shown that Indian raw baled cotton fibres contained higher concentration of endotoxins.

Endotoxin activity was highly correlated to acute reduction in FEV_1 than respirable dust and airborne gram negative bacteria (Kilburn, 1998).

Gokani *et al.* (1988) reported significant higher endotoxin concentration in carding and blowing sections of textile industry at Ahmedabad.

Endotoxin contents in cotton dust were found to be potent inducers of neutrophil migration (Rylander, 1985).

The endotoxin acting through the immunoglobulin system could initiate complement activation or activate macrophages to release C3. Either mechanism would result in leucocyte migration into the tissue, thrombocyte aggregation and

contiguous blood capillaries and histamine release. The increased vascular resistance and histamine release would then produce the characteristic disease symptoms (Greenblatt and Ziprin, 1979).

According to Rylander *et al.* (1985), there was a dose – response relationship between the endotoxin level and the presence of symptoms of byssinosis in the exposed workers as well as between endotoxin levels and an increase in blood neutrophils.

Acute airway inflammation characterised by the presence of neutrophils is a prominent feature of many lung disorders including bronchitis, byssinosis and bronchial asthma (Koyama *et al.*, 1991).

Rylander and Beijer (1987) observed that when guinea pigs were challenged with aerosolized bacterial endotoxin (lipopolysaccharide), there was an accumulation of platelets in the lungs.

Lactate dehydrogenase activity, a biochemical marker of cell injury, total cell counts and polymorphonuclear leucocytes were found to be more sensitive indices of adverse pulmonary effects of inhaled endotoxin (Gordon, 1992).

Rousselle *et al.* (1990) analysed cotton dust to have condensed tannins and endotoxins, which were suspected of contributing to the acute and chronic pulmonary responses in textile mill workers.

Water washing of cotton resulted in reduced airborne endotoxin and less bronchoconstriction (Petsonk *et al.*, 1986).

The blood histamine levels were higher than normal in workers exposed to cotton dust and with symptoms of byssinosis (Noweir *et al.*, 1984).

Mast cell degranulation with its release of histamine had been strongly implicated in the acute symptoms of textile mill workers (Ellisade *et al.*, 1980). This could induce pathophysiological changes in lungs (Parikh *et al.*, 1987).

Antweiler (1961) showed that the extracts of certain parts of cotton plant contain a histamine-liberating factor.

Malvankar *et al.*(1986) have reported that the peak expiratory flow (PEF) in cotton textile workers were maximal when the blood histamine levels were in a range of 0-5 μg/ml and dropped down to the lowest level when the blood histamine was more than 10 μg/ml.

According to Gokani *et al.* (1988), the histamine release in subjects exposed to cotton dust seemed to play a definite role in the occurrence of symptoms of byssinosis.

Lewis *et al.* (1986) have reported that aqueous extracts of cotton dust stimulated alveolar macrophage to secrete interleukin 1. The number of macrophages was correlated with the endotoxin content of the extracts.

Cooper *et al.* (1986) administered an aqueous extract of cotton bract to normal human subjects. Their findings suggested that exposure of volunteer subjects to cotton bract extracts resulted in a bronchoalveolar inflammatory response related to both complement activation and chemotactic factor synthesis by luminal cells.

This bronchoconstriction might be also due to the release of mediators by alveolar macrophages (Merril *et al.*, 1987).

The acute bronchoconstriction response might be also due to breakdown products originating from lung cell membrane phospholipids. Surfactant of mammalian lung is composed of phospholipids, which coats the interior of the lung. This material aids in the removal of foreign particles from the airways, stimulates motility of the phagocytotic and bactericidal capacity of alveolar macrophages (DeLucca *et al.*, 1991).

Studies of Mundie and Ainsworth (1986) on aetiopathogenic mechanism of bronchoconstriction in byssinosis indicated the possible involvement of histamine, 5-hydroxy tryptamine, platelet activating factor and metabolites of arachidonic acid as mediators of bronchoconstriction.

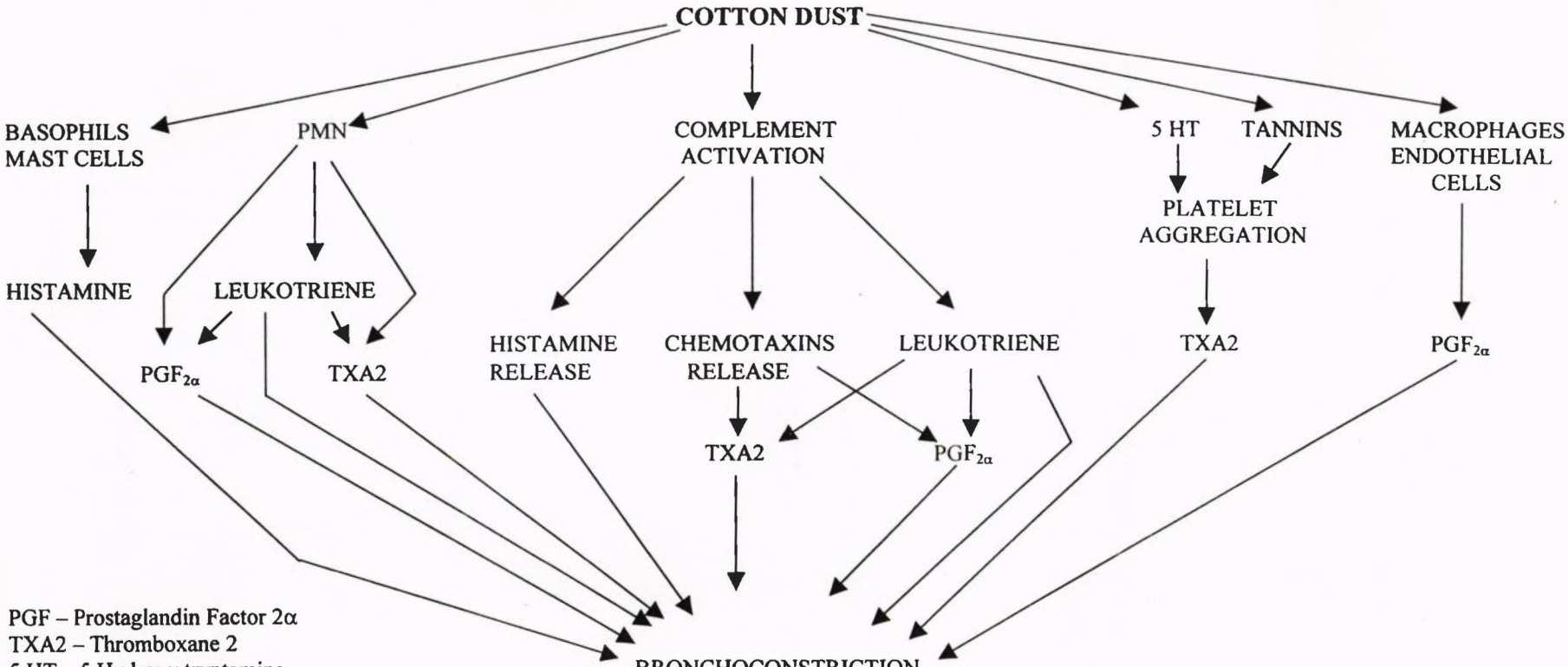
Chemotaxins were also found to exist in cotton mill dust extracts. These substances may be involved in the recruitment of cells to pulmonary surfaces and in the etiology of byssinosis in textile workers who inhale cotton dust (Ainsworth and Neuman, 1981).

Karnik *et al.* (1987) have reported increased levels of Ig G in cotton dust exposed workers. Their study also portrayed that there was a significant rise in LDH 1 and decrease in LDH 3 in the workers. The levels of Ig G were more in byssinotics when compared to chronic bronchitic workers (Kamat *et al.*, 1981).

The proposed aetiopathogenic mechanism of bronchoconstriction in byssinosis is illustrated in figure 3.

Figure – 3

PROPOSED AETIOPATHOGENIC MECHANISM OF BRONCHOCONSTRICTION IN BYSSINOSIS



PGF – Prostaglandin Factor 2α
TXA2 – Thromboxane 2
5 HT – 5 Hydroxy tryptamine

(Mundie and Ainsworth , 1986)

2.6.4 Cotton dust in ginning factory

The main sources of cotton dust production is ginning (Parkes, 1982). The first mechanical process following cotton harvesting is ginning, where the fibre or lint is separated from the seed (Parikh *et al.,* 1996). There are two types of gins - the roller type and the saw type. The roller gin separates lint or fibre from the seed by friction of a leather roller set at a small distance from a knife edge or doctor blade. The saw gin separates the lint from the seeds by means of saws mounted on a circular shaft which pull the lint while the seed is restrained by narrow grids. Introduction of saw gins reduce the content of cotton dust (Bhagia *et al.*, 1992).

The area under the ginning machine where seeds are collected is called gutter. Cotton is thrown on the front side of the ginning machine, collected by workers and transported to the hydraulic press where it is compressed into bales. The bales are then weighed, stamped and transported to the textile mill (Parikh *et al.,* 1993b).

Parikh and Bhagia (1990) observed work related complaints like dry cough, chest tightness, breathlessness and burning in eyes in ginning factory workers in Ahmedabad.

The threshold limit for cotton dust exposure as suggested by British Occupational Health and Safety (1972) is 0.5 mg/m^3. According to Ghosh et *al.* (1997), exposure to cotton dust inside the gin house leads to the development of acute effects and decline in FEV_1 among the exposed subjects comparable to bysssinosis among cotton textile workers. The ginning factory workers processing short staple cotton showed more acute changes in pulmonary functions than workers processing long staple cotton (Parikh *et al.,* 1993b).

The FEV_1 measurements for three consecutive days after holiday in ginning mill employees were studied by Madhwani *et al.* (1991). They observed a decline in FEV_1 of lung function, during a work shift which was comparatively maximum on first working day after a holiday, than on the subsequent days and was found to be a useful parameter for early detection of respiratory disorders among the employees of ginning mill. According to Parikh *et al.* (1996), ginning workers might develop acute symptoms rather than chronic because of high dust concentration. This acute effect might result in chronic respiratory disease after long duration of exposure.

The location of gin in relation to its dust and trash collecting equipment outside the gin are of major importance in the occurrence of dust in gins. The dust content of ambient air outside gins also proved to have a major impact on dust levels within gins (Bhagia *et al.*, 1989). The recent United States Environmental Protection Agency (EPA) report lists cotton gins as one of the seven primary sources of atmospheric arsenic. The gins did not have the same hourly processing capacity and the cottons ginned were dissimilar in variety, production history and method of harvest.

Based on the above literature, in the present study an attempt was made to evaluate the respiratory function and biochemical profile of women labourers working in a ginning factory in Tirupur, a textile city in Tamil Nadu.

Experimental Procedure

3.0 EXPERIMENTAL PROCEDURE

The experimental design adopted for the study **"BIOCHEMICAL PROFILE AND PULMONARY FUNCTION IN GINNING FACTORY WOMEN LABOURERS EXPOSED TO COTTON DUST POLLUTION AT TIRUPUR"** is presented under the following headings:

3.1 SURVEY ON THE PREVALENCE OF RESPIRATORY MORBIDITIES AMONG TEXTILE WORKERS IN COIMBATORE DISTRICT

3.2 SELECTION OF THE SAMPLING SITE FOR THE STUDY

3.3 SURVEY OF WOMEN LABOURERS WORKING IN THE SELECTED GINNING FACTORY

3.4 GROUPING OF THE WOMEN LABOURERS

3.5 PULMONARY FUNCTION TESTS

3.6 BIOCHEMICAL PROFILE

3.7 ANALYSIS OF COTTON DUST

3.8 ENUMERATION OF AIRBORNE GRAM NEGATIVE BACTERIA IN THE WORK AREA

3.9 STATISTICAL ANALYSIS

3.1 SURVEY ON THE PREVALENCE OF RESPIRATORY MORBIDITIES AMONG TEXTILE WORKERS IN COIMBATORE DISTRICT

Occupational lung diseases among the textile mill workers are very common due to inhalation of cotton dust.

Therefore a survey was carried out in Avinashi, Palladam, Tirupur and Coimbatore in Coimbatore district in Government, private and Employees State Insurance (ESI) hospitals to assess the incidence of pulmonary disorders among textile industry workers.

3.2 SELECTION OF THE SAMPLING SITE FOR THE STUDY

Uma Maheshwari ginning factory, Tirupur, located in the heart of the town was selected as the sampling site which covers an area of 3 acres . It is a low count cotton processing ginning factory established in 1950.The ginning machine equipped in the ginning factory is of roller type, where the lint of fibre is separated from the seed by friction of a leather roller set at a small distance from a knife edge.

The selected ginning factory has three major sections-gin house, gutter and sorting sections.In the gin house,the seeds are separated from cotton and collected in the gutter. Sorting section is involved in the sorting of cotton according to quality. Totally there were 104 women labourers engaged in the ginning of the cotton bolls. Among the 104 women labourers, 56 were employed in gin house section,38 in gutter and 10 in sorting section. There were 6 men workers employed in transporting the load of the cotton bales, pressing the cotton bolls and sewing the bags who were appointed temporarily.

Plate 1 to 6 show the different processes carried out in the selected ginning factory.

DIFFERENT PROCESSES CARRIED OUT IN THE SELECTED GINNING FACTORY

PLATE 1	MEN WORKERS ENGAGED IN TRANSPORTING COTTON BALES
PLATE 2	SORTING OF COTTON ACCORDING TO QUALITY AND REMOVAL OF UNWANTED IMPURITIES LIKE MUD, SAND, STICKS AND LEAVES
PLATE 3	TRANSFER OF COTTON FROM SORTING SECTION TO GIN HOUSE
PLATE 4	TRANSFER OF COTTON FROM SORTING SECTION INTO GINNING MACHINE IN GIN HOUSE
PLATE 5	GINNING PROCESS – SEEDS ARE REMOVED FROM THE COTTON BOLLS
PLATE 6	MEN WORKERS INVOLVED IN PRESSING OF PROCESSED COTTON


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3.3 SURVEY OF WOMEN LABOURERS WORKING IN THE SELECTED GINNING FACTORY

A questionnaire (based on the British Medical Research Council recommendation and modified for use in India) was administered to the women labourers employed in the selected ginning factory (Appendix I) in order to collect information regarding their name, age, economic background, work experience in the present occupation, anthropometric measurements, clinical conditions, dietary habits, fuel they used for cooking and chances for exposure to passive smoking.

3.4 GROUPING OF THE WOMEN LABOURERS

Based on the information collected from the women labourers they were grouped as indicated in Table 4.

TABLE – 4

GROUPING OF THE SELECTED GINNING FACTORY WOMEN LABOURERS

Age (Years) / Working Experience (Years)	BELOW 50	ABOVE 50	TOTAL
0 – 9 (41)	20	21	41
10 – 19 (18)	8	10	18
20 and above (45)	16	29	45
TOTAL (104)	44	60	104

The selected 104 women labourers working in the ginning factory formed the experimental group. Forty age and sex matched women of similar economic status was selected for the study as control subjects. They included housewives and women employed in the municipal office as social workers who were free from cotton dust pollution.

3.5 PULMONARY FUNCTION TESTS

Due to rapid industrialisation and urbanization, there is increasing number of airborne substances like dust, fumes and gases in the atmospheric environment causing contamination. Man in his working environment is continuously exposed to inhaled particles. Besides these, personal pollution like burning of cooking fuel leads to an additional burden to this environment. Many of the inhaled substances get deposited in tracheo - bronchial tree and alveoli of lung causing diseases like chronic bronchitis, emphysema, asthma, byssinosis, silicosis and asbestosis. Pulmonary function tests have proved to be of great value in the diagnosis of these diseases and in their clinical management. The pulmonary function test (PFT) is an established and sensitive method to find out restrictive and obstructive type of lung impairments.

Pulmonary function tests included spirometric analysis and chest X ray analysis.

3.5.1 Spirometric Analysis

Spirometer is a device used to assess the ventilatory function of lungs (the process by which lungs replenish the gas in alveoli). When a person breathes in and out in a spirometer, this is capable of measuring expired / inspired gas volume and plotting gas volume or flow as a function of time.

The following indices of PFT were included for assessment by spirometry :

a. Forced vital capacity (FVC) in litres
b. Forced expiratory volume in one second (FEV_1) in litres/second
c. Peak expiratory flow (PEF) in litres
d. Vital capacity (VC) in litres
e. Forced expiratory volume in one second percentage (FEV_1%) (Cotes *et al* .,1997)

Vitalograph spirometer (reading being obtained from a Data Dec Computer) was used for conducting pulmonary function tests. Before using the instrument, it was calibrated using a 1 litre syringe recommended by Vitalograph Ltd., England. Sex, ethnic identity, height, weight, age, occupation and spirometer temperature were recorded for all the subjects before testing. The tests were carried out with the subject seated and a nose clip applied (Vijayan *et al.*,1990).

The steps involved in spirometric assessment of the participants is illustrated in plates 7 to 9.

The FVC, FEV_1 and PEF were recorded thrice and the best value was taken for evaluation (Parikh *et al.*,1997).For assessing chronic changes, the observed values of FVC, FEV_1 and PEF were expressed as a percentage of the predicted values by using the regression equation developed by Vijayan *et al.* (1990).

STEPS INVOLVED IN SPIROMETRIC ASSESSMENT IN THE PARTICIPANTS

PLATE 7 CALIBRATION OF THE SPIROMETER

PLATE 8 INSTRUCTION TO THE PARTICIPANTS REGARDING SPIROMETRIC ANALYSIS

PLATE 9 CONDUCTING SPIROMETRIC ANALYSIS


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For the assessment of pulmonary function of a particular population, normal standard values of that population should be known. This is because the PFT values will vary essentially in different regions of the same country depending upon climatic condition, habit, age, sex and height. Therefore the regression equation developed by Vijayan *et al.* (1990) was taken into account for PFT assessment which is formulated for the subjects of Tamilnadu.

Spirometric analysis was carried out on the first day after a weekend holiday at the beginning of the shift and after a minimum of 7 hours exposure. This is because the chest tightness, an important symptom of byssinosis-a cotton dust induced pulmonary disorder, is most commonly manifested after a holiday (Mohan rao et al., 1998). Pulmonary function tests before and after shift might reveal the acute changes in PFT (Mohan rao, 1989).

Spirometric analysis was performed for the 104 labourers of the ginning factory and 40 control group participants as indicated in the steps given below :

3.5.1.1 Forced vital capacity (FVC)

Forced vital capacity is the total volume of air expired from maximal inspiration to the maximal inspiration being as rapid and complete as possible (Sabiston and Spencer, 1983). FVC is reduced in most diseases of the lung.

The steps involved were :

1. to breathe normally for some seconds
2. to carry out a maximal inspiration
3. to carry out a maximal forced expiration
4. to carry out a maximal forced inspiration
5. to breathe normally

3.5.1.2 Forced expiratory volume in one second (FEV_1)

Forced expiratory volume in one second (FEV_1) is the volume of air that is expired in one second. FEV_1 helps to measure the changes in expired volume against a particular time (Connellan, 1993). This is the maximal volume of gas that can be expired in the first second of a forced exhalation after a full inspiration. The FEV_1 is used as an indicator of airflow obstruction.

The steps involved were:

1. to breathe normally for some seconds
2. to carry out fast maximum inspiration and expiration sudden and fast
3. to breathe normally

3.5.1.3. Peak expiratory flow (PEF)

Peak expiratory flow is the volume of expired air at peak condition during a maximal expiration (Connellan, 1993). PEF provides a guide to the quality of forced expiration.

The steps involved were:

1. to carry out normal breathing
2. to carry out maximum inspiration slowly
3. to carry out maximum expiration suddenly and forcefully
4. to breathe normally

3.5.1.4 Vital capacity (VC)

It is the maximum amount of gas that can be expelled from the lungs following a maximal inspiration.

The steps involved were:

1. to breathe normally for some seconds
2. to carry out maximum inspiration to fill the lungs
3. to carry out maximum expiration
4. to breathe normally

3.5.1.5 Forced expiratory volume in one second percentage (FEV_1 %)

The FEV_1 % was calculated from the observed values of FEV_1 and FVC as per the method given below :

$$FEV_1\ \% = \frac{\text{Observed } FEV_1}{\text{Observed FVC}} \times 100$$

To check the reversible and irreversible nature of impairment of pulmonary functions in the selected ginning factory women labourers, they were challenged with a dose of salbutamol, a bronchodilator, which enlarges the lumen of the bronchioles to ease obstruction. The drug was delivered in the form of puff to get the optimum result after 15-30 minutes and then post bronchodilator PFT was carried out.

From the pulmonary function tests, four types of maneuver could be recognized:

1. Normal
2. Obstructive
3. Restrictive
4. Combined obstructive and restrictive (Chattopadhyay, 1999)

3.5.2 Chest X ray

Chest X-ray proves to be a supporting evidence for diagnosing any lung disorder. It is an important tool for diagnosing the different types of obstructive and restrictive lung diseases, occupational lung dysfunctions and tuberculosis (Sabiston and Spencer, 1983)

Chest X-rays were taken for the 104 ginning factory women labourers and 40 control women and the X-ray photographs were examined for any pathological conditions.

3.6 BIOCHEMICAL PROFILE

Blood is a part of the circulatory system of the body and has several functions. Much valuable information can be readily obtained from hematologic tests. A wide variety of diseases may show signs or symptoms of a hematologic disease like anemia (Linne and Ringsurd,1992). Anemia and eosinophilia are highly related to asthma and other lung dysfunctions associated with air pollutant hazards (Connellan, 1993). Pulmonary function tests supported by blood picture might confirm the clinical conditions of an individual.

The systolic and diastolic blood pressure of the selected 104 ginning factory women labourers and 40 controls were noted by using sphygmomanometer and the blood pressure was expressed in mm mercury (Appendix II).

5.0 ml of venous blood samples were collected from 104 experimental group and 40 control women for the estimation of selected blood parameters.

Plate 10 portrays the drawing of blood from the participants for biochemical analysis.

Plate 11 shows the examination of a participant of the study.

Plate 12 shows the biochemical analyser used in the study for the estimation of blood parameters.

3.6.1 Hematological Parameters

3.6.1.1 Hemoglobin

The oxygen that has diffused from the alveoli into the pulmonary blood is transported in combination with hemoglobin to the tissue capillaries where it is released for use by cells. Normally, about 97 percent of the oxygen transported from the lungs to the tissues is carried in chemical combination with hemoglobin in the red blood cells. The remaining 3 percent is carried in the dissolved state in the water of the plasma and cells. Thus, under normal conditions oxygen is carried to the tissues almost entirely by hemoglobin (Guyton and Hall, 1998). Measurement of blood hemoglobin concentration is important to study the oxygen diffusion capacity of lungs.

PLATE 10 DRAWING BLOOD FROM THE PARTICIPANTS FOR BIOCHEMICAL ANALYSIS

PLATE 11 EXAMINATION OF A PARTICIPANT OF THE STUDY

PLATE 12 BIOCHEMICAL ANALYSER USED FOR THE ESTIMATION OF BLOOD PARAMETERS

PLATE 13 BINOCULAR MICROSCOPE FOR THE ENUMERATION OF TOTAL AND DIFFERENTIAL COUNT OF LEUCOCYTES


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The hemoglobin content of the experimental and control women were estimated by converting hemoglobin to cyanmethmoglobin and treatment with Drabkin's solution and colorimetrically estimating the colour developed at 540 nm. The values were expressed in g/dl (Wintrobe *et al.*,1965).

Composition of Drabkin's solution

Sodium bicarbonate - 1.0 g
Potassium cyanide - 50 mg in 100 ml of distilled water
Potassium ferricyanide - 200 mg.

20 µl of blood was added to 5.0 ml of Drabkin's solution. The optical density was measured at 540 nm, which is directly proportional to the concentration of the pigment.

3.6.1.2 Erythrocyte sedimentation rate

The erythrocyte sedimentation rate is another hematologic determination that employs macroscopic observation. If blood is prevented from clotting (by using a suitable anticoagulant) and allowed to settle, sedimentation of the erythrocytes will occur. The rate at which the red cells fall is known as erythrocyte sedimentation rate (ESR). The rate depends on three main factors- the number and size of erythrocyte particles, plasma factors and certain technical and mechanical factors.

The rate of erythrocyte sedimentation was found out by Wintrobe method and expressed in mm/hour. Enough blood was drawn into a Pasteur pipette to fill a Wintrobe hematocrit tube to the 100mm mark. Bubbles were avoided. The

tube was placed in the support rack in an exactly vertical position so that the cells sedimented properly. Then the time was noted. At the end of one hour, ESR was read as the length of the plasma column above the cells (Wintrobe *et al.*, 1965).

3.6.1.3 Total leucocyte count

The total leucocyte count (TC) was determined by accurately diluting the blood suspension and enumerating the leucocyte number per unit volume. Leucocyte count is used to indicate the presence of infection and to follow the progress of certain diseases (Linne and Ringsurd, 1992). The method uses a diluting pipette graduated in relative units with bulb in its upper portion. After blood was drawn to the mark in capillary stem, the commercially available diluent-Turk's diluting fluid (which hemolyses RBC and stains WBC) was filled to a mark in the short capillary stem above the bulb. The dilution was 1:20. Then the number of leucocytes in a known volume of the diluted sample was determined by using a counting chamber, hemocytometer (Wintrobe *et al.*, 1965).

3.6.1.4 Differential counting of leucocytes

Differential counting refers to the enumeration and classification of the different leucocytes. It gives information regarding the status of blood leucocytes. The number and types of cells were counted and reported in number per litre (Linne and Ringsurd, 1992).

A uniformly thin smear of blood was done on a cover slip. All the leucocytes were counted and classified in a single drop of blood according to their size, nucleus and cytoplasm. An area of good cell distribution was selected under low-power magnification (100 X) and this area was then examined in detail

under oil immersion magnification. The number of neutrophils, lymphocytes, eosinophils and monocytes were recorded and the proportion of each was calculated (Wintrobe *et al.*, 1965).

The binocular microscope used in the study for the enumeration of total and differential count of leucocytes is shown in plate 13.

3.6.2 Other biochemical parameters

Among the 104 experimental group participants, 13 women labourers were selected randomly and they were subjected to the following biochemical tests in order to assess any possible correlation between the PFT impairment and the selected biochemical parameters. Ten women from the control group were also selected at random and subjected to the same selected biochemical analysis.

10.0 ml of blood was collected from 13 experimental and 10 control group participants without any anticoagulant. The blood was allowed to stand for clotting at room temperature. Serum was separated and used for selected biochemical estimations.

3.6.2.1 Immunoglobulins

Changes in serum immunoglobulins in workers exposed to cotton dust have been suggested to precede or accompany the development of byssinosis, a cotton dust related disease (Karnik *et al.*, 1987). Taylor *et al.*(1971) suggested an interaction between cotton dust antigen and serum antibody complex. The antigen reacted with IgG by precipitation and passive agglutinations.

Immunoglobulins IgA, IgM and IgG levels in both the experimental and control groups were estimated by Radial Immuno Diffusion (RID) method. The kits were purchased from "The Binding Site Limited" Birmingham, UK and the method was adopted as per the instruction given in the kit (Appendix III).

Similarly IgE levels in the experimental and control groups were estimated by Enzyme Linked Immuno Sorbent Assay: (ELISA)-two step sandwich assay (Appendix IV).

The ELISA reader used in the estimation of IgE levels is shown in plate 14.

3.6.2.2 Total proteins, albumin, globulin and albumin globulin ratio

The plasma proteins include albumin, globulins and fibrinogen. Variations in the levels of total proteins, albumin, globulin and A/G ratio are seen in many liver diseases, dehydration, edema, haemorrhage, multiple myeloma, chronic infections and others (Gowenlock *et al.*, 1996). Karnik *et al.* (1987) also have reported a significant reduction in total protein level in cotton dust exposed workers.

In the present study, total protein, albumin, globulin and albumin/ globulin ratio were determined in the experimental and control groups (Appendix V).

3.6.2.3 Separation of serum proteins by agar gel electrophoresis

Electrophoresis refers to the migration of charged solutes or particles in a liquid medium under the influence of an electrical field (Burtis and Ashwood, 1999).

Electrophoresis is now widely used to show changes in serum proteins particularly in the globulin fractions (Gowenlock *et al.*, 1996). The methodology of electrophoretic separation of serum proteins is given in Appendix VI.

The set up of electrophoretic apparatus for the separation of serum proteins is shown in plate 15.

3.6.2.4 Lactate dehydrogenase

Organs rich in lactate dehydrogenase(LDH) are liver, heart and skeletal muscles. Elevated serum LDH levels are also found in cirrhosis, hepatitis, pulmonary embolism, megaloblastic anemia and destructive renal diseases. The LDH level in serum was estimated according to the method given by Bergmeyer and Bernts (1974) (Appendix VII).

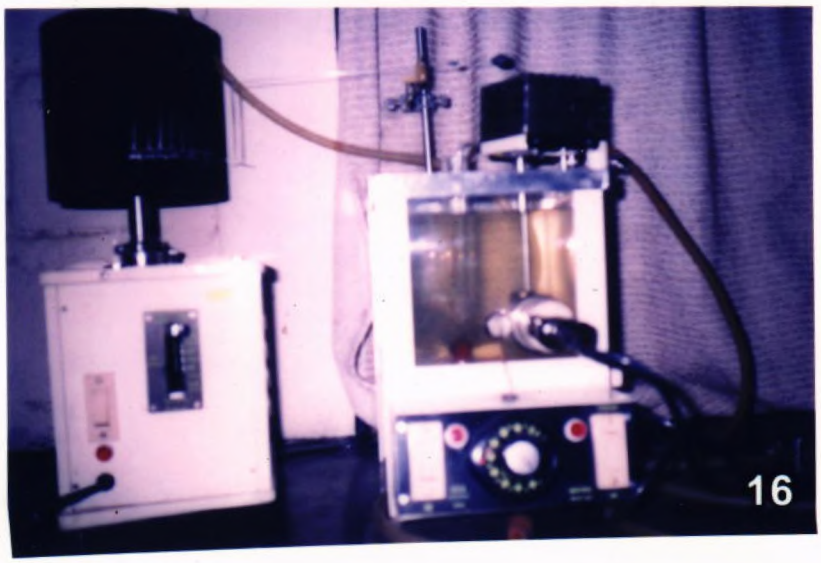
3.6.2.5 Lactate dehydrogenase isozymes

Five isozymes of lactate dehydrogenase are known to exist: LDH1 - LDH5 having diminishing electric charge from 1 to 5. The cardiac muscle is richest in LDH1 with diminishing proportions of isozymes LDH2 to LDH5 in that order, while in the liver the case is reverse, LDH5 being plentiful with diminishing amount of LDH4 - LDH1. Normal serum is richest in LDH1 and LDH2 with less LDH3 and least LDH4 and LDH5. A lesion of a particular organ results in a serum isozyme pattern more closely resembling that of the organ concerned, so that there is marked increase in the proportion of LDH1 in myocardial infarction and LDH5 in liver disease where the total LDH activity may be normal (Gowenlock *et al.*, 1996).

PLATE 14	ELISA READER USED FOR THE ESTIMATION OF IMMUNOGLOBULIN E
PLATE 15	SET UP OF ELECTROPHORETIC APPARATUS FOR THE SEPARATION OF SERUM PROTEINS
PLATE 16	ORGAN BATH SET UP FOR THE ESTIMATION OF HISTAMINE IN THE BLOOD OF PARTICIPANTS BY BIOASSAY METHOD USING GUINEA PIG ILEUM


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An attempt was made to estimate the different serum isozymes of LDH in the participants of the study (Appendix VIII).

3.6.2.6 Histamine

Cotton dust induces the release of histamine from human lung tissue. It is believed that histamine release is responsible for major symptoms of byssinosis. Acute changes in pulmonary function tests after a shift may be due to the release of histamine induced by cotton dust, which may cause bronchoconstriction of lung tissues.

In order to find the relationship between changes in PFT after a shift, histamine release and exposure to cotton dust, blood histamine levels of the13 selected ginning factory women labourers and 10 control group women were assayed.

Blood was collected three hours after commencement of shift in a day followed by weekend holiday, from antecubital vein and transferred to heparinized tubes. Processing and estimation of histamine levels in blood was done as per Parikh *et al.* (1987) as given in Appendix IX using bioassay on sensitized guinea pig ileum.

Organ bath set up for the estimation of histamine in the blood of the participants by bioassay method using guinea pig ileum is illustrated in plate 16.

3.7 ANALYSIS OF COTTON DUST

Health effects have been demonstrated from cotton dust inhalation, which not only temporarily reduced the pulmonary function, but caused subjective chest tightness, a bronchitic condition and an eventual disease of the lower airways (Montalvo, 1982). Studies of cotton textile workers have revealed an association between atopy and drop in FEV_1 over a work-shift (Jacobs *et al.*, 1993). Exposure to cotton dust in textile and ginning workers caused respiratory morbidity. Cotton dust is complex because it contains respirable portion and non-respirable portion, which includes fibrous material. Another complicating factor is the presence of respirable and non-respirable parts of cotton dust along with bacteria and fungi. Among the impurities, one or more of them is believed to contain the active agent that affects the respiratory system. The aerodynamic diameter cut off for dust entering the trachea and bronchi is believed to be 15μ (Neefus *et al.*, 1977). Bouhuys and Zuskin (1980) showed that aerosols of cotton dust extract inhaled by man produced reversible small airway obstruction within 10 minutes.

Therefore analysis of the cotton dust is required to assess its causative effect on pulmonary dysfunction.

3.7.1 Measurement of cotton dust in the ginning factory

Environmental dust samples were collected from three sections of the ginning factory namely the gin house designated as S1, gutter designated as S2 and sorting section designated as S3 and from the control area (a pollution free aseptic room in a nonindustrial area) designated as C using staplex respirable dust monitor (High Volume sampler) which has provision for collecting respirable

dust through glass fibre filter (Appendix X). The respirable dust monitor was provided by Tamil Nadu Pollution Control Board, Coimbatore.

The different sections of the selected ginning factory are represented in plates 17 to 19.

Plate 20 shows the respirable dust monitor employed in the gin house section of the selected ginning factory used in the quantification of cotton dust.

3.7.2 Estimation of endotoxin from respirable dust samples

Gram negative bacteria (GNB) and their endotoxins have been shown to contaminate cotton dusts (Pernis *et al.*, 1961). A causal relationship has been suggested to exist between pulmonary symptoms in cotton textile workers and the presence of GNB, the harmful constituent being their membrane lipopolysaccharide - endotoxin (Olenchock *et al.*, 1983).

As bacterial endotoxins have been found to release histamine (Gokani *et al.*,1993), an attempt was made to study GNB and endotoxin levels in the working environment of the selected ginning factory .

The Limulus Amebocyte Lysate (LAL) assay as outlined by Rylander and Morey (1982) was used to measure the endotoxin level from respirable dust samples (Appendix XI).

DIFFERENT SECTIONS OF THE SELECTED GINNING FACTORY

PLATE 17 GIN HOUSE

PLATE 18 GUTTER

PLATE 19 SORTING SECTION


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19

PLATE 20 RESPIRABLE DUST MONITOR EMPLOYED IN THE GIN HOUSE OF THE SELECTED GINNING FACTORY USED IN THE QUANTIFICATION OF COTTON DUST


Envirotech
RESPIRABLE DUST SAMPLER
Envirotech APM 460
20

Since the endotoxin assay should be done in very sterile environment and no such facilities were available at Coimbatore, the respiratory dust samples from S1, S2, S3 and C were aseptically assayed at Madras Industrial Co-operative Analytical Laboratory, Chennai.

3.7.3 Microscopic examination of cotton dust

A sample of cotton dust was placed in a microscopic slide and the structure, texture and size of the fibre were determined.

3.8 ENUMERATION OF AIRBORNE GRAM NEGATIVE BACTERIA IN THE WORK AREA

According to many recent reports, raw cotton contains large number of microorganisms especially gram negative bacteria (GNB). Among the several factors involved in the causation of pulmonary dysfunction, GNB and its endotoxin are considered to play an important role (Gokani et al., 1988).

For the enumeration of airborne gram negative bacteria, the petriplate exposure (sedimentation) method was employed in S1, S2, S3 sections of ginning factory and in the control area C. MacConkey's agar petriplates were exposed for 1 minute in the S1, S2, S3 area of the ginning factory and in the control area C. The plates were incubated at 35°C for 48 hours and the number of colonies were counted at the end of 48 hours. The composition of MacConkey's agar medium is given in Appendix XII.

3.9 STATISTICAL ANALYSIS

The following statistical tools were used in the present study for the interpretation of the results:

i. Student's 't' test was carried out for comparison of the values of pulmonary function parameters namely forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) before and after shift and vital capacity (VC) and FEV_1/FVC before shift and to compare the biochemical parameters, hemoglobin, erythrocyte sedimentation rate, total count, differential count of leucocytes, immunoglobulins, serum proteins, lactate dehydrogenase and histamine levels between the ginning factory women labourers and the control women

ii. Regression and correlation analysis were carried out to assess the effect of increasing age and duration of exposure to cotton dust on the values of pulmonary function parameters, in the experimental group of participants. Also correlation analysis was done between/within the pulmonary function parameters and the selected biochemical parameters

iii. Chi square analysis was performed to assess the dependence of pulmonary function parameters on (i) the surrounding environment in the different sections of the ginning factory (ii) exposure to passive smoking and (iii) use of different fuels for cooking.

Results and Discussion

4.0 RESULTS AND DISCUSSION

The results of the study **"BIOCHEMICAL PROFILE AND PULMONARY FUNCTION IN GINNING FACTORY WOMEN LABOURERS EXPOSED TO COTTON DUST POLLUTION AT TIRUPUR"** are discussed under the following headings:

4.1 SURVEY ON THE PREVALENCE OF RESPIRATORY MORBIDITIES AMONG TEXTILE WORKERS IN COIMBATORE DISTRICT

4.2 PROFILE OF THE SELECTED GINNING FACTORY WOMEN LABOURERS

4.3 PULMONARY FUNCTION TESTS

4.3.1 Spirometric Analysis

4.3.1.1 Forced vital capacity and forced expiratory volume in one second in ginning factory women labourers before shift

4.3.1.2 Peak expiratory flow in ginning factory women labourers before shift

4.3.1.3 Vital capacity and forced expiratory volume in one second / forced vital capacity percentage in ginning factory women labourers before shift

4.3.1.4 Forced vital capacity, forced expiratory volume in one second and peak expiratory flow in ginning factory women labourers after shift

4.3.1.5 Post shift difference in percentage predicted values of forced vital capacity, forced expiratory volume in one second and peak expiratory flow in ginning factory women labourers

4.3.1.6 Regression and correlation analysis of pulmonary function parameters of ginning factory women labourers with age and duration of exposure

4.3.1.7 Assessment of the pulmonary function of the ginning factory women labourers employed in different sections of the ginning factory by Chi square analysis

4.3.1.8 Assessment of the dependence of pulmonary functions on exposure to passive smoking by Chi square analysis

4.3.1.9 Assessment of the dependence of pulmonary functions on the use of different fuels for cooking by Chi square analysis

4.3.2 Interpretation of chest X-rays

4.4 BIOCHEMICAL PROFILE

4.4.1. Hematological parameters

4.4.1.1 Hemoglobin and erythrocyte sedimentation rate

4.4.1.2 Total and differential count of leucocytes

4.4.2 Other biochemical parameters

4.4.2.1 Immunoglobulins

4.4.2.2 Serum proteins

4.4.2.3 Serum lactate dehydrogenase

4.4.2.4 Blood histamine

4.5 CORRELATION ANALYSIS BETWEEN PULMONARY FUNCTION PARAMETERS AND SELECTED BIOCHEMICAL PARAMETERS

4.6 ANALYSIS OF COTTON DUST

4.6.1 Cotton dust, Endotoxin and airborne Gram Negative Bacteria in different sections of the ginning factory

4.6.2 Microscopic examination of the cotton dust

4.7 AN OVERVIEW OF INDIVIDUAL CASES OF THE STUDY WITH VARIED TYPES OF RESPIRATORY AILMENTS

4.1 SURVEY ON THE PREVALENCE OF RESPIRATORY MORBIDITIES AMONG TEXTILE WORKERS IN COIMBATORE DISTRICT

Textile industry is one of the oldest and profitable industries of India (Behnke, 1996). In a textile industry, yarn is prepared, woven or knitted and processed. Respiratory disease associated with exposure to cotton dust in textile industries was first recognized by Ramazzini who did a pioneer research on occupational health in 1977. A number of respiratory morbidities like byssinosis, chronic bronchitis and asthma were identified, categorized and studied in textile industries by many researchers (Pickering, 2000).

A survey was conducted in government, private and Employees State Insurance (ESI) hospitals of Avinashi, Palladam, Tirupur and Coimbatore in Coimbatore district of Tamil Nadu to assess the prevalence rates of respiratory morbidities among textile workers and the results are shown in Table 5 and figure 4.

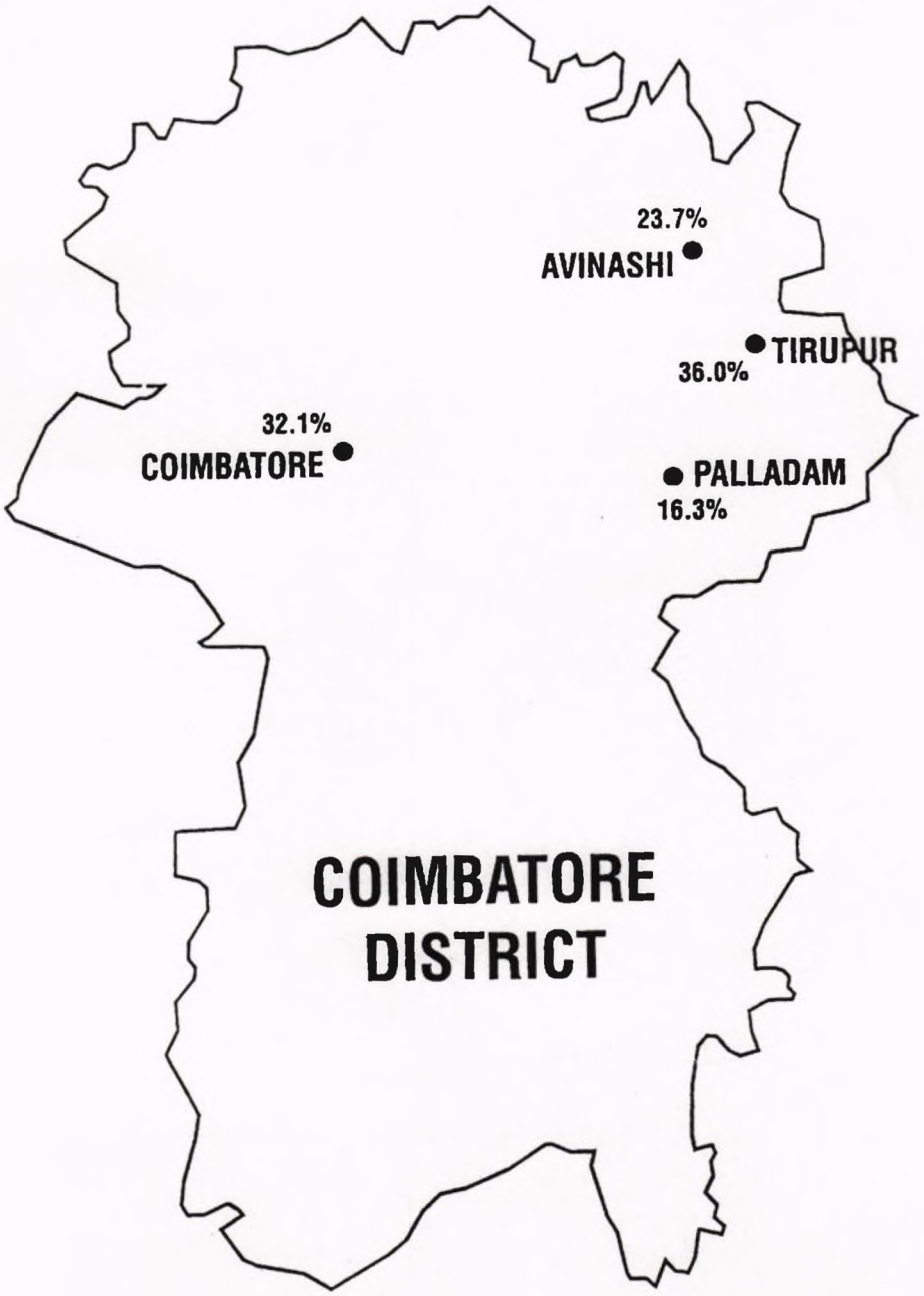
TABLE – 5

SURVEY ON THE PREVALENCE OF RESPIRATORY MORBIDITIES AMONG TEXTILE WORKERS IN COIMBATORE DISTRICT DURING 1998 - 2001

Place	Number of overall pulmonary disorder cases reported	Number of textile workers reported to have pulmonary disorders	Percentage
Coimbatore	23,648	7599	32.1
Tirupur	19,713	7101	36.0
Avinashi	971	231	23.7
Palladam	814	133	16.3

Figure - 4

PREVALENCE OF RESPIRATORY MORBIDITIES AMONG TEXTILE WORKERS IN COIMBATORE, TIRUPUR, AVINASHI AND PALLADAM IN COIMBATORE DISTRICT, TAMILNADU



The results have shown that prevalence of pulmonary disorder among textile workers was 16.3% in Palladam, 23.7% in Avinashi, 32.1% in Coimbatore and that Tirupur had a maximum of 36%. The pulmonary disorders included byssinosis, chronic bronchitis, asthma, dry cough and common cold. Anandhan *et al.* (2000) have also reported 5% chronic byssinosis, 15% asthma and related symptoms in cotton textile workers in Coimbatore. According to Pickering (2000), the prevalence of byssinosis and respiratory abnormalities in India is 29.6 to 37.8%.These rates are generally high compared to those in Indonesia (21.4 - 30%) and United Kingdom (4%) and low when compared to Ethiopia (24 - 43.2%). The rate is on par with those in Sudan (37.0%) and Egypt (38%).

The prevalence of respiratory diseases in textile workers varies according to the quality and quantity of respirable cotton dust in the work environment. It is also proportional to duration of exposure to the cotton dust.

The differences in prevalence rates of respiratory diseases in different countries might be due to dissimilar work conditions, dust concentration and economic status of people.

Although Tirupur has less number of textile mills (30) and ginning factories (25) when compared to Coimbatore (80 and 40) it shows maximum prevalence of respiratory disorders. Tirupur is regarded as a polluted area of both air and water. Heavy traffic leading to vehicular emission is another source of air pollution apart from cotton dust released from industrial operation. These factors might be the reason for the higher prevalence of respiratory disorders in Tirupur.

4.2 PROFILE OF THE SELECTED GINNING FACTORY WOMEN LABOURERS

Table 6 shows the profile of the selected ginning factory women labourers as per the information elicited by administering the questionnaire.

TABLE – 6

PROFILE OF THE SELECTED GINNING FACTORY WOMEN LABOURERS

Groups	Family income (Rupees)			Pattern of Intake of meals		Passive smoking		Fuel used for cooking			Clinical Conditions							
											BYSSINOSIS				Chronic Bronchitis	Asthma	Other Ailments	Normal
	500 – 000	1000 –000	2000 & above	Veg.	Non-Veg	Yes	No	LPG	Kerosene	Fire wood	G½*	G1*	G2*	G3*				
Ginning factory women labourers (n = 104)	12	87	5	26	78	45	59	17	53	34	11	10	4	-	9	4	46	20
Control Women (n = 40)	4	29	7	11	29	21	19	9	16	15	-	-	-	-	-	-	-	40

* G ½ , G1, G2 and G3 are the different stages of Byssinosis

Among the 104 experimental group participants, 12 had the family income of Rs. 500-1000, 87 had the family income of Rs 1000-2000 and only 5 had an income above Rs.2000. 26 members were vegetarians and 78 were non-vegetarians with a very low frequency of intake of non-vegetarian food ie., only once in a month.

Since the study involved only women workers there were no cases of direct smoking. But these women might have chances of exposure to passive smoking in their houses, which also might have equal effect on lung function as stressed by Schachter (1998). Out of the 104 experimental group participants, 45 women labourers had the chances of exposure to passive smoking.

Women using traditional fuels like firewood and cowdung are at greater risk of developing pulmonary disorders compared to those using modern fuels like LPG and kerosene. In the present study, 17 experimental group participants reported use of LPG as fuels, 53 kerosene and 34 firewood as fuels.

Byssinosis is a condition observed in cotton dust exposed workers. It is a state of reversible or irreversible breathlessness and chest tightness in one or more days of working week due to airflow obstruction (Parkes, 1982).

Byssinosis has been reported in most countries with textile industries. Greenhow (1981) had investigated and described byssinosis as asthma like condition in cotton workers worse at the beginning of the working week and most severe on returning to work after a longer period away from works. Therefore byssinosis is also ascribed as "Monday morning syndrome".

Clinically byssinotics can be graded according to their clinical conditions (Schilling *et al.*, 1963).

Grade ½ - Occasional tightness of the chest on the first day of the working week

Grade 1 - Tightness of the chest and /or difficulty in breathing on each first day only of the working week

Grade 2 - Tightness of the chest and /or difficulty in breathing on the first and other days of the week

Grade 3 - Permanent respiratory disability from reduced ventilatory capacity

According to Pickering (2000), functionally byssinosis can be categorized into two conditions:

1. Acute byssinosis with acute responses occurring in subjects exposed to cotton dust for the first time that is fully reversible

2. Chronic byssinosis that develops in workers exposed to cotton dust for many years

Chronic bronchitis is defined as coughing and phlegm for atleast three months each year for not less than two successive years (Karim *et al.*, 1986). According to Kamat *et al.* (1981), chronic bronchitis can be distinguished from acute byssinosis by showing lesser decrease in pulmonary function and is a state of irreversible airflow obstruction.

Occupational asthma may be defined as a respiratory disorder caused by the inhalation of airborne dusts, vapours or fumes encountered in work place and characterized clinically by shortness of breath, wheezing, and cough (Taylor, 1980). According to Ostro *et al.* (1998), asthma is a chronic respiratory condition characterized by airway inflammation and intermittent episodes of bronchospasm

that can be provided by a variety of stimuli, including air pollution. According to Brody and Snider (1985), asthma and dust go together.

Awad (1999) had revised clinical criteria to diagnose occupational asthma:

1. The worker has wheezing complaints and reversible airway obstruction

2. A positive reaction is evidenced for the production of specifically immunoglobulin E against occupational dust

Occupational asthma can be differentiated from byssinosis. Occupational asthma does not exhibit Monday morning chest tightness and is usually witnessed whenever the subject is exposed to dust and is reversible. An increased level of IgE is seen in asthmatic patients (Awad, 1999).

Parkes (1982) opined that byssinosis is a separate entity from asthma under the following grounds:

1. Most asthmatics are hypersensitive to histamine but this is not a regular finding in byssinosis
2. A large proportion of textile workers may be affected by byssinosis but in other forms of asthma, the number of workers affected is usually very small
3. The symptoms of byssinosis are delayed (that is not immediate) and improve during the working week
4. Skin tests with dust extracts correlate poorly with byssinosis by comparison with skin tests in asthma

In the present study, among the 104 experimental group participants, 11 reported the symptoms of Grade 1/2 byssinosis, 10 reported Grade 1

symptoms and 4 Grade 2 symptoms. Among the Grade 1/2 byssinotics, 9 had the working experience between 0-20 years and 2 had the working experience above 20 years. It may be suggested that the above 9 women labourers might have acute responses when exposed to cotton dust, which is fully reversible. All the women labourers exhibiting G 1 and G 2 symptoms had the working experience above 20 years. This suggested the development of chronic byssinosis in workers exposed to cotton dust for many years which is in accordance with the findings of Parikh *et al.* (1989) who reported that byssinosis is seen more in persons having above 20 years experience in textile industry.

No G 3 byssinotics were reported in the experimental group participants. One possibility is that due to increased respiratory disability, they would have quit the job.

The prevalence of byssinosis among textile workers have been reported by many researchers (Christiani and Wegman, 2000; Anandhan *et al.,* 2000; Pickering, 2000; Parikh *et al.*, 1996).

Among cotton textile workers, women were reported to have a higher prevalence of typical Monday symptoms than men (Jiang *et al.*, 1995). According to Niven and Pickering (1996), the prevalence of byssinosis in India was 50% in the year 1994.

Nine chronic bronchitis symptomatic cases were observed among the experimental group participants. Karim *et al.* (1986) and Schachter (1998) have also reported chronic bronchitis (29-47%) among the textile mill workers of Sudan. Kamat *et al.* (1981) have also found the prevalence of chronic bronchitis in textile mill workers in Bombay. Parikh *et al.* (1993a) in their study at Ahmedabad have reported that cotton dust exposure alone was not responsible

for chronic bronchitis and smoking had a major role in the causation of this disease. This was found to be true in the present study because, all the 9 chronic bronchitis cases reported in the present study were exposed to passive smoking. Out of the 9 chronic bronchitis workers, 7 used firewood as fuel and 2 used kerosene as fuel. Therefore it might be suggested that, apart from cotton dust, the smoke from passive smoking and firewood burning might have contributed to the chronic bronchitic condition in these women labourers.

Four asthmatic conditions were also reported in the experimental group of women labourers. This was in accordance with earlier reports of asthma among cotton mill textile workers (Woldeyohannes *et al.*, 1991; Anandhan *et al.*, 2000).

Forty six experimental group participants reported other ailments like bodyache, headache, soriasis, defective eyesights, dental problems, hypertension and diabetes. This might be due to aging, poor nutrient diet, low hemoglobin content, heavy work and also associated complications of respiratory disorders.

Regarding the menopausal status, 69 ginning factory women labourers among the104 participants and 28 control women among the 40 participants were in menopausal state. Women have more body fat than men and store more fat soluble toxic materials, even when exposed to the same amount as men. Certain stages in a woman's life – like periods of growth and development in children, may influence susceptibility to environmental agents, principally through changes in the concentration of certain hormones (Hatch, 2000).

Table 7 shows the mean age, height, weight and blood pressure of the selected ginning factory women labourers.

TABLE – 7

MEAN AGE, HEIGHT, WEIGHT AND BLOOD PRESSURE OF GINNING FACTORY WOMEN LABOURERS

Groups	Age (years)	Height (cms)	Weight (Kg)	Blood pressure mm/Hg
Ginning factory women labourers (n=104)	51.8 ± 8.3	149 ± 6.6	45.1 ± 8	117/76 ± 10.7 /1
Control women (n=40)	50.3 ± 8.9	154 ± 4.3	51.2 ± 6.2	119/82 ± 6.2/ 0.98

The mean weight (45.1 ± 8 kg), height (149 ± 6.6cms) and blood pressure (117/76 ± 10.7/1.1mmHg) of ginning factory women labourers were lower than those of control women. The reduced weight might be due to poor nourishment especially low protein and iron or lowered appetite due to mucus secretion stimulated by inhaled cotton.

Among the 104 ginning factory women labourers, 83 had weight below 45 kg and three among them were underweight (29 Kg, 32 Kg and 34 Kg). 25 women labourers showed normal blood pressure (80 -120mm Hg) and 2 women showed increased blood pressure (130/90mmHg and 132/95mm Hg).

4.3 PULMONARY FUNCTION TESTS

The pulmonary function tests define clearly the type of functional disorder of the lungs. They also measure serially the natural progression or regression of

lungs with therapy of the disorder It decides the feasibility of thoracic surgery and helps in assessing the degree of respiratory failure (Connellan, 1993).

The pulmonary function tests include spirometric analysis and chest X-ray examination.

4.3.1 Spirometric Analysis

Assessment of pulmonary function by spirometry is a routine practice in epidemiological surveys in subjects exposed to toxic dusts and air pollutants (Mohan rao and Kulkarni, 1995). The spirometric analysis includes the parameters forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), peak expiratory flow (PEF), vital capacity (VC) and FEV_1/FVC percentage, which are measured by computerized vitalograph spirometer. The pre and post shift differences in FVC, FEV_1 and PEF were determined to find out acute changes over shift. For assessing chronic changes, the observed values of FVC, FEV_1 and PEF were expressed as percentage of the predicted values by using the regression equation developed by Vijayan *et al.* (1990). To check the reversible and irreversible nature of impairment of pulmonary functions in the selected ginning factory women labourers, they were challenged with a dose of salbutamol, a bronchodilator, which enlarges the lumen of the bronchioles to ease obstructions. The drug was delivered in the form of puff to get the optimum result after 15-30 minutes and then post bronchodilator PFT was carried out.

The spirometric analysis was performed in the 104 experimental group participants of the ginning factory and the 40 control group participants.

4.3.1.1 Forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) in ginning factory women labourers before shift

The mean forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) in ginning factory women labourers before shift are shown in Table 8.

The predicted and observed values of FVC and FEV_1 in ginning factory women labourers did not differ significantly from those of control group women. The mean predicted values of FVC (2.42 ± 0.43 litres) and FEV_1 (2.05± 0.39 litres/second) were comparable to the South Indian women standards developed by Vijayan *et al.* (1990) who have reported a mean predicted FVC value of 2.37 litres and FEV_1 2.08 litres/second in South Indian women having mean age of 53 years and mean height of 152 cms.

However, the ginning factory women labourers expressed a 5 per cent significant decrease in percentage predicted values of FVC (80.7 ± 12.9 litres) and 1 per cent significant decrease in percentage predicted values of FEV_1 (74.6 ± 5.5 litres/second) with respect to control group women (FVC - 86.3 ± 19.2 litres and FEV_1 – 84.8 ± 17.1 litres/second). Similar significant decrease in percentage predicted values of FEV_1 in cotton dust exposed textile industry workers have been reported by many researchers (Jacobs *et al.*, 1993; Bhatt *et al.*, 1990; Glindmeyer *et al.*, 1994; Christiani *et al.*,1986, 1994; Schachter 1998; Fishwick *et al.*, 1994; Berry *et al.*, 1973; Fox *et al.*, 1973; Zuskin *et al.*, 1975; Mohan rao *et al.*,1991b; Parikh *et al.*, 1990; Glindmeyer *et al.*, 1991 and Panchal *et al.*,1988)

TABLE - 8

MEAN FORCED VITAL CAPACITY AND FORCED EXPIRATORY VOLUME IN ONE SECOND IN GINNING FACTORY WOMEN LABOURERS BEFORE SHIFT

Groups	Forced vital capacity (FVC) in litres			Forced expiratory volume in one second (FEV_1) in litres/second		
	Predicted	Observed	%Predicted	Predicted	Observed	%Predicted
Ginning factory women labourers (n=104)	2.42 ± 0.43	1.96 ± 0.5	80.7 ± 12.9	2.05 ± 0.39	1.54 ± 0.5	74.6 ± 5.5
Control women (n=40)	2.36 ± 0.46	2.08 ± 0.78	86.3 ± 19.2	1.98 ± 0.41	1.70 ± 0.63	84.8 ±17.1
t value	0.64	1.03	2.02 *	0.91	1.65	3.45**

* Significantly different at 5 per cent level
** Significantly different at 1 per cent level

This significant decrease in percentage predicted values of FVC and FEV_1 clearly represents the chronic obstruction in pulmonary function in the experimental group of participants (Cotes *et al.*, 1997).

Bhagia *et al.* (1992) reported that workers engaged in ginning factories might develop only acute manifestations because the process is seasonal. But chronic changes in pulmonary function were also observed in our study. This might be due to continuous and longer exposure to high cotton dust levels prevailing in the ginning environment as suggested by Parikh *et al.* (1996). Earlier reports indicated that cotton fibres processed in Coimbatore are highly contaminated with gram negative bacteria (GNB) and endotoxin. This might be responsible for the pulmonary abnormalities in the ginning factory women labourers.

In normal persons, the percentage predicted values of FVC, FEV_1 and PEF parameters are above 80% of the predicted value. Although there was a significant decrease in percentage predicted values of FVC in ginning factory women labourers (80.7 ± 12.9 %) compared to the control group, it was not significantly different from the normal predicted value of 80%. But the mean percentage predicted values of FEV_1 in the ginning factory women labourers represented not only a significant decrease in percentage predicted value compared to the control but also below normal 80% of predicted value. A reduction in this value below 80% of predicted value was diagnosed as chronic obstruction in peripheral airways. This might be because the airways are the target area for the deposition of industrial dusts and air pollutants (Bhatt *et al.*, 1990).

The number of ginning factory women labourers with varied ranges of FEV_1 are as follows:

Normal (Above 80% of predicted FEV_1)	- 24.(13.1%)
Below Normal (below 80% of predicted FEV_1)	- 80(76.9%)
Mild to moderate changes(60 to 80% of predicted FEV_1)	- 9(86.3%)
Severe changes (below 60% of predicted FEV_1)	-11(13.7%)

Two among the workers with severe changes in FEV_1 recorded very low percentage of predicted FEV_1 (42.5% and 49.5%) respectively.

4.3.1.2 Peak expiratory flow(PEF) in ginning factory women labourers before shift

The mean values of peak expiratory flow (PEF) are indicated in Table 9.

TABLE - 9

MEAN PEAK EXPIRATORY FLOW IN GINNING FACTORY WOMEN LABOURERS BEFORE SHIFT

Groups	Peak expiratory flow (PEF) in litres		
	Predicted	Observed	% Predicted
Ginning factory women labourers (n=104)	4.62 ± 0.56	2.95 ± 0.87	63.8 ± 12.6
Control Women (n=40)	4.52 ± 0.84	3.45 ± 1.4	76.3 ± 17.2
t value	0.76	3.35**	4.76 **

** - Significantly different at 1 per cent level

Table 9 shows that the mean predicted values of PEF in ginning factory women labourers (4.62 ± 0.56 litres) did not differ significantly from that of control women. The predicted PEF values of the ginning factory women labourers were comparable with the South Indian women standard value (4.5 litres) developed by Vijayan *et al.* (1993).

However the mean values of observed (2.95 ± 0.87 litres) and percentage predicted PEF (63.8 ± 12.6%) in the ginning factory women labourers were significantly decreased at 1 per cent level compared to the control women. This indicated a significant chronic loss in PEF in ginning factory women labourers. Similar chronic decrease in PEF was also reported by Mohan rao and Bhatt (1988) in cotton dust exposed workers. PEF is used to assess the diurnal variation in airway calibre, variation over a working shift and cyclic variation related to the pattern of employment including weekends and holidays (Cotes *et al.*, 1997). The PEF in ginning factory women labourers might be reduced as a result of flow limitation due to obstruction in small airways which have diameter

less than 2 mm (Vijayan *et.al.*, 1993). This airway obstruction in ginning factory women labourers might be induced by histamine liberated from inhaled cotton dust (Mohan rao and Bhatt, 1988). 86.5% of the total 104 ginning factory women labourers (90) showed a decline in percentage predicted PEF values. Among them 67% (60 out of 90) showed mild to moderate change in PEF i.e percentage predicted PEF values between 60 and 80%. Remaining 33% (30 out of 90) showed severe (below 60 % of predicted value) change in PEF.

Five among them showed very low percentage predicted PEF values (48.9, 45.1, 43.6, 47.5 and 42.9 %) respectively.

The flow volume curves of ginning factory women labourers exhibiting normal, byssinotic, chronic bronchitic and asthmatic symptoms are illustrated in figures 5,6,7 and 8.

In a normal ginning factory woman labourer, the flow in the curve rises rapidly to a peak and then declines steadily throughout expiration. The expiratory peak flow is less than inspiratory flow as shown in figure 5.

In the ginning factory woman labourer with byssinotic symptoms (figure 6), the flow volume curve shows flow rates falling rapidly after peak flow with low flow rates in later part of the curve. The pattern is typical of lower airways obstruction. There is a considerable reversibility after treatment with bronchodilator.

In the chronic bronchitic symptomatic ginning factory woman labourer, the flow volume curve (figure 7) showed characteristic indentation of severe lower airways obstruction. There was only a small degree of reversibility of FEV_1 and FVC after treatment with bronchodilator.

Figure - 5

FLOW VOLUME CURVE OF A NORMAL GINNING FACTORY WOMAN LABOURER

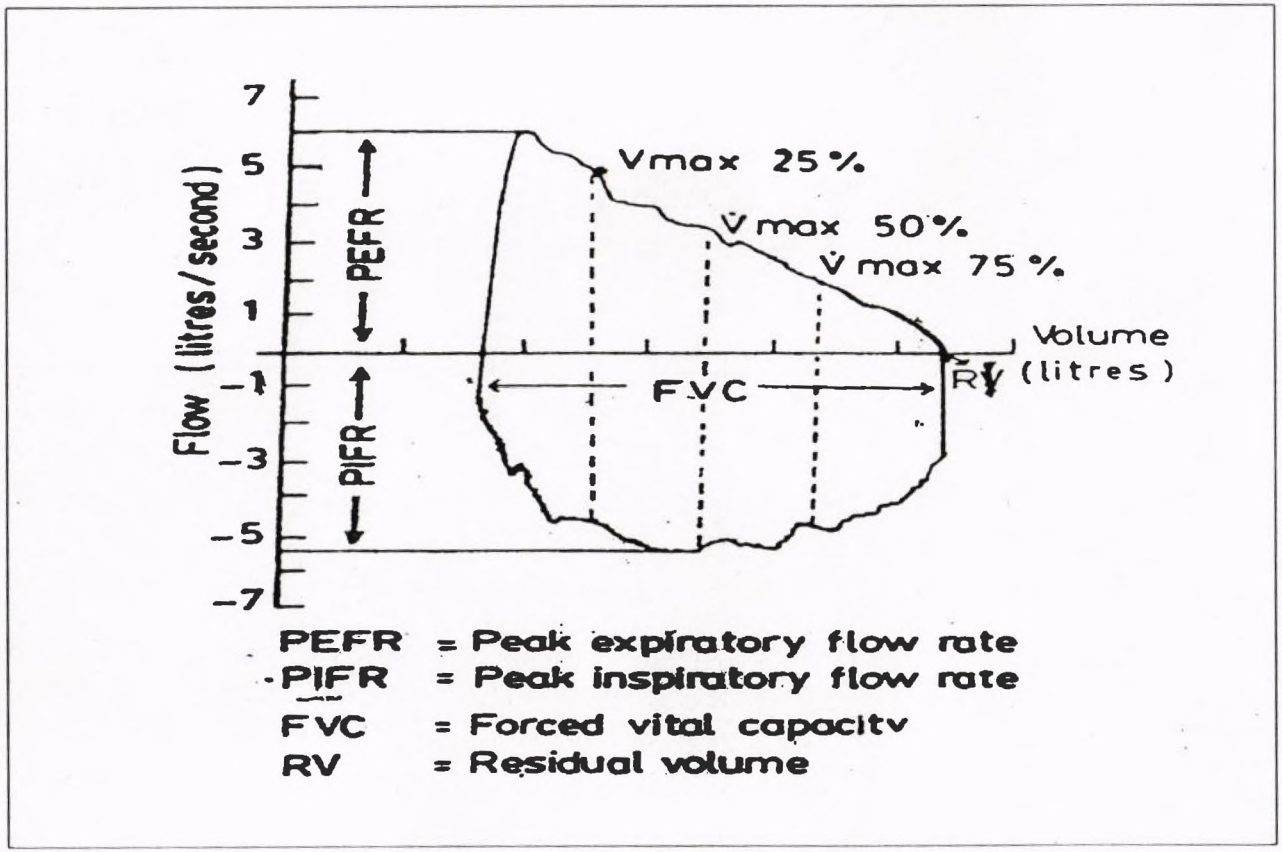


Figure - 6

FLOW VOLUME CURVE OF A GINNING FACTORY WOMAN LABOURER EXHIBITING BYSSINOTIC SYMPTOMS

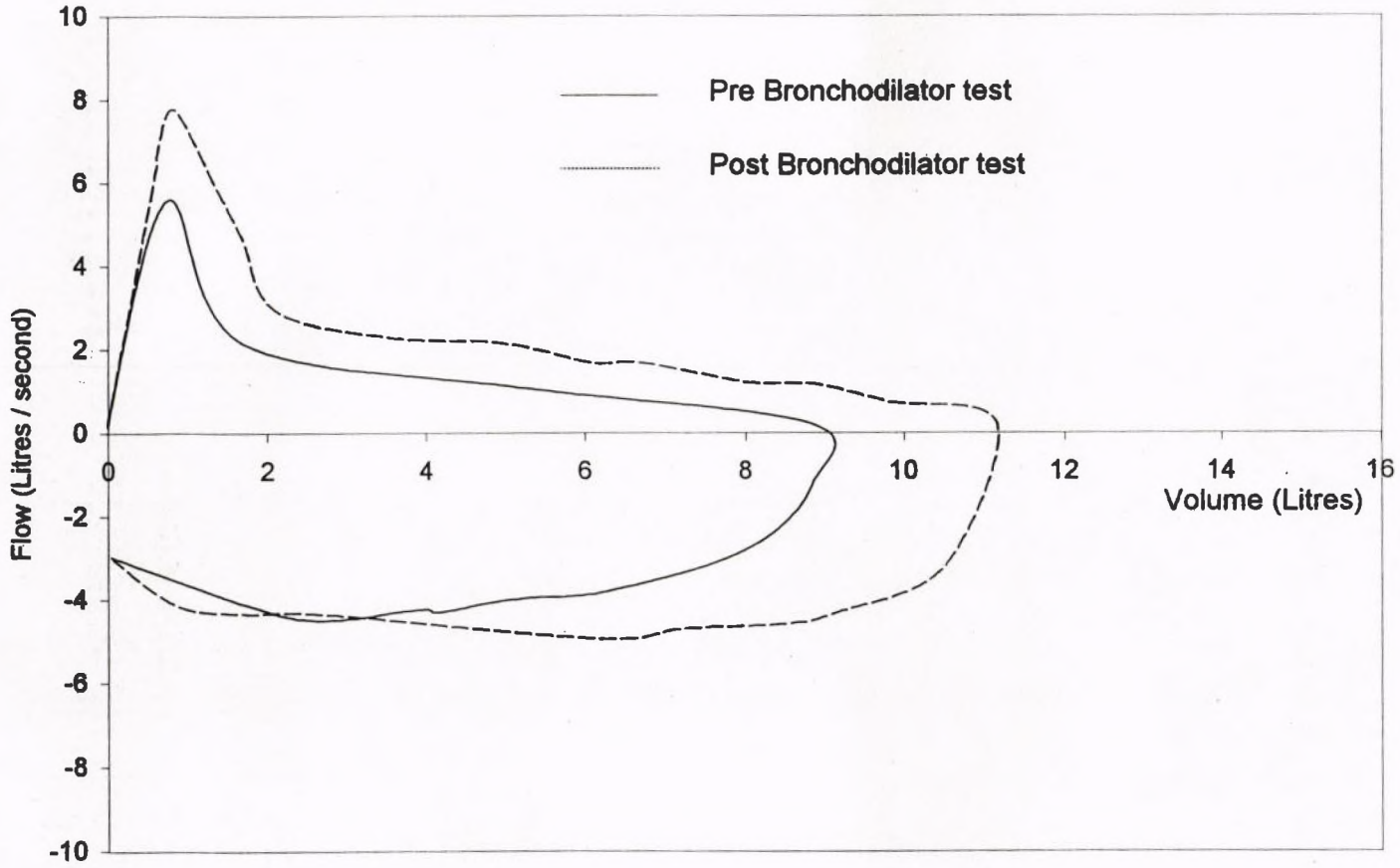
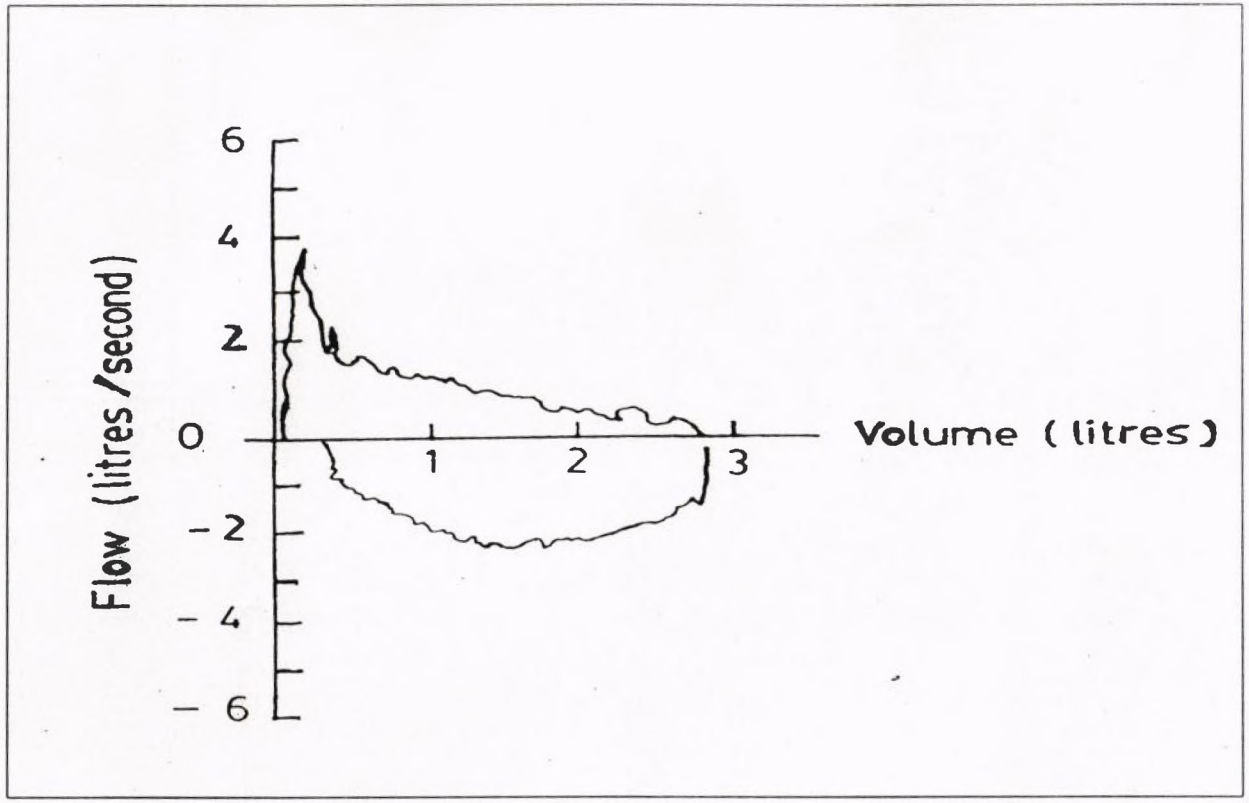


Figure - 7

FLOW VOLUME CURVE OF A GINNING FACTORY WOMAN LABOURER EXHIBITING CHRONIC BRONCHITIC SYMPTOMS



In the woman labourer showing asthmatic symptoms, the flow in the curve rises to a peak and then rapidly falls. Remainder of expiration is made at low flow rates. Inspiratory flow rates are much higher. There is a considerable reversibility after treatment with bronchodilator (figure 8).

4.3.1.3 Vital capacity (VC) and forced expiratory volume in one second / forced vital capacity (FEV_1/FVC) percentage in ginning factory women labourers before shift

The mean vital capacity (VC) and FEV_1/FVC percentage values in the ginning factory women labourers before shift are shown in Table 10.

TABLE - 10

MEAN VITAL CAPACITY AND FEV_1 / FVC PERCENTAGE IN GINNING FACTORY WOMEN LABOURERS

Groups	Vital capacity (VC) in litres	FEV_1/ FVC (%)
	%Predicted	%Predicted
Ginning factory women labourers (n= 104)	83.7 ±6.07	77.6 ± 9.88
Control women (n= 40)	85.3 ±6.69	83.7 ±9.65
t value	1.39	3.36 **

** Significantly different at 1 per cent level

There was no significant change in VC in the ginning factory women labourers compared to the control women. From table 10, it has also been observed that the percentage predicted values of FEV_1 / FVC was significantly decreased at 1 per cent level in ginning factory women labourers (77.6 ± 9.88%) than that of the control group women (83.7 ± 9.65%). Decreased values of

FEV_1/FVC are indicative of lung obstruction. In a normal individual, FEV_1/FVC ratio is usually more than 75% of FVC observed in them. In lung restrictive defects, both FVC and FEV_1 are decreased, but FEV_1/FVC ratio is 75% of FVC. In lung obstructive defects, FVC and FEV_1 may be normal or decreased but their ratio gets reduced. Therefore determination of FEV_1/FVC ratio serves as a valid tool in assessing lung obstruction (Golwalla and Golwalla, 1985).

Chattopadhyay (1999) has proposed spirometric assessment of obstruction and restriction using FEV_1/FVC ratio. Normal persons have FVC values above 80% of the predicted value and FEV_1/FVC above 75%. In restrictive defects, FVC is below 79.99% and FEV_1/FVC is above75%. In obstructive cases FVC is above 80% but FEV_1/FVC is below 74.99%;mixed obstructive and restrictive defects express both FVC below 79.99% and FEV_1/FVC below 74.99%.

Four types of maneuver can be recognized from spirometry:

1. Normal - When the subjects exhale forcibly from total lung capacity to residual volume, the FEV_1 and FVC are measured. In a normal person, the volume of FEV_1 and FVC are within the range of predicted for that individual which depends on his age, height, weight, sex and ethnic identity. He will also be able to exhale 80% or more of the VC or FVC in the first second (FEV_1/FVC%).

2. Obstructive - This type of disorder is mainly of two types a) reversible b) irreversible. In obstructive disease, the subjects take a long time to exhale his FVC and the ratio of FEV_1/FVC will be below 75%. The nature of obstruction can be studied by administration of bronchodilator aerosol, salbutamol. If it is reversible in nature,the bronchodilation increment of

FVC and FEV_1 will be 15 – 20 %, which occurs, in asthmatic patients. The obstruction is irreversible in nature in the case of chronic bronchitis.

3. Restrictive - This pattern is seen when lung parenchyma is involved with diseases causing fibrosis. Because of the fibrosis, the tissue shrinks and is nonelastic. The lungs are functionless and stiff on forced exhalation. Therefore the characteristic findings is a reduction in VC and FVC both which may be below 80% of the normal standard predicted value. Because the airways are normal, the proportion of FVC blown out in first second will still be 80% or more. This pattern is observed in fibrosing alveolitis, sarcoidosis and mineral dust pneumoconiosis.

4. Combined obstructive and restrictive - This type is the combination of the obstructive and restrictive in same person.

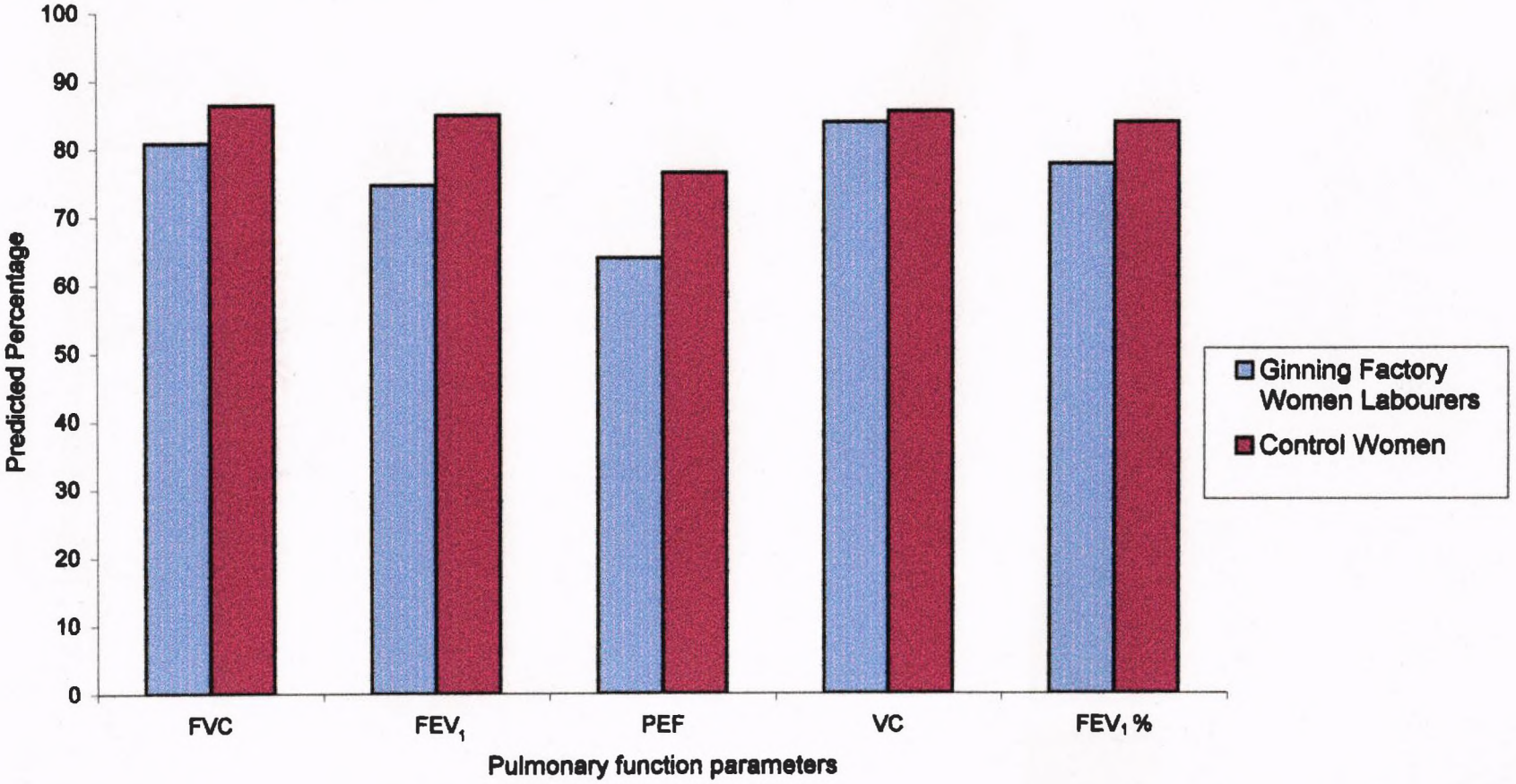
In the present study, among the 104 ginning factory women labourers, 64 were normal (61.5%), 35 had obstructive PFT (33.7%), 1 had restrictive PFT (0.9%) and 4 were of the type mixed obstructive and restrictive (3.8%). There was higher prevalence of obstructive conditions 87.5% (35 out of the total 40 respiratory abnormality cases) in the ginning factory women labourers.

The continuous cotton dust exposure in the ginning factory women labourers should have led to increased airway reactivity resulting in fixed airways obstruction (Bouhuys *et al.,*1977).

Among the 35 lung obstructive cases 33 showed mild obstruction (FEV_1/FVC percentage between 65 – 74.99) and 2 exhibited moderate effect (FEV_1/FVC percentage between 50 – 64.99). None of the women reported to have severe lung obstruction (FEV_1/FVC percentage below 50%).

Figure - 9

MEAN PERCENTAGE PREDICTED VALUES OF PULMONARY FUNCTION PARAMETERS IN GINNING FACTORY WOMEN LABOURERS BEFORE SHIFT



Lung obstruction was more prevalent among byssinotics (60%) compared to chronic bronchitis (25.7%) and asthmatics (14.3%).

35 ginning factory women labourers who showed obstruction were challenged with the bronchodilator salbutamol to explain the nature of reversibility. The obstruction was reversible in 30(85.7%) ginning factory women labourers and irreversible in 5(14.3%) women labourers. As explained by Chattopadhyay (1999), the irreversibility was prevalent more among labourers who reported chronic bronchitic symptoms.

Figure 9 illustrates the mean percentage predicted values of FVC, FEV_1,PEF, VC and FEV_1% in ginning factory women labourers before shift.

4.3.1.4 Forced vital capacity, forced expiratory volume in one second and peak expiratory flow in ginning factory women labourers after shift

The decrement of ventilatory capacity after work in an individual might lead to permanent respiratory disabilities later. Further, the average acute decline in ventilatory capacity over a day's work in a group of workers might serve as a 'biological monitor' of the working environment (Berry *et al.,* 1973). In order to evaluate the acute effect of cotton dust on workers, the pulmonary function tests were also carried out in the ginning factory women labourers after a shift period with 7 hours exposure to cotton dust.

The mean forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) in ginning factory women labourers after shift are portrayed in Table 11 and figure 10.

TABLE –11

MEAN FORCED VITAL CAPACITY, FORCED EXPIRATORY VOLUME IN ONE SECOND AND PEAK EXPIRATORY FLOW IN GINNING FACTORY WOMEN LABOURERS AFTER SHIFT

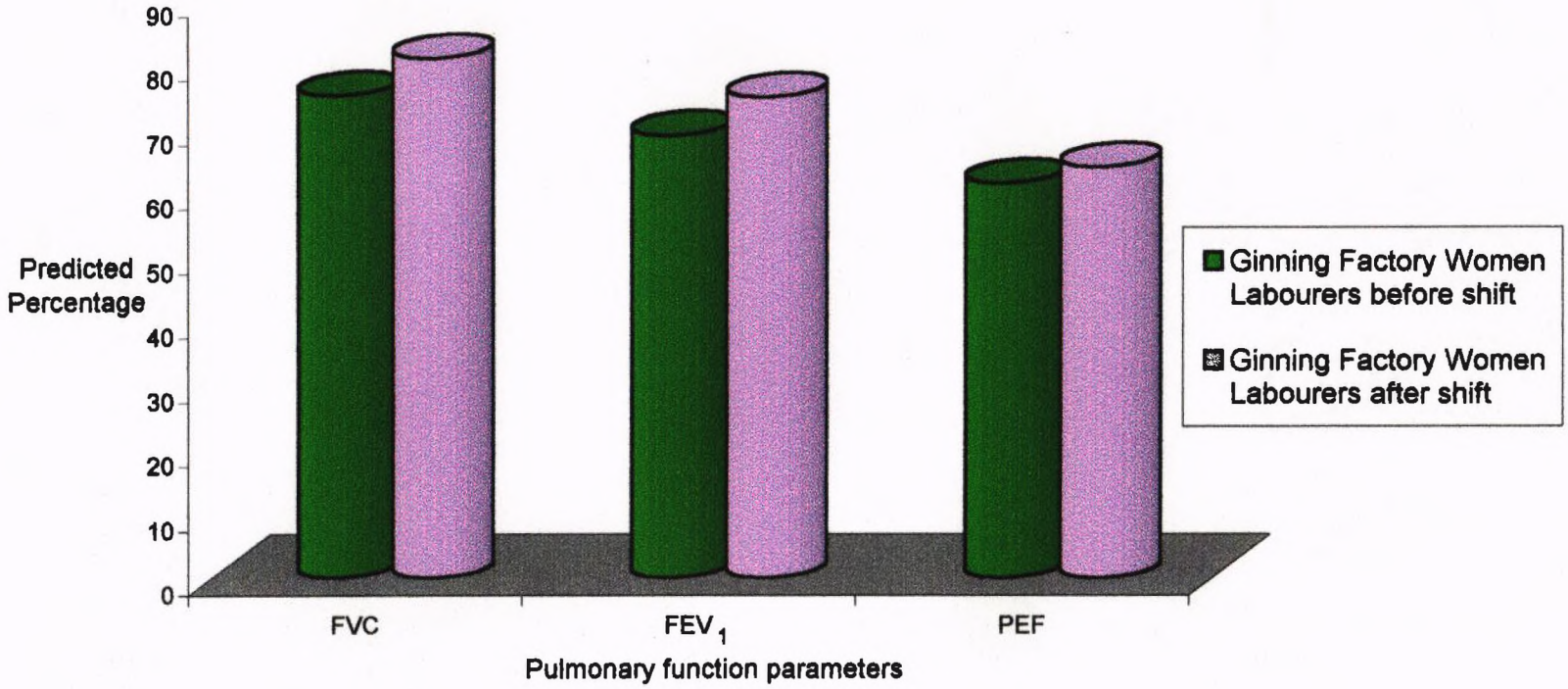
Groups	Forced vital capacity(FVC) in litres			Forced expiratory volume in one second (FEV_1) in litres/second			Peak expiratory flow (PEF) in litres		
	Predicted	Observed	%Predicted	Predicted	Observed	% Predicted	Predicted	Observed	% Predicted
Ginning factory women labourers (n=104)	2.42±0.43	1.82±0.49	74.9±12.56	2.05±0.39	1.42±0.47	68.7±15.14	4.62±0.57	2.83±1.04	61.3±13.1
# Control women (n=40)	2.36±0.46	2.07±0.78	86.2±19.19	1.98 ±0.41	1.7±0.63	84.9±17.36	4.52±0.84	3.44±1.41	76.2±17.39
t value	0.71	2.30**	4.15**	0.92	2.94**	5.52**	0.78	3.43**	5.57**

** Significantly different at 1 per cent level

Pulmonary function parameters FVC, FEV_1 and PEF were estimated in the control group of participants twice with an interval of seven hours and compared with before and after shift values of the experimental group

Figure - 10

MEAN PERCENTATGE PREDICTED VALUES OF PULMONARY FUNCTION PARAMETERS IN GINNING FACTORY WOMEN LABOURERS AFTER SHIFT



The mean values of observed and percentage predicted values of FVC (1.82 ± 0.49 litres, 74.9 ± 12.6 %), FEV_1 (1.42 ± 0.47 litres / second, 68.7 ± 15.14%) and PEF (2.83 ± 1.04 litres, 61.3 ± 13.1 %) after shift were found to be significantly decreased at 1 per cent level in ginning factory women labourers than in the control women.

These results were in consistance with the findings of Parikh *et al.* (1993b). They have reported a significant decrease in FVC and FEV_1 after a shift in ginning factory labourers in Ahmedabad, Similar post shift decrease in the values of FVC, FEV_1 and PEF were elucidated by many researchers (Fishwick *et al.,* 1996; Shoba *et al.,* 1997; Li *et al.,* 1995; Zuskin *et al.,* 1975) among textile workers.

The present study results suggested that the significant acute decrease in FEV_1 and PEF might be due to the histamine released by cotton dust, which would have caused narrowing of bronchioles by muscle contractions. These contractions should have produced changes in the ventilatory capacity after the shift as suggested by Shah and Rajagopal (1985).

The reduction in FEV_1 and PEF indicates the obstruction in central and smaller airways of respiratory system (Shoba *et al.,* 1997). In ginning factory women labourers, 96.2 percent (100 out of 104) showed reduction in FVC, FEV_1 and PEF after the shift. The reductions in FEV_1 and PEF were identified to be higher (99% and 97%) compared to the reduction in FVC (94%).

The reduction in FVC, FEV_1 and PEF were below the normal (below 80% of predicted values) in 90% (90 out of 100) of the above case.

The reduction in FVC, FEV_1 and PEF were more prevalent among byssinotics compared to other symptomatic women labourers, but the reduction in both FEV_1 and PEF were common among all groups. Fishwick *et al.* (1992) have also reported impaired FVC only in byssinotic subjects. Mohan rao *et al.* (1991b) have also reported similar findings in textile mill workers of Ahmedabad. Parikh *et al.* (1990) have mentioned that with increasing grades of byssinosis, the mean FEV_1 declined increasingly during the shift and similar results were observed in the present study also.

4.3.1.5 Post shift difference in percentage predicted values of forced vital capacity, forced expiratory volume in one second and peak expiratory flow in ginning factory women labourers

Pulmonary function tests before and after the shift reveal the acute effect of cotton dust on the pulmonary functions of the ginning factory women labourers. The post shift difference values in pulmonary function parameters also explains the mild to severe effect of cotton dust on ventilatory capacity (Mohan rao *et al.*, 1991b).

The mean post shift change in percentage predicted values of pulmonary function indices namely forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) in the ginning factory women labourers are illustrated in Table 12.

The mean post shift change in percentage predicted values of FVC (-7.86 ± 4.76 %), FEV_1 (-7.28 ± 8.44%) and PEF (-4.13 ± 3.28%) in ginning factory women labourers were found to be significantly increased at 1 per cent level compared to the control women.

Similar significantly increased post shift change in FEV_1 of –0.19 ± 0.28 % was also reported by Parikh *et al.* (1993b) in ginning factory labourers in Wardha.

TABLE - 12

MEAN POST SHIFT DIFFERENCE IN PERCENTAGE PREDICTED VALUES OF FORCED VITAL CAPACITY, FORCED EXPIRATORY VOLUME IN ONE SECOND AND PEAK EXPIRATORY FLOW IN GINNING FACTORY WOMEN LABOURERS

Groups	Post shift change in % predicted values of pulmonary function parameters		
	Forced vital capacity	Forced expiratory volume in one second	Peak expiratory flow
Ginning factory women labourers (n=104)	-7.86 ± 4.76	-7.28 ± 8.44	-4.13 ± 3.28
Control women # (n=40)	-0.06 ± 1.5	-0.15 ± 1.37	-0.2 ± 1.3
t value	10.30**	5.30 **	7.36 **

** Significantly different at 1 per cent level

Pulmonary function parameters FVC, FEV_1 and PEF were estimated in the control group of participants twice with an interval of seven hours and compared with before and after shift values of the experimental group

Many workers (Fishwick *et al.*, 1994; Schachter, 1998; Berry *et al.* 1974) have reported an increased post shift difference in FEV_1 values among textile workers.

Mast cell degranulation with its release of histamine has been strongly implicated in this acute post shift differences in FVC, FEV_1 and PEF (Bhatt *et al.*, 1990). Cotton dust and endotoxin might have induced the release of histamine from mast cells (Parikh *et al.*, 1987).

Among the 104 ginning factory women labourers, 96 % (100 out of 104) exhibited post shift differences in the FVC, FEV_1 and PEF values. These differences were found to be higher in byssinotics compared to the rest of the respiratory ailments. According to the classification suggested by Environmental Health Criteria reported by WHO (1983), these changes in pulmonary indices after shift could be regarded as acute effect of cotton dust on ventilatory function. They have proposed clinical grading system based on the percentage of reduction in FEV_1 after the shift : No effect – 5-10% reduction; Moderate effect – 10-20 % reduction and severe effect – more than 20% reduction. Based on the above criteria ,among the104 selected ginning factory women labourers of the study, 19.2 % were normal (20 out of 104), 42.3% had mild change (44 out of 104) 31.7% had moderate change (33 out of 104) and 6.7% had severe change (7 out of 104). Severe change in FEV_1 after shift was observed only in byssinotics. This was in accordance with the findings of Parikh *et al.* (1990).

The results of the present study suggested that the women labourers of the ginning factory are exposed to higher levels of cotton dust and this had led to the development of acute manifestation (Bhagia *et al.*, 1992).

4.3.1.6 Regression and correlation analysis of pulmonary function parameters of ginning factory women labourers with age and duration of exposure

Differences in pulmonary function may be due to ethnic origin, physical activity, environmental conditions, altitude, tobacco smoking, age, height, sex and socio economic status (Vijayan *et al.*, 1990). The prevalence of respiratory diseases increases with increase in duration of exposure to organic dusts (Fox *et al.*, 1973).

Therefore an attempt was made to evaluate the pulmonary function parameters namely forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) in ginning factory women labourers on the basis of their age (below 50 years and above 50 years) and duration of exposure to cotton dust (0 – 9 years, 10 – 19 years and 20 years and above).

Table 13, 14, and 15 give the regression and correlation analysis of percentage predicted indices of FVC, FEV_1 and PEF in ginning factory women labourers with their age (categorized into two groups : below and above 50 years) and duration of exposure to cotton dust (categorized into three groups : 0 – 9 years, 10 – 19 years, 20 years and above).

Age (below 50 years and above 50 years) did not show significant correlation with FVC, FEV_1 and PEF among the ginning factory women labourers. Similarly no significant correlation between FVC, FEV_1 and PEF and duration of exposure of 0 – 9 years and 10 – 19 years was observed. But the ginning factory women labourers above 50 years of age showed a significant negative regression with FVC (- 0.739) at 1 per cent level, FEV_1 (- 0.525) at 5 per cent level and PEF (- 0.558) at 5 per cent level with more than 20 years duration of exposure to cotton dust.

Likewise the multiple correlation analysis conducted to determine the combined effects of age and duration of exposure showed a 5 per cent significant correlation of percentage predicted FVC (0.521), FEV_1 (0.2853) and PEF (0.3305) with age above 50 years and duration of exposure above 20 years.

TABLE - 13

REGRESSION AND CORRELATION ANALYSIS OF PERCENTAGE PREDICTED INDICES OF FORCED VITAL CAPACITY IN GINNING FACTORY WOMEN LABOURERS BELOW AND ABOVE 50 YEARS OF AGE WITH DURATION OF EXPOSURE TO COTTON DUST 0 – 9 YEARS, 10 – 19 YEARS AND ABOVE 20 YEARS

Pulmonary function parameter	Age groups	Years of exposure	Regression coefficient		Correlation coefficient		
			Age	Duration of exposure	Multiple R	Age	Duration of exposure
Forced vital capacity (FVC)	Below 50	0 – 9	- 0.723	- 0.995	0.3716	- 0.339	- 0.231
		10 – 19	1.919	1.418	0.7148	0.649	0.451
		20 and above	0.133	- 0.489	0.2285	- 0.045	- 0.220
	Above 50	0 – 9	- 1.273	1.159	0.3278	- 0.261	0.253
		10 – 19	- 0.642	2.430	0.5469	- 0.257	0.382
		20 and above	- 0.003	- 0.739**	0.521 *	- 0.089	- 0.521

* - Significant at 5 per cent level

** - Significant at 1 per cent level

TABLE - 14

REGRESSION AND CORRELATION ANALYSIS OF PERCENTAGE PREDICTED INDICES OF FORCED EXPIRATORY VOLUME IN ONE SECOND IN GINNING FACTORY WOMEN LABOURERS BELOW AND ABOVE 50 YEARS OF AGE WITH DURATION OF EXPOSURE TO COTTON DUST 0 – 9 YEARS, 10 – 19 YEARS AND ABOVE 20 YEARS

Pulmonary function parameter	Age groups (Years)	Years of Exposure	Regression coefficient		Correlation coefficient		
			Age	Duration of Exposure	Multiple R	Age	Duration of exposure
Forced expiratory volume in one second (FEV_1)	Below 50	0 – 9	- 0.809	- 1.816	0.4569	- 0.377	- 0.343
		10 – 19	1.495	- 0.944	0.5703	0.509	- 0.123
		20 and above	- 0.281	- 0.423	0.1806	- 0.179	- 0.102
	Above 50	0 – 9	- 0.304	1.597	0.2584	- 0.100	0.255
		10 – 19	- 0.935	2.883	0.5815	- 0.342	0.344
		20 and above	0.186	- 0.525*	0.2853*	0.024	- 0.276

* Significant at 5 per cent level

TABLE - 15

REGRESSION AND CORRELATION ANALYSIS OF PERCENTAGE PREDICTED INDICES OF PEAK EXPIRATORY FLOW IN GINNING FACTORY WOMEN LABOURERS BELOW AND ABOVE 50 YEARS OF AGE WITH DURATION OF EXPOSURE TO COTTON DUST 0 – 9 YEARS, 10 – 19 YEARS AND ABOVE 20 YEARS

Pulmonary function parameter	Age groups (Years)	Years of Exposure	Regression coefficient		Correlation coefficient		
			Age	Duration of Exposure	Multiple R	Age	Duration of exposure
Peak expiratory flow (PEF)	Below 50	0 – 9	- 0.51	- 2.13	0.4474	- 0.300	- 0.396
		10 – 19	- 0.958	0.529	0.3617	- 0.332	0.057
		20 and above	- 0.136	- 0.628	0.2849	- 0.174	- 0.280
	Above 50	0 – 9	- 0.523	- 0.03	0.1348	- 0.135	0.022
		10 – 19	0.141	0.174	0.1137	0.108	0.068
		20 and above	0.004	- 0.558*	0.3305*	- 0.054	- 0.330

* Significant at 5 per cent level.

These findings suggest that age had no significant effects on percentage predicted values of pulmonary function, Vijayan *et al.* (1990) also did not observe any significant age related decline in FVC and FEV_1.

The ginning factory women labourers recorded a significant relationship between percentage predicted pulmonary function parameters and duration of exposure of more than 20 years. The above findings suggested that neither age nor duration of exposure (except above 20 years) independently had an influence

on percentage predicted values of FVC, FEV_1 and PEF among ginning factory women labourers. But both age and duration of exposure together had a significant influence on the percentage predicted values of FVC, FEV_1 and PEF in these women labourers.

Continuous exposure to cotton dust for more than 20 years should have led to increased airway reactivity thereby resulting in fixed airways obstruction which eventually would have led to decrease in percentage predicted values of FVC, FEV_1 and PEF in ginning factory women labourers(Bouhuys *et al.*, 1977).

Shah and Rajagopal (1985) have also observed a significant decrease in FVC and FEV_1 in cotton textile workers having the duration of exposure 20 – 30 years. Higher prevalence of chronic respiratory changes due to cotton dust pollution was also reported by Parikh *et al.* (1990) in textile workers having working experience above 20 years. An association between increased duration of exposure to cotton dust and impaired FVC was also observed by Fishwick *et al.*(1994). Parkes (1982) has also observed that the abnormalities in respiratory function were associated with dust concentration and years of exposure and that it was apparently more in women.

4.3.1.7 Assessment of the pulmonary function of the ginning factory women labourers employed in different sections of the ginning factory by Chi square analysis

Three distinct sections of the ginning factories include the gin house (area where seeds are separated from cotton bolls by roller gins), the gutter (area where the separated seeds are collected) and sorting section (area where the cotton bolls are sorted according to their quality). An attempt was made to study the sectionwise changes in pulmonary function parameters in the ginning factory women labourers who are employed in the different sections of the ginning factory.

Table 16 illustrates the number of women labourers with normal and altered levels of pulmonary function parameters namely forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) who are employed in the gin house, gutter and sorting sections of the ginning factory.

TABLE - 16

PULMONARY FUNCTION PROFILE OF THE GINNING FACTORY WOMEN LABOURERS EMPLOYED IN DIFFERENT SECTIONS OF THE GINNING FACTORY

S.No	Sections of Ginning Factory	Distribution of ginning factory women labourers					
		FVC % Pred		FEV_1 % Pred		PEF % Pred	
		Above 80% (Normal)	Below 80% (Affected)	Above 80% (Normal)	Below 80% (Affected)	Above 80% (Normal)	Below 80% (Affected)
1	S1 (n=56)	20 (36)	36 (64)	6 (11)	50 (89)	2 (4)	54 (96)
2	S2 (n=38)	15 (40)	23 (60)	11 (29)	27 (71)	6 (16)	32 (84)
3	S3 (n=10)	8 (80)	2 (20)	5 (50)	5 (50)	1 (10)	9 (90)
	Total	43 (41)	61 (59)	22 (21)	82 (79)	9 (9)	95 (91)
χ^2 value		6.9484 *		10.032**		4.300 *	

* Significant at 5 per cent level

** Significant at 1 per cent level

S1 - gin house, S2 - gutter, S3 - sorting section

Values given in parentheces denote the percentage of the women labourers in each section with the specific pulmonary function status

Among the 104 women labourers working in the selected ginning factory, 56 are employed in gin house section, 38 are employed in gutter section and 10 are employed in the sorting section.

The pulmonary function status of ginning factory women labourers. employed in the different sections of ginning factory is shown in figure 11.

In normal persons, the percentage predicted values of FVC, FEV_1 and PEF are above 80% of the predicted value. In chronically impaired respiratory abnormal cases, it is below the expected 80% of the predicted values (Bouhuys *et al.*, 1977).

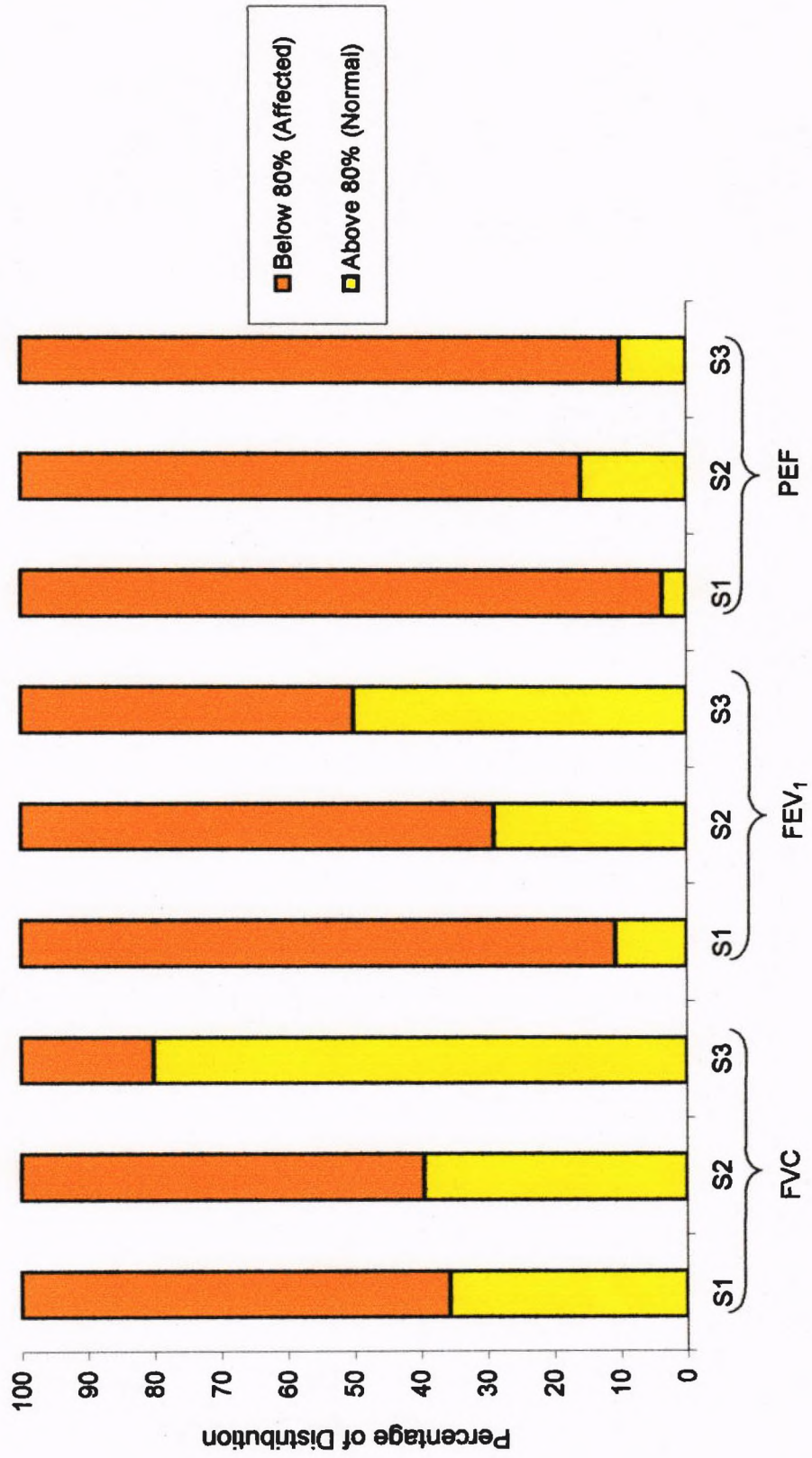
Among the 56 women labourers employed in the gin house, 64, 89 and 96 percentage workers showed decreased pulmonary function parameters FVC, FEV_1 and PEF respectively. Among the 38 women labourers employed in the gutter 60, 71 and 84 percentage workers showed decreased FVC, FEV_1 and PEF respectively. In the sorting section 20, 50 and 90 percentage workers showed less than normal levels of FVC, FEV_1 and PEF respectively.

Chi square analysis revealed that the abnormalities in the pulmonary function were significant in ginning factory women labourers employed in all the three sections of the ginning factory. The results suggested increased cotton dust pollution in the gin house, gutter and sorting section ie., in the entire premises of the ginning factory.

Parikh and Bhagia (1990) have observed that the work related complaints of the ginning factory workers was more in gin house workers compared to those working in other sections. Similar findings were also reported by Montalvo (1982) in Missisipi ginning factories.

Figure - 11

PULMONARY FUNCTION STATUS OF GINNING FACTORY WOMEN LABOURERS EMPLOYED IN DIFFERENT SECTIONS OF THE GINNING FACTORY



High content of cotton dust, endotoxin levels and gram negative bacteria observed in these sections would have reduced the values of pulmonary function parameters, which eventually should have led to higher prevalence of abnormal cases in the three sections of the ginning factory.

4.3.1.8 Assessment of the dependence of pulmonary functions on exposure to passive smoking by Chi square analysis

Passive smoking is as much harmful as direct smoking. The secondhand smoke is a carcinogen – a substance that definitely causes cancer. An equal number of passive smokers like women and children suffer from a host of respiratory diseases. Today, passive smoking ranks behind direct smoking and alcohol as the third leading preventable cause for cancer and impending death. Passive smoking affects the heart and lung function, decreasing the ability of people to work normally (Joshi, 2000).

Although there are many studies relating the pulmonary function and direct smoking in textile workers, there is no study conducted so far, to establish a clear relationship between the effect of passive smoking and pulmonary functions in textile or ginning factory workers. Women are prone easily to infections due to stress and strains. Many nonsmoking women are exposed to passive smoking at home and public places and experience pulmonary and hematological disorders.

This phase of the study was aimed to find the effect of passive smoking on the pulmonary functions of ginning factory women labourers and control women who are basically nonsmokers but were exposed to passive smoking in their residence. Women whose family men smoked more than 10 cigarettes / beedies per day were categorized as 'Yes' to passive smoking and others were categorized as 'No'. The duration of exposure to passive smoking in these women could not be ascertained.

Table 17 shows the distribution of the participants of the study with above and below normal level of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) with chances of exposure to passive smoking. Among the 104 women labourers, 45 had the chances of exposure to passive smoking and 21 control women out of 40 had the chances of exposure to passive smoking.

Results of the Chi square analysis revealed that passive smoking did not influence pulmonary function parameters namely FVC, FEV_1 and PEF and that the attributes passive smoking and pulmonary function parameters are independent of each other.

This suggests that the decrease in the pulmonary function among the ginning factory women laboures might be only due to the exposure to the main air pollutant cotton dust in the work area.

4.3.1.9 Assessment of the dependence of pulmonary functions on the use of different fuels for cooking by Chi square analysis

Some of the highest exposures to air pollutants in developing countries occur inside homes where biofuels are used for daily cooking. Inhalation of these pollutants may cause deleterious effects on health. Exposure to biofuel smoke has been associated with the occurrence of chronic lung disease, respiratory symptoms like cough, expectoration, dyspnoea and poor lung function (Dutt *et al.*,1996). Women using biofuels like firewood are more liable to have reduced pulmonary functions than women using kerosene or LPG (Mohan rao *et al.*,1991 b) .

TABLE – 17

DISTRIBUTION OF THE PARTICIPANTS OF THE STUDY WITH PULMONARY FUNCTION PARAMETERS ABOVE AND BELOW NORMAL LEVELS WITH CHANCES OF EXPOSURE TO PASSIVE SMOKING

Pulmonary function parameters	Chances of Passive Smoking	Number of participants			
		Ginning factory women labourers		Control women	
		Above 80% (Normal)	Below 80% (Affected)	Above 80% (Normal)	Below 80% (Affected)
Forced vital capacity (FVC)	No	26 (44)	33 (56)	9 (47)	10 (53)
	Yes	17 (38)	28 (62)	12 (57)	9 (43)
	Total	43 (41)	61 (59)	21 (53)	19 (47)
	χ^2 value	0.1975 ^{NS}		0.0907 ^{NS}	
Forced expiratory volume in one second (FEV_1)	No	16 (27)	43 (73)	12 (63)	7 (37)
	Yes	6 (13)	39 (87)	11 (52)	10 (48)
	Total	22 (21)	82 (79)	23 (58)	17 (42)
	χ^2 value	2.1409 ^{NS}		0.1356 ^{NS}	
Peak expiratory flow (PEF)	No	6 (10)	53 (90)	8 (42)	11 (58)
	Yes	3 (7)	42 (93)	8 (38)	13 (62)
	Total	9 (9)	95 (91)	16 (40)	24 (60)
	χ^2 value	0.0770 ^{NS}		0.000 ^{NS}	

^{NS} - Not significant

Values given in parentheces denote the percentage of the women labourers in each section with the specific pulmonary function status

It was aimed in the present study to assess the pulmonary functions of ginning factory women labourers using different fuels for cooking.

Table 18, 19 and 20 show the distribution of the participants of the study with above and below normal levels of forced vital capacity (FVC), forced expiratroy volume in one second (FEV_1) and peak expiratory flow (PEF) who used LPG, kerosene and firewood as fuels for cooking in their houses.

Among the 104 women labourers, 17 used LPG, 53 used kerosene and 34 used firewood as fuels for cooking. Out of the 40 control women 9 used LPG, 16 used kerosene and 15 used firewood as fuels for cooking.

Results of Chi square analysis revealed that the use of LPG, kerosene and firewood did not influence the pulmonary function parameters namely FVC, FEV_1, and PEF in ginning factory women labourers. This indicated that the cotton dust in the work area is the sole causative agent for the abnormalities in the pulmonary function among the ginning factory women labourers. The control women also exhibited no significant influence of use of different fuels on pulmonary function parameters FEV_1 and PEF. The reason for the dependence of FVC values on the type of fuel used among the control women could not be ascertained.

TABLE – 18

DISTRIBUTION OF THE PARTICIPANTS OF THE STUDY WITH PERCENTAGE PREDICTED VALUES OF FORCED VITAL CAPACITY ABOVE AND BELOW NORMAL LEVELS USING LPG, KEROSENE AND FIREWOOD AS FUELS FOR COOKING

Fuel used for cooking	Number of participants			
	Ginning factory women labourers		Control women	
	Above 80% (Normal)	Below 80% (Affected)	Above 80% (Normal)	Below 80% (Affected)
LPG	10 (59)	7 (41)	8 (89)	1 (11)
Kerosene	18 (34)	35 (66)	8 (50)	8 (50)
Firewood	15 (44)	19 (56)	5 (33)	10 (67)
Total	43 (41)	61 (59)	21 (52)	19 (48)
χ^2 value	3.4405^{NS}		7.0287 *	

^{NS} - Not significant

* Significant at 5 per cent level

Values given in parentheces denote the percentage of the women labourers in each section with the specific pulmonary function status

TABLE - 19

DISTRIBUTION OF THE PARTICIPANTS OF THE STUDY WITH PERCENTAGE PREDICTED VALUES OF FORCED EXPIRATORY VOLUME IN ONE SECOND ABOVE AND BELOW NORMAL LEVELS USING LPG, KEROSENE AND FIREWOOD AS FUELS FOR COOKING

Fuel used for cooking	Number of participants			
	Ginning factory women labourers		Control women	
	Above 80% (Normal)	Below 80% (Affected)	Above 80% (Normal)	Below 80% (Affected)
LPG	6 (35)	11 (65)	7 (78)	2 (22)
Kerosene	10 (19)	43 (81)	9 (56)	7 (44)
Firewood	6 (18)	28 (82)	7 (47)	8 (53)
Total	22 (21)	82 (79)	23 (57)	17 (43)
χ^2 value	2.4547 ^{NS}		2.245 ^{NS}	

^{NS} - Not significant

Values given in parentheces denote the percentage of the women labourers in each section with the specific pulmonary function status

TABLE - 20

DISTRIBUTION OF THE PARTICIPANTS OF THE STUDY WITH PERCENTAGE PREDICTED VALUES OF PEAK EXPIRATORY FLOW ABOVE AND BELOW NORMAL LEVELS USING LPG, KEROSENE AND FIREWOOD AS FUELS FOR COOKING

Fuel used for cooking	Number of participants			
	Ginning factory women labourers		Control women	
	Above 80% (Normal)	Below 80% (Affected)	Above 80% (Normal)	Below 80% (Affected)
LPG	2 (19)	15 (88)	4 (44)	5 (56)
Kerosene	3 (6)	50 (94)	7 (44)	9 (56)
Firewood	4 (12)	30 (88)	5 (33)	10 (67)
Total	9 (9)	95 (91)	16 (40)	24 (60)
χ^2 value	1.2251^{NS}		0.4456^{NS}	

^{NS} - Not significant

Values given in parentheces denote the percentage of the women labourers in each section with the specific pulmonary function status

4.3.2 Interpretation of chest X-rays

Occupational lung dysfunctions may be either obstructive or restrictive or both together. Example-Asbestosis, Silicosis, Byssinosis etc., (Connellan, 1993). Chest X - ray proves to be a supporting evidence for diagnosing any lung disorder. It also plays a central role in detecting, treating and following the course of diseases involving the lungs (Murray and Nadel, 1994). Chest X-rays were taken for all the 104 experimental group participants. Seventy of them revealed normal pattern; Thrity four of them showed mild variation. Obstructive lung diseases (which involves airways) like byssinosis, chronic bronchitis and asthma show no specific radiograph abnormalties (Parkes,1982).This might be the reason for the absence of any specific abnormalities in the X-rays of majority of women labourers.

The chest X-rays of an apparently normal middle aged ginning factory woman labourer, a woman labourer exhibiting byssinotic symptoms, a woman labourer with chronic bronchitic symptoms and a woman labourer with asthmatic symptoms are illustrated in plates 21 to 24 with notes of interpretation.

PLATE 21 CHEST X-RAY OF A NORMAL GINNING FACTORY WOMAN LABOURER

The plate shows the chest X-ray of an apparently normal healthy woman aged 56. Here the phenic angles is at right side. There is no hazziness. The position of heart is correct with 2/3rd on left side and 1/3rd on right side. There is no fracture in the ribs.

PLATE 22 CHEST X-RAY OF A GINNING FACTORY WOMAN LABOURER SHOWING BYSSINOTIC SYMPTOMS

The plate shows the X-ray of a ginning factory women labourer aged 56. No specific abonormalities is noticed except mild sputum retention and obstruction.

PLATE 23 CHEST X-RAY OF A GINNING FACTORY WOMAN LABOURER SHOWING CHRONIC BRONCHITIC SYMPTOMS

The plate shows the X-ray of a ginning factory women labourer aged 56. There is hazziness in the X-ray distributed bilaterally indicating mild sputum retention. The phenic angle is not curved as in the normal. There fore the entry of air inside the lungs is impaired. The X-ray represents mild chronic obstruction. No other specific abnormalities is noticed.

PLATE 24 CHEST X-RAY OF A GINNING FACTORY WOMAN LABOURER SHOWING ASTHMATIC SYMPTOMS

The plate shows the X-ray of a ginning factory women labourer aged 56. There is obstruction due to mucus plug in the lower lobe of the right lungs. No other specific abnormalities is noticed.


R
21


22


23


24

Table 21 indicates the magnitude of health hazards in the ginning factory.

TABLE - 21

EVALUATION OF RESPIRATORY SYMPTOMS, X- RAY ABNORMALITY AND PULMONARY FUNCTION ABNORMALITIES IN GINNING FACTORY WOMEN LABOURERS

Group No.	Group	Total (n=104)	
		Number	Percentage
1	X ray abnormality + respiratory symptoms + PFT abnormality	13	12.5
2	X ray abnormality + respiratory symptoms	6	5.8
3	X ray abnormality + PFT abnormality	15	14.4
4	Only X ray abnormality	0	0
5	Respiratory symptoms + PFT abnormality	10	9.6
6	Only respiratory symptoms	28	26.9
7	Only PFT abnormality	20	19.2
8	Absolutely normal	12	11.5

Groups 1 to 4 - need promotion of health by changing the place of their occupation, dust control in working environment and clinical management as the reversibility of disease in these group is not possible.

Group 5 to 7 - promotion of health by usage of respiratory masks, dust control devices should be applied to these groups.

Group 8 - preventive methods such as usage of respiratory masks should be undertaken.

4.4 BIOCHEMICAL PROFILE

Blood is a fluid connective tissue circulating in the body. It provides one of the methods of communication between the cells of different parts of the body. The blood carries oxygen and nutrients to the tissues and carbondioxide and waste products from the tissues to the excretory organs. In addition,it conveys antibodies to the site of injury or disease and hormones or chemical messengers from the endocrine glands to various target organs. Blood is the medium of transportation of all these substances. Blood constitutes approximately 8% of the body weight or 5.6 litres in a 70 kg man(Berry, 1995).

Blood analysis is an useful tool in diagnosing various pathological conditions. Therefore the present study was focused to analyse some biochemical parameters in the blood of ginning factory women labourers and to correlate the blood findings with the pulmonary abnormalities.

4.4.1 Hematological parameters

4.4.1.1 Hemoglobin and erythrocyte sedimentation rate

A sufficient concentration of hemoglobin in blood is essential for adequate transport of oxygen and carbondioxide between the lungs and other tissues. Blood hemoglobin concentration may be diminished as a consequence of

hemorrhage or hemolysis or as a result of impaired blood formation in the bone marrow . Blood hemoglobin exchanges gas through the lungs and this process is impaired in various disorders. Measurement of the blood hemoglobin concentration is important as an initial step in the detection of anemia (diminished hemoglobin concentration) or erythrocytosis (increased RBC count and hemoglobin concentration) (Burtis and Ashwood., 1999). The major function of erythrocytes is to transport hemoglobin, which carries oxygen from the lungs to the tissues.

Therefore measurement of hemoglobin concentration in venous or capillary blood is one of the most frequently performed clinical laboratory tests. The present study also was aimed to estimate the blood hemoglobin levels and erythrocyte sedimentation rate in ginning factory women labourers who are exposed to cotton dust pollution.

The mean levels of hemoglobin and erythrocyte sedimentation rate (ESR) in ginning factory women labourers is illustrated in Table 22 and figure 12.

TABLE - 22

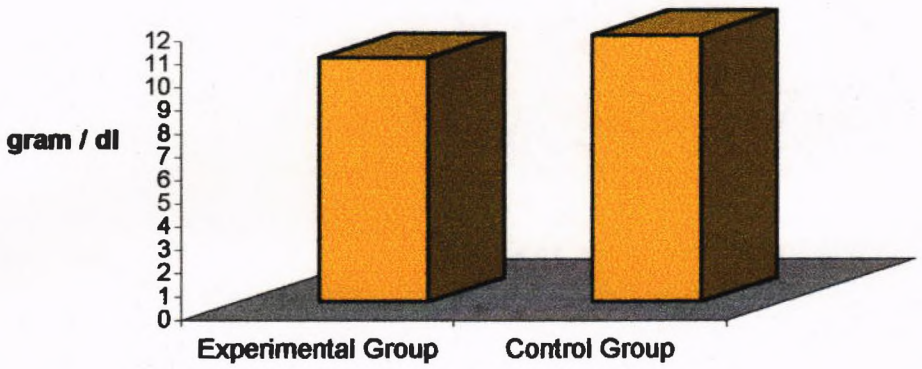
MEAN HEMOGLOBIN AND ERYTHROCYTE SEDIMENTATION RATE IN GINNING FACTORY WOMEN LABOURERS

Groups	Hemoglobin(g/dl)	Erythrocyte sedimentation rate (mm/hour)
Ginning factory women labourers (n=104)	10.5 ± 1.89	24 ± 4.58
Control women (n=40)	11.5 ± 1.1	20.8 ± 3.46
t value	3.13**	3.99**

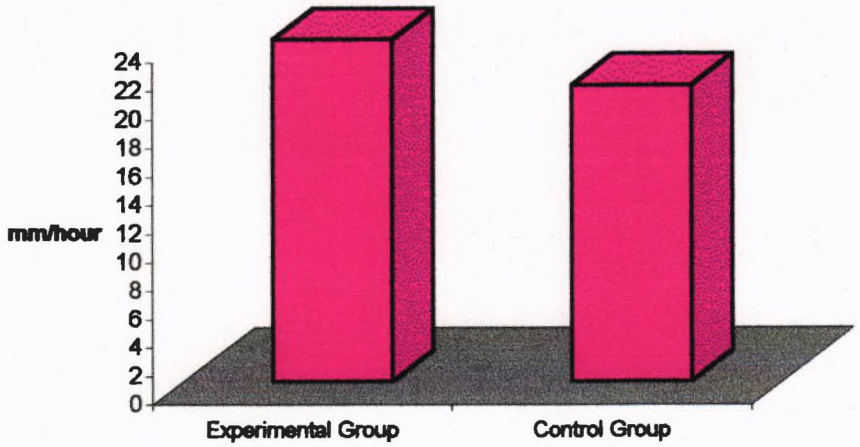
** - Significantly different at 1 per cent level

Figure- 12

MEAN HEMOGLOBIN LEVELS AND ERYTHROCYTE SEDIMENTATION RATE IN GINNING FACTORY WOMEN LABOURERS



Hemoglobin



Erythrocyte Sedimentation Rate

The mean levels of hemoglobin in ginning factory women labourers (10.5 ±1.89 g/dl) was significantly lower than that of the control women at 1 per cent level. Normal values of hemoglobin in women range from 12-16 g/dl. Seventy seven women labourers were found to have hemoglobin levels below 9.0 g/dl. Among them two were severely anemic (5.6g/dl and 7.7 g/dl). This might be due to their low dietary intake of protein and iron, menopausal state along with respiratory ailments. Also the decreased hemoglobin status might reflect the reduced oxygen diffusion capacity of the lungs in conditions of respiratory disorders.

The experimental group women recorded significant increase ($P<0.1$) in ESR (24 ± 4.58 mm/hour) compared to the control group. The normal limits of ESR is 0-20 mm/hour, which is generally increased when the size of erythrocytes is increased (Linne and Ringsurd,1992). Therefore high levels of ESR might be due to the clogging or rouleaux formation of erythrocytes. The deficiency of hemoglobin and proteins might be the reason for this increase accounting for erythrocytosis among the experimental group of participants. ESR is also increased in chronic infectious diseases like asthma and in anemias, which favour the rouleax formation of erythrocytes (Treseler, 1988). Forty three women who had decreased levels of hemoglobin recorded high ESR. Contaminated cotton dust would have been responsible for the development of infections and clogging of erythrocyte, thereby causing an increase in ESR in the ginning factory women labourers.

Out of the 104 women labourers, 93 had ESR values higher than the normal limits. Among them 5 had ESR values above 30 mm/hour. The high ESR values were more prevalent among chronic bronchitis and asthmatic workers compared to byssinotics and other workers in this study.

4.4.1.2 Total and differential count of leucocytes

At all times, our bodies are exposed to bacteria, viruses, fungi and parasites, all of which occur even normally and to varying degrees in the skin, the mouth, the respiratory passage ways, the intestinal tract, the lining membranes of the eyes and urinary tract. Many of these agents are capable of causing serious disease if they invade the deeper tissues. Our bodies have a special system composed of blood leucocytes for combating these different infections. The types of leucocytes normaly found in the blood are polymorphonuclear neutrophils, polymorphonuclear eosinophils, lymphocytes and monocytes. Neutrophils, eosinophils and monocytes protect the body against invading organisms by phagocytosis. The lymphocytes function mainly in connection with immune system (Guyton and Hall, 1998).

Therefore the measurement of blood leucocytes in the ginning factory women labourers was found imperative in the present study.

Table 23 and figure 13 show the mean levels of total and differential count of leucocytes in ginning factory women labourers.

The mean levels of total count (9693 ± 1841x10^6/L), percentage of neutrophil, (63 ± 7%) and eosinophil (5.13 ± 2.08%) were significantly greater in the ginning factory women labourers at 1 per cent level and the percentage of lymphocytes (32 ± 8 %) was significantly decreased in the ginning factory women labourers at 1 per cent level compared to the control group.

Chronic infections seen in the ginning factory women labourers might have increased the mean values of total count of leucocytes in them. Normally the values of total count range from 4000-10,000 x 10^6/L.

TABLE - 23

MEAN TOTAL AND DIFFERENTIAL COUNT OF LEUCOCYTES IN GINNING FACTORY WOMEN LABOURERS

Groups	Total count of leucocytes(x 10^6/L)	Differential count(%)			
		Neutrophil	Lymphocyte	Eosinophil	Monocyte
Ginning factory women labourers (n=104)	9693 ± 1841	63 ± 7	32± 8	5.13 ± 2.08	1.33 ± 0.49
Control women (n=40)	8748 ± 1300	61 ±6.7	37± 7	1.8 ± 1.65	1.12 ±0
t value	2.97**	1.39**	3.69**	9.09**	--

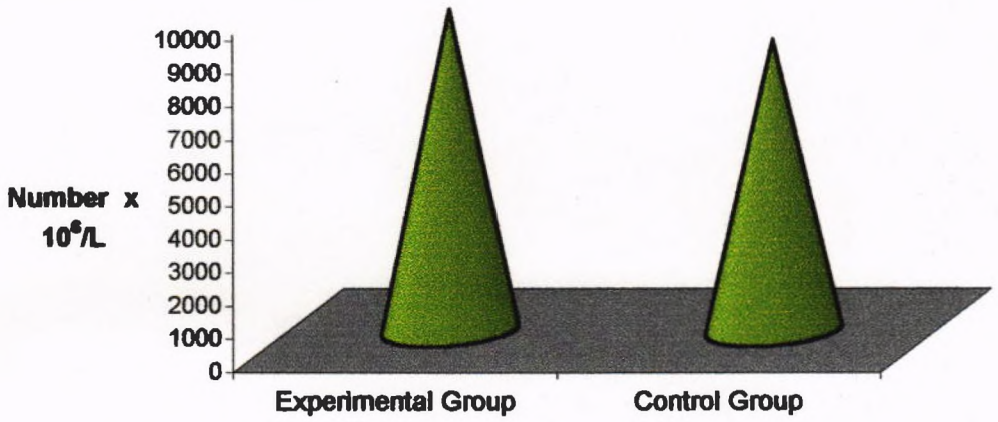
* * Significantly different at 1 per cent level

A non significant increase in total count was observed by Cooper et al. (1986) when aqueous extract of cotton bracts were administered to normal volunteers.

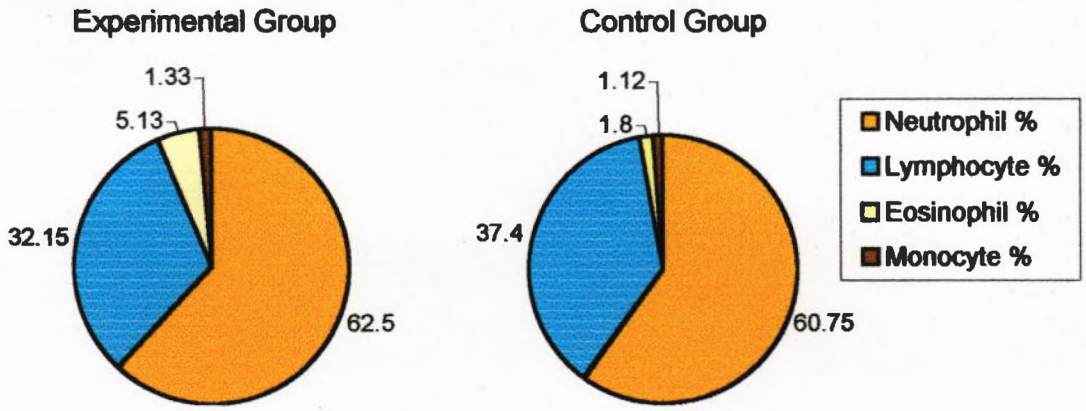
The normal levels of the different types of leucocytes are Neutrophils-62%, Lymphocytes - 30%, Eosinophils – 2.3% and Monocytes – 5.3% (Guyton and Hall, 1998). The mean percentage of neutrophil (63 ± 7%) in ginning factory women labourers was significantly greater at 1 per cent level than that of the control women. This is in agreement with the findings of Rylander and Haglind (1985). They observed an increased neutrophil content in cotton dust exposed workers. This increase might reflect the migration of neutrophil into the respiratory epithelium, causing mobilization of neutrophils from the venous marginal pools. Neutrophils might be activated by the endotoxin present in cotton dust and release mediators for inflammation and bronchoconstriction. A similar finding was also confirmed by Burrel and Ye (1990) and Ainsworth and Neuman (1981).

Figure- 13

MEAN TOTAL AND DIFFERENTIAL COUNT OF LEUCOCYTES IN GINNING FACTORY WOMEN LABOURERS



Total Count



Differential Count

Recruitment of polymorpho leucocytes (neutrophils) to the surfaces of airways of hamsters and guinea pigs had been demonstrated following inhalation of aerosols of cotton mill and trash dust extracts (Kilburn *et al.*, 1973; Rylander and Lundholm., 1978). Polymorpho leucocytosis was found to occur in human beings exposed to cotton dust (Pernis *et al.*, 1961; Merchant *et.al.*,1975). Rohrbach *et al.*(1985) observed that the reversible bronchoconstriction that results from inhalation of cotton mill dust in byssinotic workers was accompained by influx of neutrophils in airways. According to Rastogi and Husain (1992) this infux represents an increase of the body's defences toward inhaled agents.

Endotoxin in cotton dust may be the potent inducer of the neutrophil migration (Rylander, 1985). This was further confirmed by Koyama *et al.*(1991) who observed that bronchial epithelial cells stimulated by endotoxin release chemotactic activity for neutrophils.

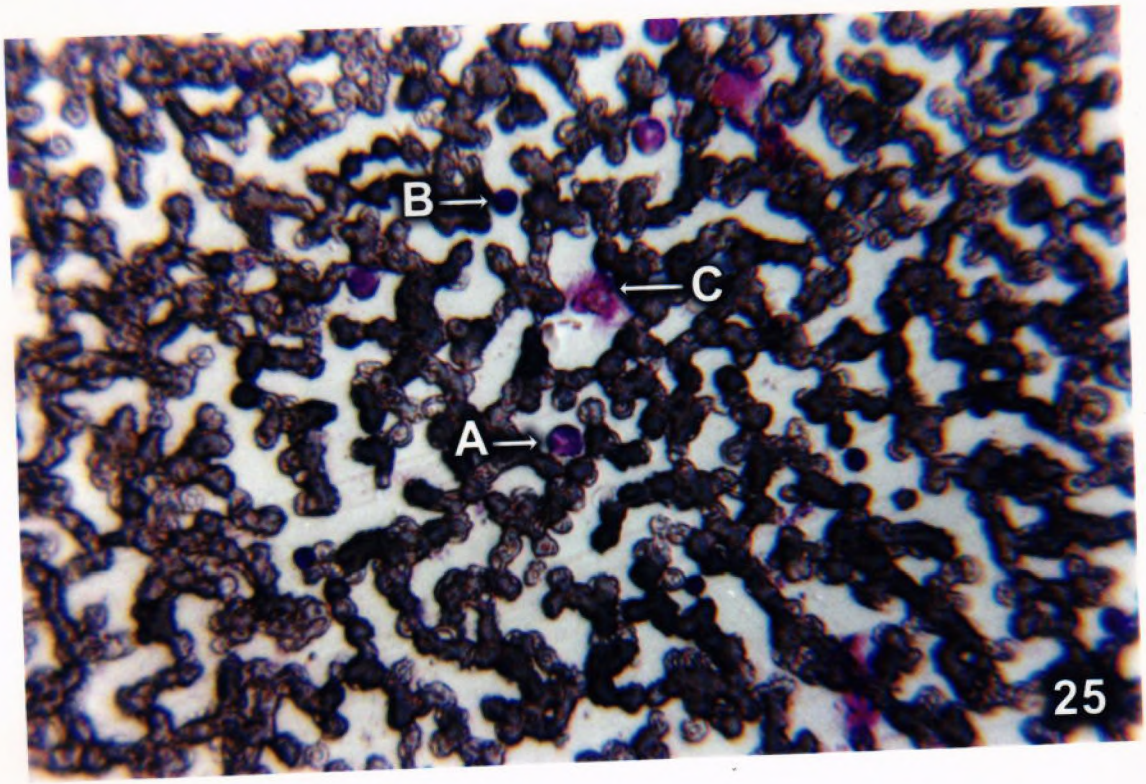
The reason for the significant reduction in the circulating lymphocytes content in ginning factory women labourers could not be ascertained.

The mean eosinophil content of ginning factory women labourers (5.13 ± 2.08%) was also found to be significantly increased at 1 per cent level compared to that of the control group. The normal range of eosinophil content is 0-3%. The increase in eosinophils in the experimental group compared to controls suggested an allergic process commonly found in asthma and pulmonary eosinophilia as opined by Golwalla and Golwalla (1985). The cotton dust inhaled by these women would have induced the allergic response in them.

Plate 25 shows the distribution of different leucocytes in the serum of a ginning factory woman labourer.

PLATE 25 MICROSCOPIC SLIDE SHOWING THE DISTRIBUTION OF DIFFERENT LEUCOCYTES IN THE SERUM OF A GINNING FACTORY WOMAN LABOURER

A-NEUTROPHIL
B-LYMPHOCYTE
C-EOSINOPHIL


B
C
A
25

Increased eosinophil content (above 7%) was observed in all the four asthmatic cases among the experimental group of the participants compared to other cases of respiratory ailments.

4.4.2 Other biochemical parameters

Among the 104 experimental group participants, 13 women labourers were selected randomly and they were subjected to the following biochemical tests in order to assess any possible correlation between the PFT impairment and the selected biochemical parameters. Ten women from the control group were also selected at random and subjected to the same selected biochemical analysis.

4.4.2.1 Immunoglobulin

The immunoglobulins are those proteins, which function as antibodies against xenobiotic antigens. On electrophoresis they mainly occupy the γ globulin position but also occur in the β and $\alpha 2$ globulins. Changes in serum immunoglobulins in workers exposed to cotton dust have been suggested to precede or accompany the development of byssinosis. Taylor *et al.* (1971) suggested an interaction between cotton dust antigen and serum antibody complex; the antigen was found to react with IgG by precipitation and passive agglutination. They also suggested a specific relationship between the antibody titers in byssinosis and the extent of exposure to cotton dust.

Therefore an attempt was made to estimate the levels of immunoglobulins in a subgroup of the ginning factory women labourers.

Table 24 and figure 14 illustrate the mean immunogloblin levels in the ginning factory women labourers.

TABLE - 24

MEAN IMMUNOGLOBULIN LEVELS IN GINNING FACTORY WOMEN LABOURERS

Groups	Immunoglobulins			
	Ig A mg/dl	Ig M mg/dl	Ig G mg/dl	Ig E IU/ml
Ginning factory women labourers (n=13)	217 ± 91	142 ± 57	1627 ± 582	433 ± 58
Control women (n=10)	116 ± 20	98 ± 14	798 ± 117	408 ± 32
t value	3.45**	2.38*	4.41**	1.63

* Significantly different at 5 per cent level
** Significantly different at 1 per cent level

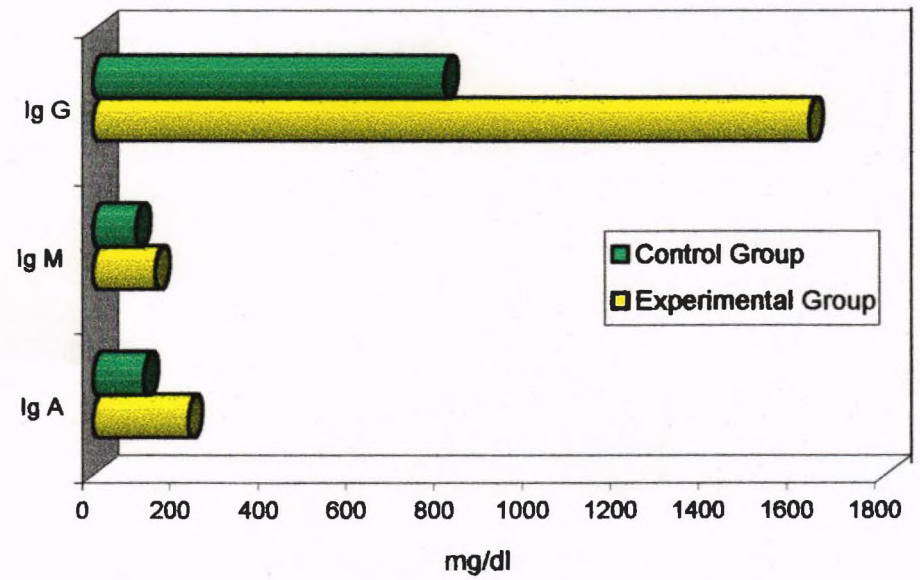
Normal values of IgA is 71 to 360 mg/dl, IgM – 40 to 260 mg/dl, IgG - 620 - 1840 mg/dl and IgE- upto 200 IU/ml (Fauci *et al.*, 1998).

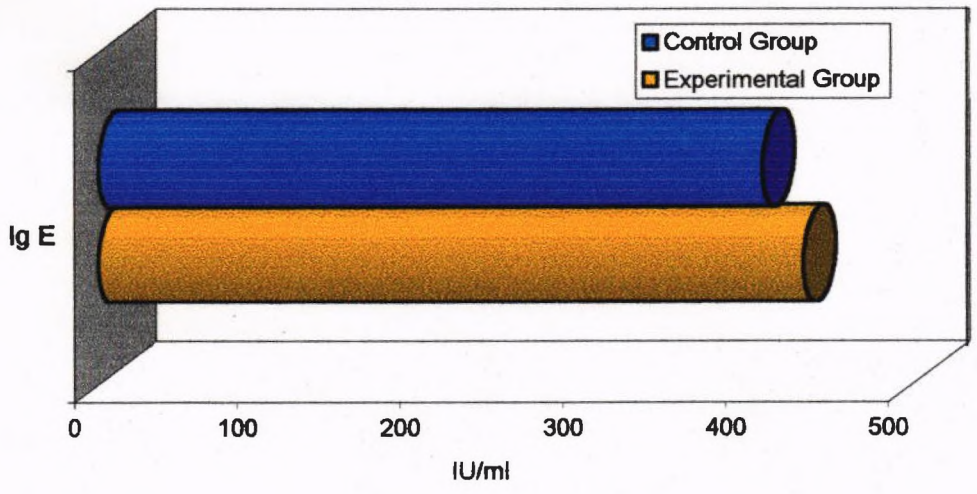
A significant increase in IgA (217 ± 91 mg/dl) at 1 per cent level, IgM (142 ± 57 mg/dl) at 5 per cent level and IgG (1627± 582 mg/dl) at 1 per cent level were observed in the ginning factory women labourers. No significant change was noticed in IgE levels between the two groups.

When comparing the immunoglobulin levels among the ginning factory women labourers exhibiting different clinical symptoms, the levels of IgA were high in Grade 2 byssinotics compared to other grades of byssinotics, chronic bronchitis, asthma and other respiratory disorders. The levels of IgM were high in

Figure- 14

MEAN IMMUNOGLOBULIN LEVELS IN GINNING FACTORY WOMEN LABOURERS





Grade 2 byssinotics and chronic bronchitis cases. IgG levels were increased only in all grades of byssinosis especially in Grade 2 byssinotics. IgE was seen increased only in all the four asthmatic cases and in one chronic bronchitis worker. One asthmatic worker showed very high IgE levels of 2185 IU/ml.

Similar changes in immunoglobulin levels were observed in textile workers by many researchers. Kamat *et al.* (1981) reported a significant rise in IgG in byssinotics. Karnik *et al.* (1987) have observed a significant increase in IgG level in byssinotics (1720.6 ± 450.6 mg/dl) and non byssinotics (1610.5 ± 288.7mg/dl), a non significant rise in IgA levels in byssinotics and nonbyssinotics (294.3 ± 132.7 mg/dl and 213.1 ± 75.5mg/dl) and IgM in byssinotics and non byssinotics (161.7 ± 73.3 mg/dl and 148.1 ± 45.6 mg/dl). According to Parkes (1982), precipitating IgG antibody against an antigen in cotton is present in cotton workers. Our findings are in agreement with this fact that the antibody titre is highest in workers with byssinosis, lower in those without byssinosis and lowest in the unexposed subjects. It has been thought that the symptoms of byssinosis are caused either directly by a late arthus type reaction in the walls of airways or indirectly by the reaction liberating a pharmacologically active substance. The fact that symptoms of Grade 2 and Grade 3 byssinosis disappeared while the workers were still exposed to the dust could be explained on the grounds that, as long as exposure continues, antibody is progressively removed from the circulation insufficient to produce a reaction; whereas after a period away from the dust, during which antibody is not removed, its titre has increased by the time the worker is re-exposed as suggested by Massoud and Taylor (1964). The elevated IgG antibody titres are probably markers of exposure to cotton dust rather than indicators (Pickering, 2000).

According to Zuskin *et al.*(1992), cotton dust induced respiratory disease may be due to pre existing or occupationally induced allergy and atopy

predisposes to byssinotic condition. A nonspecific inflammatory reaction (non-atopic) initiated by mast cell derived mediators may also be responsible for some of the airway effects observed in byssinotics. Immunoglobulin assays in textile workers showed high IgG values among workers with work related symptoms especially cough, but not among those with bronchitis symptoms.

Since IgA is the predominant antibody in nasal secretions, its levels may be increased in mucus secretion by stimulatory effect of gram negative bacteria and its endotoxin present in cotton dust exposed by ginning factory women labourers. Thus IgA appears to be essential to ward off "sino-bronchial" infections (Chatterjea and Shinde, 1995).

IgM antibody is predominant in early responses to most antigens. Early exposures to cotton dust, gram negative bacteria and/or endotoxin should have induced the formation of IgM antibodies in ginning factory women labourers who have less years of working experience.

Our findings on IgE which showed non significant increase in ginning factory women labourers was in accordance with the results of Zuskin *et al.* (1992). They have reported a nonsignificant increase in IgE levels of textile workers. A nonsignificant increase in Ig E levels was also reported by Khare *et al.* (1992) in cotton mills workers working in the card and blow room sections at Indore.

These findings are in agreement with the report of Pickering (2000) who observed that the total IgE levels in textile mill workers showed no difference and there is no relationship between the clinical grades of byssinosis and the levels of IgE.

PLATE 26	RADIAL IMMUNO DIFFUSION SHOWING PRECIPITIN ARCS OF IMMUNOGLOBULIN A
PLATE 27	RADIAL IMMUNO DIFFUSION SHOWING PRECIPITIN ARCS OF IMMUNOGLOBULIN G
PLATE 28	RADIAL IMMUNO DIFFUSION SHOWING PRECIPITIN ARCS OF IMMUNOGLOBULIN M


Hu IgA NL BINDARID
RA010 Batch : 14340
10
12
1
26


Hu IgG NL BINDARID
RA004 Batch : 14161
10
12
1
27


Hu IgM NL RID Plate
RA012 Batch : 13814
28

The same negative pattern was observed by Pertronic and Bovenzi (1983) when they examined serum IgE concentrations in patients with byssinosis with different grades of chronic change in FEV_1. The results of this study support the hypothesis that there is no relationship between total IgE concentration and byssinosis.

Plates 26 to 28 show the radial immuno diffusion showing preciptin arcs of IgA, IgG and IgM.

4.4.2.2 Serum proteins

The plasma proteins include albumin, globulins and fibrinogen. Normal total plasma proteins average over 7 grams per 100 ml with a range from 6.3 to 7.9. (Albumin-3.7 to 5.3 g/dl; Globulin-1.8 to 3.6 g/dl; Fibrinogen -200–400 mg/dl)

The normal values of albumin globulin ratio varies from 2.5:1 to about 1.2:1. Increase in total protiens is seen in dehydration and decrease is seen in proteinurias. Marked changes in the levels of albumin and globulin level are used in the diagnosis of many diseases. Similarly electrophoretic fractionation of serum proteins have revealed a number of significant variations in the size of the globulin fractions in certain diseases (Gowenlock *et al.*, 1996).

The levels of mean serum proteins, albumin globulin ratio and the percentage of albumin and globulin fractions in the experimental group of participants are shown in Table 25.

TABLE – 25

MEAN SERUM PROTEIN LEVELS IN GINNING FACTORY WOMEN LABOURERS

Groups	Total proteins (g/dl)	Albumin globulin ratio	Serum proteins (%)				
			Albumin	Globulin			
				α_1	α_2	β	γ
Ginning factory women labourers (n=13)	7.53±0.57	1.43 ± 0.26	64.6± 7.15	2.96 ± 0.97	10.9 ± 3.64	11.9 ± 3.64	9.77 ± 4.07
Control women (n=10)	7.73 ± 0.38	1.57 ± 0.05	67.1 ± 2.89	3.76 ± 0.26	9.52 ± 0.33	10.4 ± 1.01	9.34 ± 2.58
t value	1.02	1.73	1.00	2.50	1.05	1.27	0.30

There was no significant change in the levels of total proteins, albumin globulin ratio, percentage of albumin and globulin levels in the serum of ginning factory women labourers compared to the control group. But an anaylsis of theindividual values revealed that the levels of total proteins in all grades of byssinotics were found to be decreased. Similar decrease was also seen in albumin globulin ratio in byssinotics. But the levels of β and γ globulins were found to be increased in byssinotics compared to the other experimental group participants and control group women.

Plate 29 and Figure 15 illustrate the electropherogram of serum proteins in two ginning factory women labourers – one normal pattern that of a women labourer without any respiratory ailments and the other one an abnormal pattern that of a woman labourer with impaired respiratory functions.

4.4.2.3 Serum lactate dehydrogenase

Lactate dehydrogenase is widely distributed, being found in all cells in man, but is especially plentiful in cardiac and skeletal muscle, liver, kidney and the red blood cells. An increase in serum lactate dehydrogenase is found in myocardial infarction, muscular dystrophy, myoglobinuria, infective hepatitis, leukemia, pernicious anemia, megaloblastic anemia, hemolytic anemia and renal diseases and in generalized carcinomatosis. The normal range of lactate dehydrogenase in serum is 230 – 460 IU/L (Gowenlock *et al.*, 1996).

Five isozymes of lactate dehydrogenase are known to exist LDH1 to LDH5 having diminishing electric charge from 1 to 5. Cardiac muscle is richest in LDH1 with diminishing proportions of LDH2-5 in that order, while in liver, the reverse is the case, LDH5 being most plentiful with diminishing amount of LDH4 -1.

PLATE 29 ELECTROPHEROGRAM OF SERUM PROTEINS IN TWO GINNING FACTORY WOMEN LABOURERS

a - ALBUMIN
b - α1 GLOBULIN
c - α2 GLOBULIN
d - β GLOBULIN
e - γ GLOBULIN

Top - Normal pattern
Bottom - Abnormal pattern

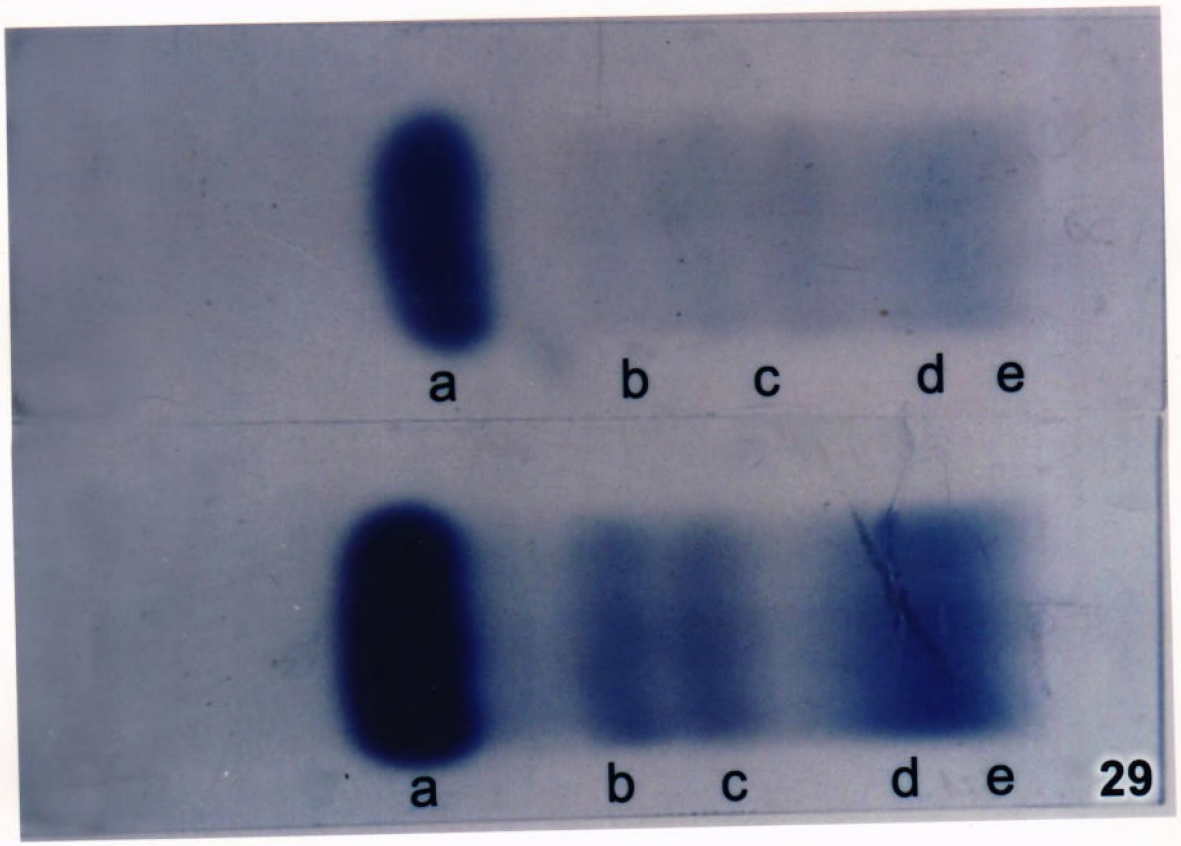
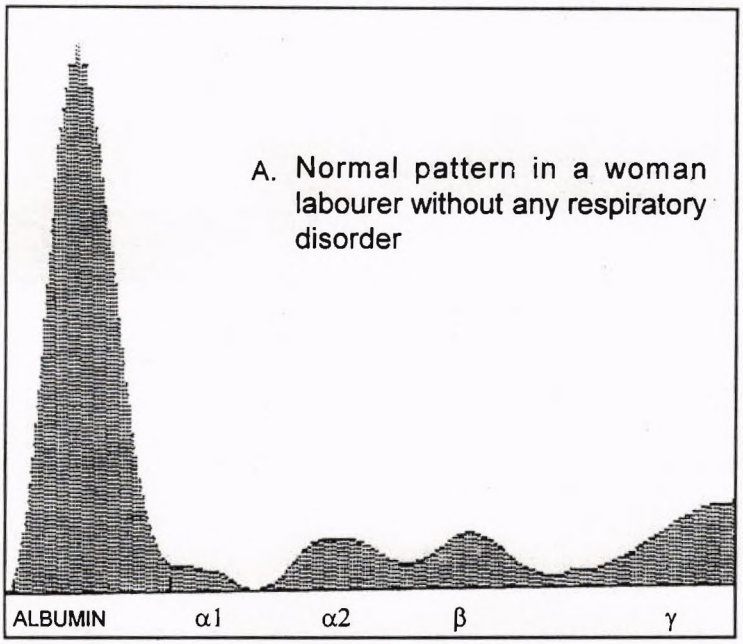
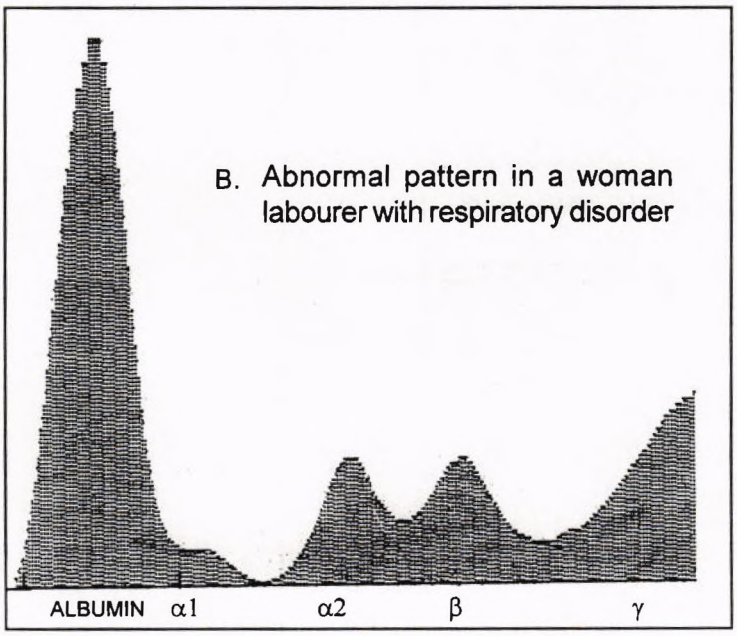

a b c d e
a b c d e

Figure - 15

ELECTROPHEROGRAM OF SERUM PROTEINS IN TWO GINNING FACTORY WOMEN LABOURERS





Normal serum is richest in LDH1 and LDH2 with less of LDH3 and least of LDH4 and LDH5 which sometimes may even not be detected. A lesion of a particular organ results in a specific serum isozyme pattern more closely resembling that of an organ concerned. Changes may be seen even when total lactate dehydrogenase activity is still within normal limits.

In the present study, an attempt was made to estimate the total LDH level in serum and to assess LDH isozyme patterns particularly LDH3 levels which is the primary LDH isozyme of the lungs.

The mean serum lactate dehydrogenase levels and its isozymes patterns are illustrated in Table 26.

TABLE - 26

MEAN SERUM LACTATE DEHYDROGENASE LEVELS IN GINNING FACTORY WOMEN LABOURERS

Groups	Lactate dehydrogenase IU/L	Lactate dehydrogenase isozymes (%)		
		LDH1	LDH2	LDH3
Ginning factory women labourers (n=13)	367 ± 59	41 ± 1.7	44± 1.1	14 ± 1.5
Control women (n=10)	373 ± 23	41 ± 0.9	44 ± 1	14 ± 1.8
t value	0.27	1.03	0.54	0.50

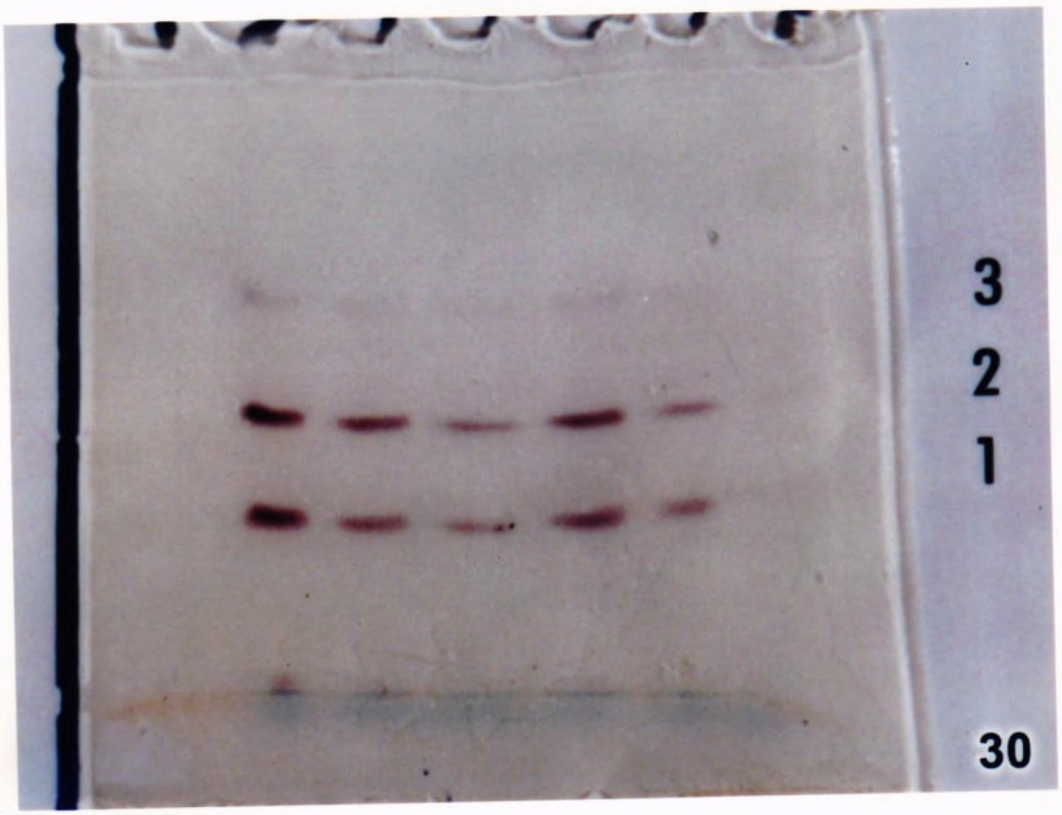
There was no significant change in total LDH level and in LDH1, LDH2 and LDH3 levels in serum among the ginning factory women labourers compared to those of the control women.

PLATE 30 PAGE ISOZYME PATTERNS OF SERUM LACTATE DEHYDROGENASE IN FIVE SELECTED GINNING FACTORY WOMEN LABOURERS

1 - LACTATE DEHYDROGENASE 1

2 - LACTATE DEHYDROGENASE 2

3 - LACTATE DEHYDROGENASE 3


3
2
1
30

Individual data indicated that the increase in LDH1 and decrease in LDH3 were prominant in the case of byssinotics compared to other group. A significant alteration in LDH1 and LDH3 isozymes in byssinotics was also observed by Karnik et al. (1987). Though a significant variation of the LDH3 isoenzyme is expected in byssinotics, because of primary lesion in lungs and respiratory pathways, compared to the control group, the sample size of 13 experimental group participants in the present study taken for the assessment of LDH isoenzymes might be one of the reasons for the non significant variation recorded in the study.

Lactate dehydrogenase isozyme patterns of five selected ginning factory women labourers is shown in plate 30.

Figure 16 shows the electropherogram of lactate dehydrogenase isozymes in a ginning factory woman labourer.

4.4.2.4 Blood histamine

Cotton dust extract induces the release of histamine from samples of human lung tissue invitro. Therefore it is believed that histamine release is responsible for the major symptoms of byssinosis, viz, "chest tightness". (Parikh *et.al*,1987). The nature of the respiratory symptoms and results of experimental studies suggest that local non allergic histamine release by cotton dust may be involved in the aetiology of byssinosis (Douglas *et al.*, 1984). Antihistamines are reported to allay development of the symptoms of byssinosis in experimental studies. Increased quantities of metabolites of histamine are excreted following exposure to textile dusts (Rastogi and Husain, 1992). Therefore an attempt was made to assess the blood histamine levels on Mondays after 2 hours working shift in ginning factory women labourers to demonstrate the acute constrictor effects of textile dusts through release of histamine invivo.

Figure -16

PAGE ISOZYME PATTERNS OF SERUM LACTATE DEHYDROGENASE IN A GINNING FACTORY WOMAN LABOURER

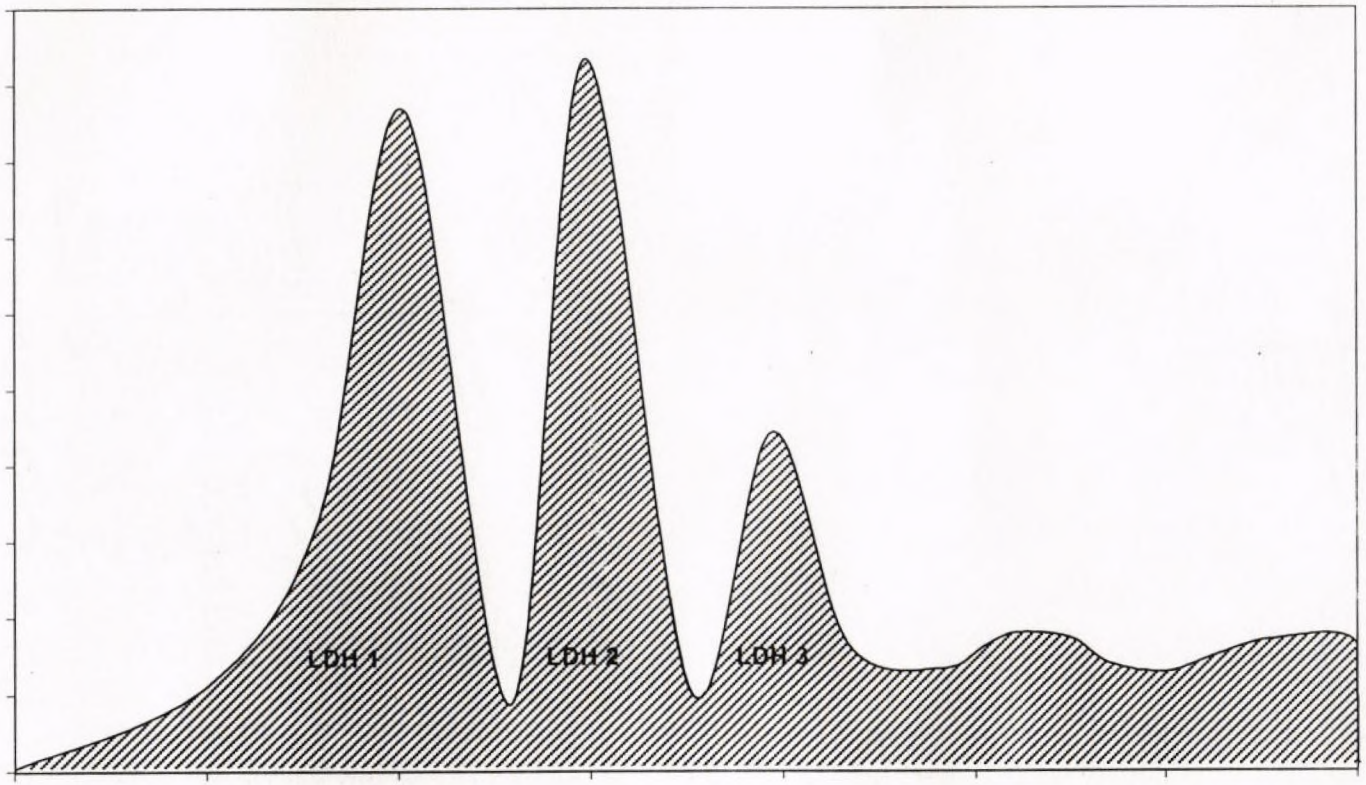


Table 27 portrays the mean blood histamine levels in ginning factory women labourers.

TABLE - 27

MEAN BLOOD HISTAMINE LEVELS IN GINNING FACTORY WOMEN LABOURERS

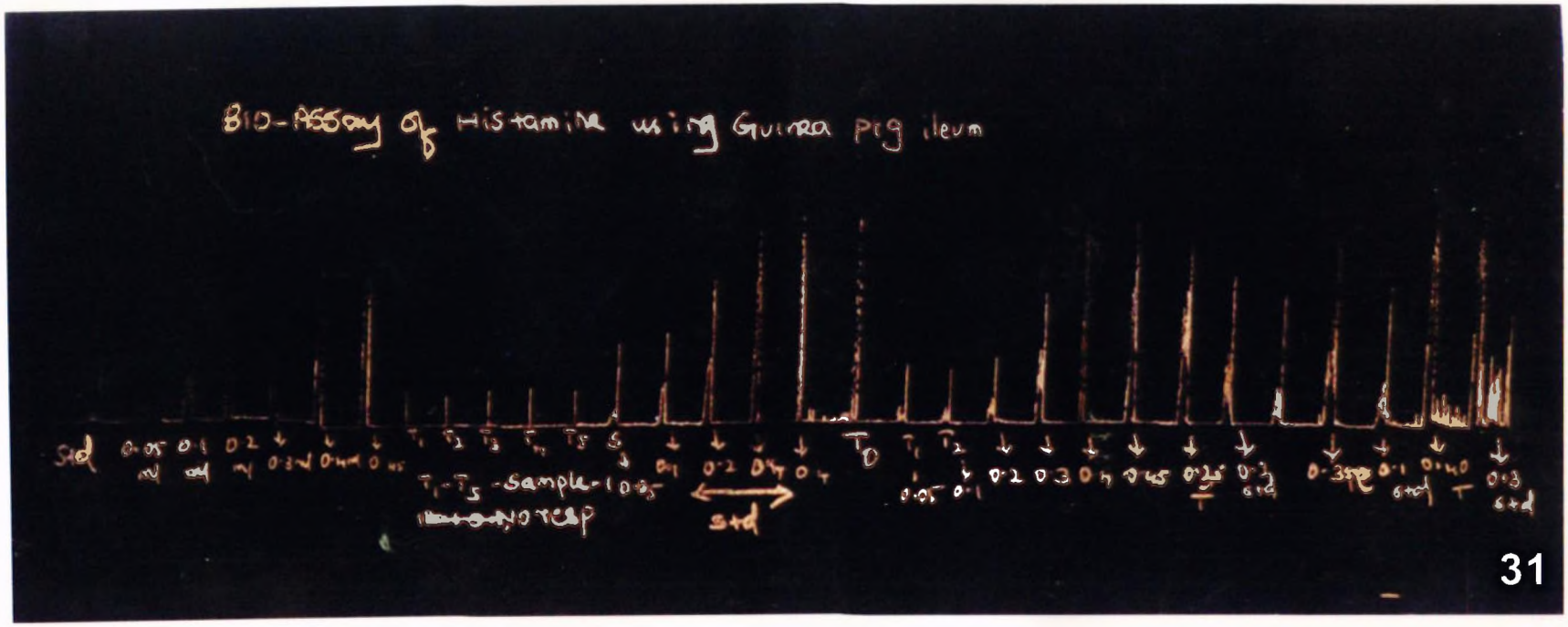
Groups	Blood Histamine (μg/ml)
Ginning factory women labourers (n=13)	9.42 ± 5.8
Control women (n=10)	0.11 ± 0.11
t value	5.01**

** - Significantly different at 1 per cent level

The mean blood histamine in ginning factory women labourers (9.42 ± 5.8μg/ml) was significantly increased at 1 per cent level compared to that of the control women. Bhatt *et al.* (1989) have also reported significantly high histamine levels (6.02 ± 4.79μg/ml) in cotton dust exposed textile workers at Ahmedabad. Likewise Patel *et al.* (1986) have also observed significantly increased histamine levels in cotton mill workers (byssinotics 10.24 ± 2.15μg/ml and non byssinotics – 1.44 ± 1.39 μg/ml). Similar results were observed in the present study also where byssinotics showed increased histamine levels compared to those with other clinical symptoms. Increased histamine level on the first working day was in agreement with Monday morning syndrome. One Grade 1 byssinotic worker showed the highest blood histamine level (23 μg/ml).

The hymograph pattern obtained in histamine estimation by bioassay method using guinea pig ileum is portrayed in plate 31.

PLATE 31 HYMOGRAPH PATTERN OBTAINED IN THE ESTIMATION OF HISTAMINE BY BIOASSAY METHOD USING GUINEA PIG ILEUM


BIO-Assay of Histamine using Guinea Pig ileum
Std
T_1-T_5 -sample-
Std
T_0
Std
Std
Std

Nowier *et al.* (1984) also reported higher blood histamine levels in cotton dust exposed workers.

This increased level of blood histamine in ginning factory women labourers might be due to the histamine-liberating factor of cotton extracts namely endotoxins or gram negative bacteria (Antweiler, 1961). It may also be due to the release of leucocytes mainly basophils, which contain histamine granules and respond to agents that cause release of histamine (Ainsworth *et al.*, 1977). This was also supported by the work of Ellisade *et al.* (1980) and Panchal *et al.* (1988) who suggested that mast cell degranulation with its release of histamine had been strongly implicated in the acute symptoms in cotton textile workers.

4.5 CORRELATION ANALYSIS BETWEEN PULMONARY FUNCTION PARAMETERS AND SELECTED BIOCHEMICAL PARAMETERS IN GINNING FACTORY WOMEN LABOURERS

Diagnostic laboratories assess the functions of the organs and various systems during ailments through a battery of biochemical parameters supported by physiological function tests and other biomedical assessments. Correlation analysis among these different parameters might help the physicians to get a clear picture of the pathological conditions for proper diagnosis. Therefore correlation analysis was carried out between pulmonary function parameters namely percentage predicted values of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) with selected biochemical parameters hemoglobin, erythrocyte sedimentation rate (ESR), total count (TC), differential count of leucocytes (DC), immunoglobulins, serum proteins, serum lactate dehydrogenase (LDH) and blood histamine levels in the experimental group of participants.

The values of FVC, FEV_1 and PEF were found to be significantly negatively correlated with ESR ($P<0.05$). PEF was significantly negatively correlated with total protein ($P<0.05$) and total count of leucocytes ($P<0.05$). The reason for this correlation pattern between the pulmonary function parameters and the biochemical parameters could not be ascertained. No significant correlation was observed between/within pulmonary function parameters and other biochemical parameters.

Correlation between the selected biochemical parameters assessed in the study is shown inTable 28.

TABLE – 28

PAIRS OF BIOCHEMICAL PARAMETERS SHOWING SIGNIFICANT CORRELATION

Variables	Correlation	Correlation Coefficient
Ig G / Histamine	Positive	0.6995*
Ig G / β Globulin	Positive	0.5748*
Ig M / α1 Globulin	Negative	-0.6181*
Ig M / α2 Gloublin	Positive	0.5748*
Albumin / β Globulin	Negative	-0.9081**
Albumin / γ Globulin	Negative	-0.5739*
LDH1 / LDH3	Negative	-0.8120**

* Significant at 5 per cent level

** Significant at 1 per cent level

In the present study, histamine was found be highly correlated with Ig G levels as also observed by Kamat *et al.* (1981) in byssinotic cotton textile workers. The results of the present study were also in accordance with the work of Karnik *et al.* (1987) who observed significant increase in LDH3 associated with decrease in LDH1 (negative correlation), significant decrease in albumin with decrease in β and γ globulin (negative correlation) in byssinotic cotton textile workers.

4.6 ANALYSIS OF COTTON DUST

Cotton dust is a complex, which contains a respirable portion and a non-respirable portion including fibrous material. Impurities are associated with parts of the cotton plant. Among the impurities, bacteria and fungi are believed to affect the respiratory system (Neefus *et al.*, 1977). Continuous cotton dust exposure leads to increased airway reactivity which leads to fixed airways obstruction (Bouhuys *et al.*, 1977). The gram negative bacteria (GNB) which contaminate the cotton dust, contain a compound known as endotoxin in their outer cell wall. This is a lipopolysaccharide, which is present between the protein molecules of the cell wall (Rylander, 1985). These endotoxins cause a series of biological effects like inflammation and attenuation of immune system. Lung is a target organ for endotoxin-induced damage. Olenchock *et al.* (1989) observed that controlled exposure of humans to endotoxin laden cotton dusts have led to decrease in pulmonary function. Gokani *et al.* (1993) have also mentioned that the inhalation of bacterial endotoxins may be one of the responsible factors for the induction of bronchoconstriction in byssinotics.

4.6.1 Cotton dust, Endotoxin and airborne Gram Negative Bacteria in different sections of the ginning factory

The cotton dust levels (total and respirable) and endotoxin levels present in respirable cotton dust were estimated in different sections of ginning factory namely gin house(S1),gutter(S2) and sorting section(S3) and in the control area(C). Airborne gram negative bacterial contents were also estimated qualitatively by petriplate exposure method. The results are portrayed in Table 29 and figure 17.

TABLE - 29

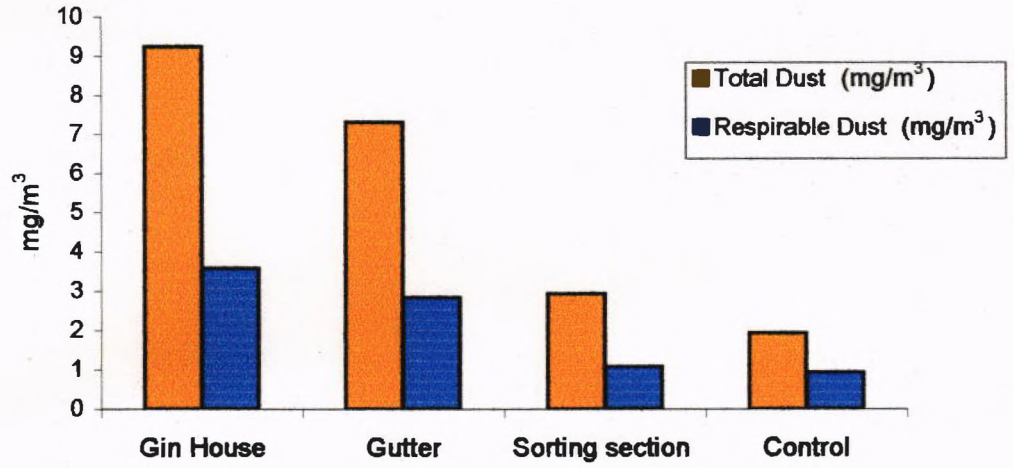
TOTAL DUST, RESPIRABLE DUST, ENDOTOXIN AND AIRBORNE GRAM NEGATIVE BACTERIA IN DIFFERENT SECTIONS OF THE GINNING FACTORY AND IN THE CONTROL AREA

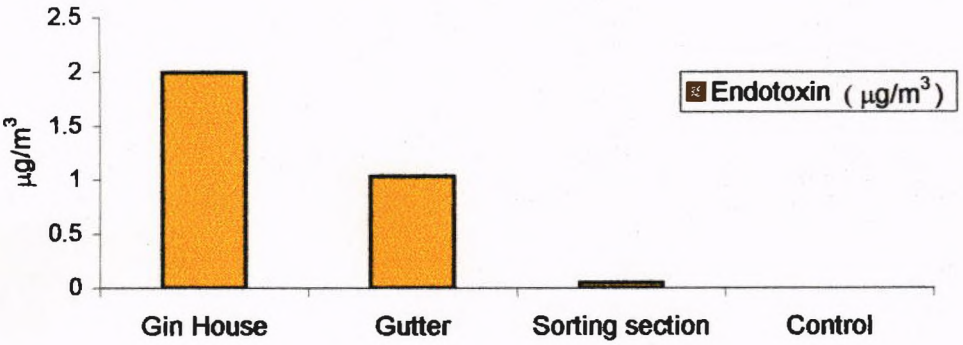
Section		Total dust (mg/m^3)	Respirable dust(mg/m^3)	Endotoxin ($\mu g/m^3$)	Airborne gram negative bacteria (No: of organisms per minute)
Gin house	S1	9.25	3.575	1.99	156
Gutter	S2	7.31	2.831	1.03	137
Sorting section	S3	2.94	1.084	0.05	89
Control Area	C	1.93	0.930	0.001	23

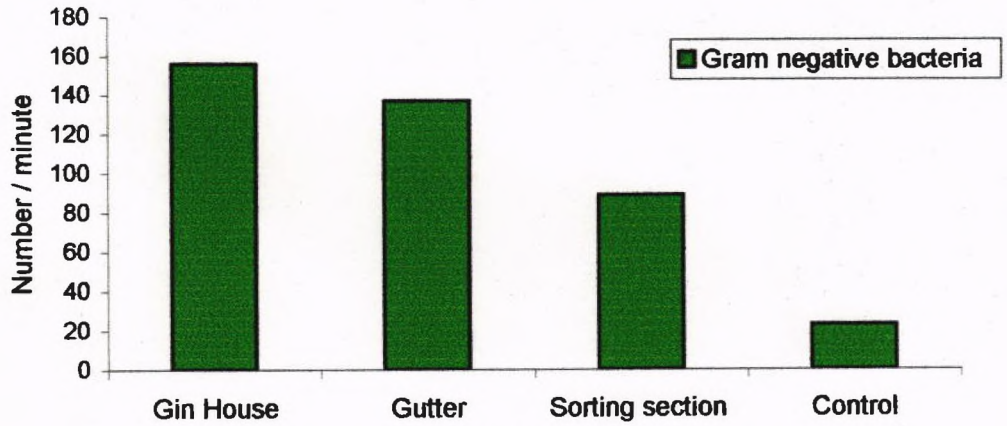
Table 29 shows that the total and respirable dust levels in the different sectionsof ginning factory the - gin house(S1)-(9.25 mg/m^3 and 3.575 mg/m^3), gutter (S2)-(7.31 mg/m^3 and 2.831 mg/m^3) and sorting section(S3) – (2.94 mg/m^3 and 1.084 mg/m^3) were high compared to the control area (C)-(1.93 mg/ m^3 and 0.930 mg/ m^3). The vertical elutriator is now adays widely used for cotton dust sampling but was not available to the investigator. Hence the respiratory dust monitor (High volume sampler) used by Bhagia *et al.*(1992) in ginning mills at Ahmedabad was used for cotton dust sampling.

Figure- 17

TOTAL DUST, RESPIRABLE DUST , ENDOTOXIN AND AIRBORNE GRAM NEGATIVE BACTERIA IN DIFFERENT SECTIONS OF THE GINNING FACTORY







In 1972, British Occupational Hygiene Society (BOHS) sub-committee on cotton dust reported that prevalence of Grade II symptoms of byssinosis was less than 4% when cotton dust concentration was less than 0.5 mg/m^3. This level was accepted as a threshold limit value (TLV) for cotton dust exposure.

Our results showed that the respirable dust levels obtained from all the sections of ginning factory were comparatively higher compared to the TLV, Similar high values of cotton dust was also reported by Bhagia *et al.* (1992). i.e $7.87 \pm 3.06 mg/m^3$ in gin house, $6.96 \pm 2.5 mg/m^3$ in gutter and $7.05 \pm 3.33 mg/m^3$ in pressing. Parikh *et al.* (1993b) have also reported much higher cotton dust levels in ginning mills using roller type gins. The mean cotton dust levels in two roller gins varied from 8.99 mg/m^3 to 119.36 mg/m^3. But Griffin and Columbus (1982) have observed respiratory dust at a lower level of 0.282 mg/m^3 in gin house, 0.354 mg/m^3 in gutter and 0.289 mg/m^3 in pressing in a ginning factory at Mississippi delta. The presence of higher levels of cotton dust in Indian ginning factories might be due to the use of less sophisticated methods in ginning, use of roller gins which produce more dust than saw gins, lack of adequate ventilation to remove dust, less effective methods for cleaning dust, less awareness about the hazards of cotton dust, use of non-pretreated cotton where impurities are not removed and use of low count cotton varieties, a low quality cotton producing more dust.

From Table 29, it is also evident that the endotoxin levels in cotton dusts in different sections of ginning factory (1.99 $\mu g/ m^3$ in gin house, 1.03 $\mu g /m^3$ in gutter and 0.05 $\mu g/m^3$ in sorting section) were comparatively higher compared to those in control area (0.001 $\mu g/m^3$). Cinkotai *et al.*(1987) measured the endotoxin concentration from card room of seven textile mills and found them to be in the range of 0.2 to 6 $\mu g/ m^3$. The results of the present study were also similar to the findings of Rylander and Morey (1982) who reported that the concentration of

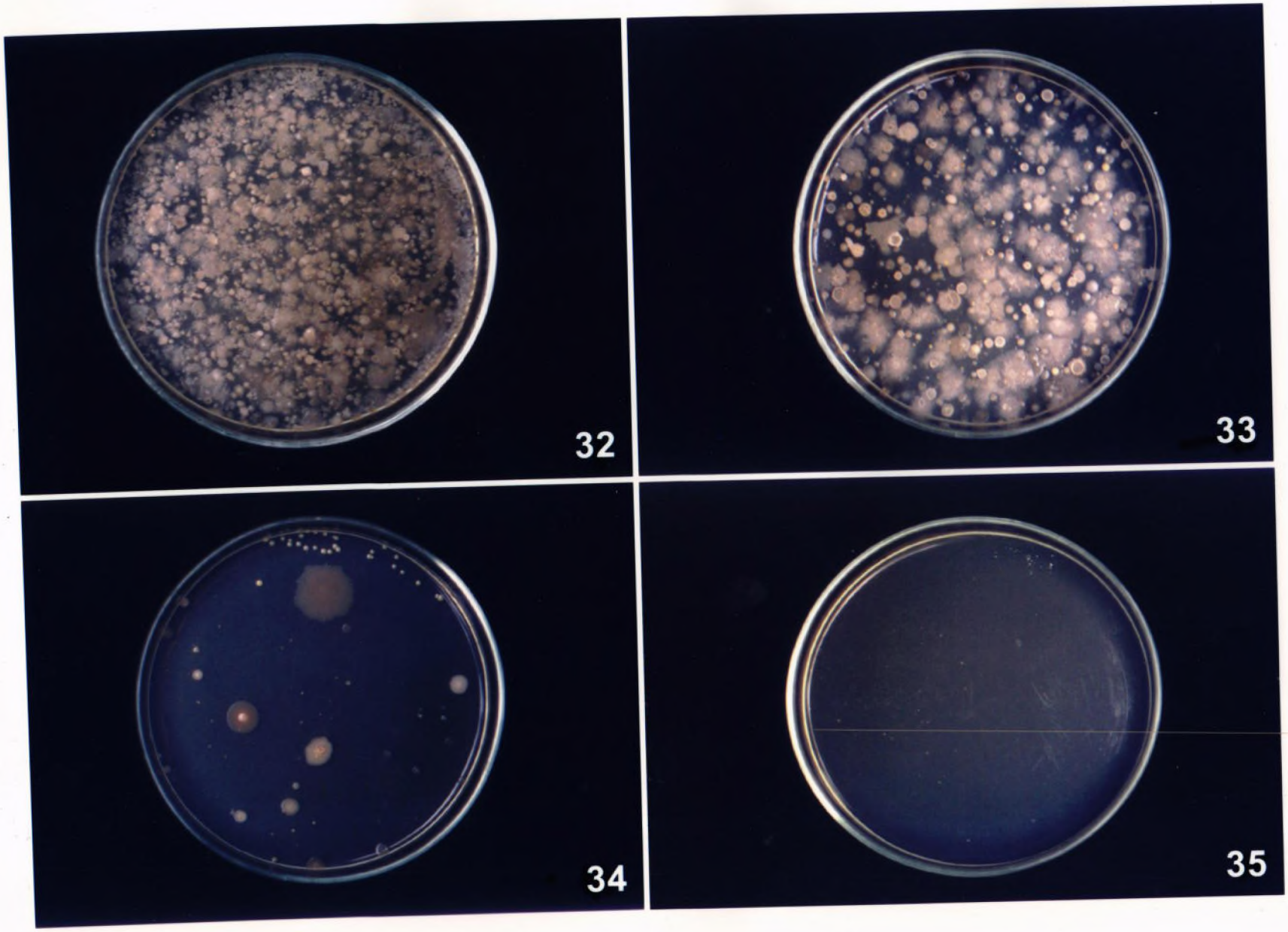
endotoxin in textile mills were in the range of 0.02 to 2.2μg/m^3. Gokani *et al.* (1988) estimated the concentration of endotoxins in textile mills of Ahmedabad and found it be 1.78 ± 0.42 μg/m^3 in card room and 0.19 ± 0.09 μg/m^3 in blow room. They have also reported (1993) that Indian raw baled cotton fibres had significantly higher concentration of endotoxins. Similar high content of endotoxin was also observed by Ghosh *et al.* (1998) in ginning factory at Ahmedabad (gin house 2.77 μg/m^3, press – 1.52 μg/m^3 and office 0.97 μg/m^3). The results of the present study were in agreement with the findings of Gokani *et al.* (1993).

Qualitative estimation of airborne gram negative bacteria (GNB) in different sections of ginning factory showed that the levels were (gin house-156/minute, gutter – 137/minute and sorting section – 89/minute) high compared to those in the control area (23/minute).

The GNB enumerated in the present study were higher when compared with the findings of Bhagia *et al.* (1996) who reported 59 gram negative bacteria/minute in gin house and 29/minute in press department of a ginning factory at Samlaya, Gujarat. The levels recorded in the present study were also higher when compared to the findings of Ghosh *et al.* (1998) who have reported 70 microorganisms/minute in gin house, 80 in press and 11 in the office of a ginning factory located at Ahmedabad. Coimbatore district is relatively rich in moisture and humid than Gujarat. This humid atmosphere and increased storage condition of cotton bales should have influenced the growth of gram negative bacteria and its endotoxin in the cotton processed in Coimbatore district. In a similar analysis, Gokani *et al.* (1988) had observed high prevalence of gram negative bacteria (66.6%) in Coimbatore cotton fibers when compared to Gujarat cotton fibers.

Plate 32 to 35 show the petriplates with gram negative bacteria in gin house, gutter and sorting sections of the ginning factory and in the control area.

PLATE 32	AIRBORNE GRAM NEGATIVE BACTERIA IN THE GIN HOUSE SECTION OF GINNING FACTORY
PLATE 33	AIRBORNE GRAM NEGATIVE BACTERIA IN THE GUTTER SECTION OF GINNING FACTORY
PLATE 34	AIRBORNE GRAM NEGATIVE BACTERIA IN THE SORTING SECTION OF GINNING FACTORY
PLATE 35	AIRBORNE GRAM NEGATIVE BACTERIA IN THE CONTROL AREA


32
33
34
35

4.6.2 Microscopic examination of the cotton dust

A sample of respirable cotton dust was placed in a microscopic slide and the structure, texture and size of the fibre were found out.

The microscopic view of cotton dust is shown in plate 36.

The cotton dust when viewed through the microscope appeared fibrous in nature and the size of cotton fibre was approximately 10-100 μ. The aerodynamic diameter cut off for dust entering the trachea and bronchi is 15 μ (Neefus *et al.*, 1977). Particles of size approximately 5 – 200 μ find some way to enter the nasal system and evoke many respiratory disorders like pneumoconiosis, byssinosis, asthma, wheezing, bronchitis and emphysema (Stern,1977). In the present investigation, cotton fibres of size 10-100 μ might have entered the nasal system in ginning factory women labourers and evoked the lung obstructive diseases.

4.7 AN OVERVIEW OF INDIVIDUAL CASES OF THE STUDY WITH VARIED TYPES OF RESPIRATORY AILMENTS

The profile of three individual ginning factory women labourers with three types of respiratory ailments namely byssinosis, chronic bronchitis and occupational asthma as revealed by the findings of the study are presented in Table 30.

PLATE 36 MICROSCOPIC VIEW OF COTTON DUST


36

TABLE - 30

AN OVERVIEW OF INDIVIDUAL CASES OF THE STUDY WITH VARIED TYPES OF RESPIRATORY AILMENTS

Profile	Case 1 (Byssinosis)	Case 2 (Chronic bronchitis)	Case 3 (Occupational astma)
Age (years)	57	55	54
Height (cm)	153	144	145
Weight (kg)	43	55	34
Years of experience	20	25	25
Occupation	ginning factory worker(gutter)	ginning factory worker(gutter)	ginning factory worker(gin house)
Family monthly income (Rs.)	1000 – 1500	500 – 1000	500 – 1000
Menopausal status	Yes	Yes	Yes
Exposure to passive smoking	Yes	Yes	No
Fuel used for cooking	Kerosene	Firewood	Kerosene
Pattern of Intake of meals	Non Veg.	Veg.	Veg.
Clinical conditions	Cough, Shortness of breath especially on Mondays and Tuesdays after Sunday holiday. The chest tightness was persistent for three hours after the starting of the work in the shift. This symptom was observed for the past two years. She reported to have headache and short sight, had been previously hospitalised for hysterectomy. No family history of asthma and diabetes	Productive cough with shortness of breath for the past ten years, also had frequent episodes of bronchial infection. Had body aches and running nose often. Had not been hospitalised before except for family planning operation 20 years before. No family history of asthma or diabetes.	Wheezing and cough continuously throughout the week irrespective of the day for the past five years. The wheezing became worsened when exposed to cotton dust. Had been once hospitalised for the severe wheezing and treated with bronchodilator. Her father had asthma.

Profile	Case 1	Case 2	Case 3
Pulmonary function parameters			
Spirometry			
a) Forced vital capacity (FVC)			
Pre shift			
Observed (litres)	2.96	1.95	2.83
% predicted	57	68.1	57
Post Bronchodilator			
% predicted	77.5	74.4	81.5
% change	+20.5	+6.3	+24.5
Post shift			
% predicted	46.1	70.1	36.1
Post shift difference	-10.9	-9.3	-20.9
b) Forced expiratory volume in one second (FEV_1)			
Pre shift			
Observed (litres/second)	1.59	1.11	1.49
% predicted	39	38.9	39

Profile	Case 1	Case 2	Case 3
Post Bronchodilator			
% predicted	72	45.1	63.2
% change	+33	+6.2	+24.2
Post shift			
% predicted	25.5	35	21.5
Post shift difference	-13.5	-10.1	-17.5
c) Peak expiratory flow (PEF)			
Pre shift			
Observed (litres)	3.13	2.43	3.27
% predicted	66	44	66
Post Bronchodilator			
% predicted	82	48.6	84.6
% change	+16	+4.6	+18.2
Post shift			
% predicted	57	41.5	51.2
Post shift difference	-9	-7.1	-14.8
d) FEV1/FVC %			
Pre shift			
Observed (%)	49.9	56.9	53.87
% predicted	57	57	57

Profile	Case 1	Case 2	Case 3
Post Bronchodilator			
% predicted	76.1	59.2	77.5
% change	+19.1	+2.2	+20.5
Post shift			
% predicted	39.2	50	44.37
Post shift difference	-10.7	-9.2	-9.5
Flow volume Curve	Flow rates falling rapidly after peak flow with low flow rates in later part of the curve. The pattern is typical lower airways obstruction. There was considerable reversibility after treatment with bronchodilator (Figure 6)	Characteristic indentation of severe lower airways obstruction. There was only a small degree of reversibility of FEV_1 and FVC after treatment with bronchodilator (Figure 7)	The flow rises to peak and rapidly falls. Remainder of the expiration was made at low flow rates. Inspiratory flow rates were much higher. There was a considerable reversibility with bronchodialator (Figure 8)
Chest X-Ray	No other abnormality except mild sputum retention and lung obstruction (Plate 22)	Normal and mild obstruction (Plate 23)	Mild obstructive pattern (Plate 24)

Profile	Case 1	Case 2	Case 3
Biochemical profile			
Hemoglobin (g/dl)	6.0	12.1	9.4
Erythrocyte sedimentation rate (mm/hour)	26	26	25
Blood pressure (mm/Hg)	110/70	130/80	110/80
Total count of Leucocytes (x 10^6/L)	9800	10200	9200
Differential count (%)			
Neutrophil	55	62	50
Lymphocyte	43	30	30
Eosinophil	02	06	20
Monocytes	-	02	-
Total protein (g/dl)	8.00	7.42	7.40
Albumin/ Globulin	1.18	1.81	1.51
Albumin %	62.73	72.77	61.46
Globulin %			
α1	3.6	1.76	3.56
α2	8.98	7.18	8.91
β	13.39	8.22	8.67
γ	11.27	10.04	17.37

Profile	Case 1	Case 2	Case 3
Immunoglobulins (Ig)			
Ig A (mg/dl)	390	236	231.6
Ig M (mg/dl)	132	109.9	83
Ig G (mg/dl)	2380	843	1570
Ig E (IU/ml)	354.8	337.90	2185
Histamine (μg/ml)	20	3.75	10
Serum Lactate dehydrogenase (IU/L)	313.9	371.1	313.9
LDH1 (%)	44.13	38.63	44.13
LDH2 (%)	43.93	44.95	42.03
LDH3 (%)	11.96	16.42	13.28

Case 1

The above case showed low hemoglobin and ESR compared to normal levels. Total count, differential count, albumin, globulins were found to be normal. Ig G and histamine were found to be very higher. LDH and it isozyme levels were found to be normal. All the percentage predicted values of pulmonary function indices namely FVC, FEV_1, PEF and FEV_1/FVC% were remarkably below the normal 80% and suggested chronic obstruction which was found to be reversible after bronchodilator administration. The PFT after shift also revealed considerable difference indicating acute bronchoconstriction due to cotton dust. Chest X ray also revealed no specific abnormalities. Therefore the above finding relating to clinical condition namely chest tightness, blood profile of increased Ig G,PFT abnormalities (chronic and acute change) and chest X-Ray suggested that the woman may be suffering from cotton induced reversible obstructive lung disorder namely Grade 1 byssinosis.

Case 2

The above case showed normal levels of hemoglobin, ESR, total count, differential count, albumin, globulins and LDH. This suggested chronic obstruction when relating to the episode of productive cough, bronchial infection together with slight increase in histamine levels and Ig E levels along with characteristic irreversible decrease in % predicted values of pulmonary function indices namely FVC, FEV_1, PEF and FEV_1/FVC %.

Case 3

The above woman showed normal levels of hemoglobin, ESR, total count, albumin, globulins and LDH. The level of eosinophil count and Ig E were extremely high. They also reported high level of histamine. Correlating these

with symptoms of wheezing, allergy chest tightness along with the PFT abnormalities (decrease in % predicted values of FVC, FEV_1, PEFand FEV_1/FVC%) suggested obstruction which was found to be reversible after bronchodilator administration. The above woman may be suggested to have occupational asthma.

Summary and Conclusion

5.0 SUMMARY AND CONCLUSION

Occupational lung diseases among the industrial workers are very common due to inhalation of various types of dusts. Dust is an important air pollutant released during textile industry operations. Cotton dust is shown to evoke many respiratory disorders like bronchial asthma, chronic bronchitis, allergy and byssinosis. The first mechanical process following cotton harvesting in textile industry is ginning. Gin workers have much higher exposure to cotton dust than textile workers. The present study has been focussed on the assessment of the pulmonary function and biochemical profile in ginning factory women labourers at Tirupur. Women employees were selected from a ginning factory, which processes low count cotton using roller type gins.

A survey was conducted in government, private and Employees State Insurance (ESI) hospitals of Avinashi, Palladam, Tirupur and Coimbatore in Coimbatore district to assess the prevalence of respiratory morbidities among textile workers.

Assessment of the pulmonary function in the selected ginning factory women labourers included analysis of spirometric parameters namely forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), peak expiratory flow (PEF), vital capacity (VC), forced expiratory volume in one second percentage (FEV_1%) and chest X-ray. The chronic pulmonary function changes in the ginning factory women labourers were assessed by expressing the observed values of FVC, FEV_1 and PEF as a percentage of predicted value. These pulmonary function parameters namely FVC, FEV_1 and PEF were performed before and after shift to reveal the acute changes. Regression and correlation analysis were carried out to establish any possible relationship of

pulmonary function tests (PFT) with age and duration of exposure to cotton dust among the workers.

Diagnostic laboratories assess the functions of the organs and various systems during ailments through a battery of biochemical parameters supported by physiological function tests and other biomedical assessments.Correlation analysis among these different parameters might help the physicians to get a clear picture of the pathological conditions for proper diagnosis.Therefore correlation analysis was also carried out within and between pulmonary function parameters and biochemical parameters. Chi square analysis was done to identify the effect of passive smoking and type of fuel used for cooking on their pulmonary functions. The working area sectionwise changes in PFT were also analysed by Chi square method in workers employed in the different sections of the ginning factory.

Selected biochemical analyses were carried out in these women labourers which included hemoglobin, erythrocyte sedimentation rate (ESR), total and differential count of leucocytes (TC, DC), immunoglobulins, serum proteins, lactate dehydrogenase (LDH) and histamine. Age and sex matched women participants served as controls who were selected and analysed for the same parameters for comparison.

Three individual ginning factory women labourers with the three types of respiratory ailments namely byssinosis, chronic bronchitis and occupational asthma were chosen for the case study and an overview of their pulmonary and biochemical parameters were compared and assessed with clinical symptoms.

Cotton dust particles, the causative agent for respiratory disorders in the different sections of target area were analysed for their size, total dust, respirable

dust and endotoxin. Air borne gram negative bacteria, another source of contamination of cotton in the ginning area, responsible for respiratory disorders were also estimated in the different sections of the ginning factory.

The survey results have shown that the prevalence of respiratory abnormalities like byssinosis, chronic bronchitis, asthma, dry cough and common cold among the textile workers was more in Tirupur when compared to other areas in Coimbatore district.

Pulmonary function tests carried out in the individuals revealed that the percentage predicted values of FVC, FEV_1, PEF AND FEV_1% were significantly reduced in the women labourers than in control women suggesting chronic lung obstruction. The reduction in FEV_1 and PEF indicated the lower airways obstruction. This obstruction in airways were observed in 33.7% of the total population taken for the study. Using salbutamol, a bronchodilator, it was observed that the obstruction was reversible in 85.7% of the ginning factory women labourers who showed obstruction.

Significant acute changes in pulmonary function after shift were also observed in ginning factory women labourers which might be due to the release of histamine in the women labourers by cotton dust or endotoxin which caused narrowing of bronchioles by muscle contraction. These chronic and acute changes were more prevalent among women labourers exhibiting byssinotic symptoms than the other workers with other symptomatic respiratory ailments.

Correlation and Regression analysis revealed that neither age nor duration of exposure independently had an influence on percentage predicted values of FVC, FEV_1, and PEF among the ginning factory women labourers. But, both age and duration of exposure to cotton dust together had a significant

influence on the percentage predicted values of FVC, FEV_1 and PEF among these women.

Chi square analysis indicated that the abnormalities in the pulmonary function were siginificant in ginning factory women labourers employed in all the three sections of the ginning factory. These results indicated the increased cotton dust pollution in the entire premises of the ginning factory.

Results of Chi square analysis also revealed that use of different fuels for cooking and exposure to passive smoking had no influence on pulmonary function parameters namely FVC, FEV_1 and PEF in the women labourers. This indicated that the cotton dust in the work area is the sole causative agent for the abnormalities in the pulmonary function among the ginning factory women labourers.

Chest X ray of seventy women labourers exhibited normal pattern; thirty four showed mild variations.

Hemoglobin was significantly decreased in the women labourers compared to the control women suggesting prevalence of anemia in them. Low dietary intake of protein and iron and menopausal state along with resspiratory ailments might be the reason for this. Also the decreased hemoglobin status might reflect the reduced oxygen diffusion capacity of the lungs in conditions of respiratory disorders.

There was also significant increase in ESR in the women labourers than in the control women indicating chronic infections like asthma, chronic bronchitis and byssinosis in the experimental group of women. Low hemoglobin would have accounted for rouleaux formation of erythrocytes leading to increased ESR.

A significant increase in the values of total count was also observed in the women labourers suggesting chronic infections. The levels of neutrophils and eosinophils were also found to be significantly increased in these women labourers when compared to control women. The increase in neutrophils might reflect the activation by endotoxin present in cotton dust which should have released mediators for inflammation and bronchoconstriction. The increase in eosinophils in the experimental group suggested allergic processes like asthma and eosinophilia.

There was also a significant reduction in the circulating lymphocyte count in the women labourers than in the control women for which the reason could not be ascertained.

The ginning factory women labourers also exhibited a significant increase in the levels of immunoglobulins (IgA, IgM and IgG). The elevated IgG antibody probably serves as a markers of exposure to cotton dust. Since IgA is the predominant antibody in nasal secretions, its level might be increased in mucus secretions by the stimulatory effect of gram negative bacteria and its endotoxin present in cotton dust to which the women labourers are exposed. Early responses to antigens like cotton dust, gram negative bacteria and endotoxin should have induced the increased formation of IgM antibody in the women labourers. Byssinotics showed high level of IgG when compared to other symptomatic workers.

The blood histamine levels of the ginning factory women labourers were found to be significantly higher than in the control women. This increased level of blood histamine in these women labourers might be due to histamine liberating factor in the cotton dust namely the endotoxin and gram negative bacteria. It might also be due to the release of leucocytes mainly basophils, which release histamine in response to agents like endotoxin and gram negative bacteria.

There was a negative correlation between the pulmonary function parameters and ESR. There was significant positive correlation between IgG and histamine, IgG and β globulin, IgM and α2 globulin. Significant negative correlation was observed between IgM and α1 globulin, albumin and β globulin, albumin and γ globulin and between LDH1 and LDH3

The total and respirable dust in the different sections of the ginning factory, were comparatively higher than in the control area and the prescribed threshold limit value (TLV). The endotoxin content in cotton dust was also found to be higher in the different sections of the ginning factory than in the control area. There was also increased gram negative sbacterial content in the ginning atmosphere.

The cotton dust when viewed through the microscope appeared fibrous with a size of 10 – 100 μ. This should have entered the respiratory pathway which can allow particles below 15 μ in diameter.

To conclude, the present study showed that the presence of pulmonary function abnormalities together with respiratory symptoms were high in the selected ginning factory women labourers. Significant changes were noticed in the levels of the biochemical parameters hemoglobin, ESR, total count, neutrophil, eosinophil, IgA, IgG, IgM and histamine. High levels of dust, endotoxin and gram negative bacterial content were also noted in the target area in the present study. Although the ginning work is seasonal, both acute and chronic lung diseases were visualized in the present study indicating both short term and long term effect of cotton dust in ginning workers as confirmed by changes in selected biochemical parameters and pulmonary function tests.

The following recommendations could be suggested for controlling the occupational lung diseases caused by cotton dust in the ginning factory women labourers;

1. TREATMENT

- Workers with Grades G1 and G2 byssinosis should be removed from areas of dust exposure
- The therapeutic use of antihistamines, salbutamol, beclomethasone and sodium cromoglycate can be used for treatment to some extent
- The women labourers should be made aware of the hazards of cotton dust
- These women should be advised to take more calorie, iron and protein rich diet to avoid anemic conditions

2. PREVENTION

Dust Control

- The most effective preventive measure is the replacement of synthetic by natural fibres
- The removal of dust in the gin house is inefficient due to unsatisfactory design, application and maintenance of machinery. So local exhaust ventilation is a must in the ginning environment
- General ventilation is also necessary and recirculated air can be efficiently filtered
- Dust from machines, gin floors, ventilation equipment and other surfaces can be removed by vacuum cleaners
- These women employed particularly in gin house and gutter section may be recommended to wear efficient air filters/respirators

- ❖ Periodical cotton dust sampling is necessary to evaluate the air pollution in ginning factories
- ❖ High tech new machineries can replace old ones that may discharge less amount of dust
- ❖ Better quality cotton (high count) which discharge less fly content can be generally used in all the textile manufacturing units
- ❖ Introduction of saw type gins instead of roller type gins generally will reduce the dust to some extent
- ❖ Spraying of ripening cotton with bactericides and fungicides can reduce the bacterial and endotoxin content of the cotton balls before it has been brought for ginning
- ❖ Treatment of raw cotton with gaseous hydrogen chloride or acetic acid can be employed, as it has been found that the above chemicals inactivate the active component in cotton bracts and dust
- ❖ Cotton steaming reduces its biological activity due to bacteria and endotoxin. Therefore preprocessing of cotton with steaming may be employed before ginning
- ❖ Evaluation of workplace conditions every six months and environmental monitoring with regards to dust standards is advisable

Medical surveillance of workers

(i) Pre-employment examination

- ❖ All the women labourers in the ginning factory should be examined before employment Examinations should include a questionnaire similar to that used in the present study with additional details of atopic family history, personal history of allergy and asthma, physical examination, pulmonary function tests and a chest radiograph. Atopic subjects may be probably excluded from employment

- ❖ Women labourers with chronic or recurrent diseases should be placed in low or no risk areas
- ❖ Individuals with FEV, less than 60 percent of the predicted normal value should not be exposed to dust

(ii) Periodical medical examinations

- ❖ Periodical medical examinations serve two purposes to identify workers who develop pronounced reaction to the dust and to provide a biological assessment of the efficiency of dust control and sampling

- ❖ During the first month of their employment, the FEV_1 values of the ginning factory women labourers should be recorded before and after 6 hours of commencing the shift on the first day of a working week. If a significant decrease occurs they should be transferred to a less dusty area

- ❖ Systematic clinical examination and recording of FEV_1, FVC and PEF should be done annually in all exposed workers. Those who are prone to develop substantial disability can be identified by comparing the annual fall of their FEV_1 with the predicted normal value. They should be moved to no-risk area as soon as this is recognized

- ❖ All the above medical facilities should be freely given to the employees by the proprietors or local volunteer medical bodies

- ❖ Above all, the Government should take legal action on the units which continuously showed high dust fall rate and which did not follow the above amenities

LIMITATIONS OF THE PRESENT STUDY

- Since the ginning process is only seasonal, the present study could not be extended to examine the PFT in ginning workers in different seasons to assess if there is any seasonal variations in the pulmonary functions

- Owing to the poor co-operation of the management and employees, assessment of blood parameters before and after shift, lung lavage test and lung biopsy could be not carried out

- Multiple sampling of cotton dust and endotoxin was not conducted owing to the limited availability of sampling machines. Vertical elutriator was not available to the investigator

- The study could not be extended to other ginning factories because of non cooperation of the proprietors

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Appendices

APPENDIX I

QUESTIONNAIRE ADMINISTERED TO THE GINNING FACTORY WOMEN LABOURERS

1. NAME :
2. FATHER'S/ HUSBAND'S NAME :
3. AGE (YEARS) :
4. ADDRESS :

5. FAMILY INCOME :
   - below Rs. 500 ☐
   - Rs.500 - Rs.1000 ☐
   - Rs.1000-Rs.2000 ☐
   - Rs.2000 and above ☐

6. WORK EXPERIENCE (YEARS) :
7. ANTHROPOMETRIC MEASUREMENTS
   - HEIGHT(cm) :
   - WEIGHT (Kg) :

8. MENOPAUSAL STATUS
   - PREMENOPAUSAL STATE : ☐
   - MENOPAUSAL STATE : ☐

9. CLINICAL CONDITIONS :
   - i) WHEEZING IN CHEST : YES/NO
   - ii) COUGH : WHITE/YELLOW/GREEN/DRY/ BLOOD IN SPUTUM
   - iii) DURATION OF COUGH :
   - iv) FREQUENCY OF ATTACKS : SEASONAL/IRRELEVANT/CONTINUOUS
   - v) SEASONAL VARIATION : YES/NO
   - vi) RELATED TO EXPOSURE TO: DUST /SMOKE/FUME/ALLERGENS
   - vii) ANY ASSOCIATED RHINITIS : SNEEZING/ RUNNING NOSE

viii) CHEST TIGHTNESS : ON EVERY 1st DAY AFTER HOLIDAY ONLY/ PERSISTANT FOR 1st & 2nd DAY AFTER HOLIDAY / PERSISTANT THROUGHOUT THE WEEK

10. GENERAL ENQUIRY :

i) PREVIOUS HISTORY OF HOSPITALIZATION : WHEN
: WHERE
: FOR WHAT

ii) DIABETES : YES/NO

iii) HEART DISEASE : YES/NO

iv) TUBERCULOSIS : YES/NO

v) PREVIOUS FAMILY HISTORY :

11. DIETARY HABITS

i) NO. OF MEAL/DAY : THRICE/TWICE/ONCE

ii) PATTERN OF INTAKE OF MEALS : VEGETARIAN/NON VEGETARIAN

12. PASSIVE SMOKING : YES/NO

13. FUEL USED FOR COOKING : LPG/KEROSENE/FIRESTICKS / COWDUNG

APPENDIX II

DETERMINATION OF BLOOD PRESSURE USING SPHYGMOMANOMETER (Oser, 1976)

Principle

When pressure is given to the blood vessel by the cuff of the sphygmomanometer, the vessel is pressed and blood flow is obliterated. When pressure is slowly released, blood just begins to flow through the narrowed blood vessel and the pattern of flow is changed from streamline flow (silent) to turbulent flow (noisy). When the pressure is further released, normal streamline flow sets in and the sound is no longer heard. Therefore, as pressure is released, the flowing variation of sound is heard.

First phase-sudden appearance of a clear tapping sound. This indicates systolic pressure. It persists while the pressure falls through 15 mm Hg. Second phase - tape sound is replaced by a murmur persisting for 15 mm Hg. Third phase-murmur is replaced by a clear loud sound lasting for next 20 mm Hg. Fourth phase- the sound becomes muffled and begins to fade rapidly. Fifth phase - absence of all sound.

Procedure

The sphygmomanometer was kept at the level of the heart and the cuff was tied around the upper arm. The pressure was raised to 200 mmHg by pumping the hand pump. A stethoscope was placed with its chest piece on the brachial artery, a little below the cuff. The pressure in cuff was slowly released and when the tapping sound was fast heard, the corresponding pressure in mm of Hg was recorded as systolic pressure. The pressure was released further and the pressure at which the sound disappeared was recorded as diastolic pressure.

APPENDIX III

ESTIMATION OF IMMUNOGLOBULINS A, M AND G BY RADIAL IMMUNO DIFFUSION (RID)

(Fahey and McKelvey, 1965; Mancini *et al.*, 1965)

Principle

Single radial immunodiffusion tests have evolved from the work of Fahey and McKelvey(1965) and Mancini *et al.*(1965). They are specific for the various proteins in serum or other fluids and depend on the various proteins with the specific antibody. When the wells in antibody containing gels are completely filled with the antigen, the precipitin rings develop after 10-20 hours at room temperature and are measured.

The diameter of the ring and the logarithm (base 10) of the protein concentration are related in a linear fashion. Using appropriate reference standards, the concentration of unknown samples are measured. Radial immuno diffusion is based on the diffusion of antigen from a circular well radially into a homogenous gel containing specific antiserum for each particular antigen. A circle forms on precipitated antigen and antibody and continues to grow until equilibrium is reached. The diameter of the rings are a function of antigen concentration. After overnight incubation, the zone diameters of reference sera are plotted against the logarithm (base 10) of the antigen concentration. If equilibrium is reached, the reference sera zone diameters are squared and plotted against their concentration. A linear relationship does not occur at intervals in between.

Specimen preparation and handling

1. Collected whole blood without anticoagulant and allowed to clot at room temperature.
2. Separated serum by centrifugation at about 2000 g within 2-3 hours after collection

Procedure

Materials provided: 24(3x8) well radial immunodiffusion plate

Performance of test

1. Removed plates from refrigerator to room temperature approximately 30 minutes before filling wells. (Do not open bag until ready for use).
2. Delivered serum specimen to well by placing 5 µl pipette tip at the top of the agar surface. Avoided bubbles to ensure proper volume and diffusion of sample.
3. Marked the time of completion on plate cover and replaced cover.
4. Replaced plate in bag and resealed carefully.
5. Incubated plates upright on a flat surface at room temperature (20-24°C) for 16-20 hours for overnight readings and over 48 hours for end point readings.
6. Measured diameters of precipitin zones to within 0.1 mm.

Calibration

1. Using the reference sera provided in kits, determined their ring diameter to the nearest 0.1 mm.
2. Using 2 or 3 cycle semi-logarithmic graph paper, plotted the concentration on the Y axis and zone diameters on the X axis for each protein for overnight readings.
3. Using regular graph paper, plotted the concentration on the Y axis and the zone diameter squared on X axis for each protein for end point readings.
4. Drew a straight line of "best fit" between three points.

Results

Determined the concentration of each unknown specimen protein by reading its zone diameters on the reference curve and the corresponding concentration from the Y axis.

APPENDIX IV

ESTIMATION OF IMMUNOGLOBULIN E BY ENZYME- LINKED IMMUNO SORBENT ASSAY [ELISA]

(Kjellmann *et al.*,1976 ; Dati, F and Ringel, K.P.,1982)

Principle

Immunoglobulin (Ig) E assays are indicated for the diagnosis and monitoring of allergies. Elevated IgE levels are observed in hay fever, asthma, allergic bronchitis and atopic dermatitis, ELISA is used for the assay of IgE. The antibodies are absorbed to a solid support called polystyrene microtiter plate. The support after coating with Ab is washed. The serum containing Ag (IgE) is added and it gets bound to the adsorbed Abs. Then an enzyme linked Ab called conjugate (Horse serum peroxidase + anti IgE Ab) is added which also binds to the Ag. The chromogenic substrate (ABTS-H_2O_2) for the enzyme is added and the colour is proportional to the bound enzyme and the amount of Ag.

Procedure

Pipetted into tubes (Semi micro curvette-1cm light path)	Standard	Control Serum	Sample
	0.1 ml	0.1 ml	0.1 ml

Added incubating solution 1 vigourously as soon as possible after pipetting standard, control serum and sample.

Solution I	1.0 ml	1.0 ml	1.0 ml

Incubated for 60±5 minutes, then aspirated the tube contents. Discarded and rinsed the tubes once by filling to the rim with washing solution within 30 minutes. Completely aspirated the tube contents within a further 5 – 30 minutes.

Commenced the next pipetting within next 30 minutes at the latest.

Solution II	1.0 ml	1.0 ml	1.0 ml

Incubated for 60 ± 5 minutes and then aspirated contents. Discarded and rinsed the tubes once by filling to the rim with washing solution within 30 minutes;completely aspirated the solution within a further 5-30 minutes.

Commenced the next step of pipetting immediately

Substrate Chromogen solution	1.0 ml	1.0 ml	1.0 ml

Incubated for 60 ± 5 minutes, (Do not shake). Avoided direct sunlight.

Mixed prior to measurement. Transferred tube contents to cuvette and read absorbance at 420 nm using spectrophotometer. Constructed a calibration curve for the assay.

APPENDIX V

ESTIMATION OF TOTAL PROTEIN, ALBUMIN ,GLOBULIN AND A/G RATIO IN BLOOD (BIURET METHOD)

(Samuel ,1992)

Principle

The biuret method depends on the presence of peptide bonds in all proteins. These peptide bonds react with Cu^{2+} ions in alkaline solutions to form a coloured product whose absorbance is measured spectrophotometrically at 540 nm. The intensity is proportional to the number of peptide bonds in protein.

Reagents

1. Biuret Reagent

   Dissolved 9.0 g Sodium potassium tartarate in 500 ml of 0.2 N Sodium hydroxide. Added 3 g of Copper sulphate and dissolved by stirring, then added 5.0 g of Potassium iodide and made the volume to 1.0 litre with 0.2 N Sodium hydroxide.

2. Sodium sulphite solution 28%

   Dissolved 140 g of anhydrous Sodium sulphite in distilled water at 40°C and made up the volume to 500 ml. Kept the solution in the water bath at 37°C to prevent crystallization.

3. Ether
4. Sodium chloride - 0.9%
5. Calcium chloride - 25%
6. Protein standard: Diluted 2 ml of Bovine albumin protein standard solution to 25 ml with distilled water. Measured accurately 1.0 ml protein into tubes and stored at 20°C. (The nitrogen content of the standard solution is marked by the manufacturer and it is in the range 9-11 mg/ml).

Procedure

Test for total protein: Mixed 0.2 ml of plasma with 2.8 ml of distilled water. The concentration is 1/15 of original sample.

Albumin: In a 10 ml centrifuge tube took 5.5 ml of 28% Sodium sulphite solution. Added 0.5 ml of plasma, mixed by inversion. Added 1.0 ml of ether, stoppered the tube and inverted it gently for 20 times. Removed the stopper and centrifuged for 10 minutes. Withdrew 3 ml of supernatant layer. The concentration of albumin was 1/12 of that of original serum.

Standard: 3 ml of standard protein solution

Blank : 3 ml of distilled water.

Added 5.0 ml of Biuret reagent to each tube, mixed thoroughly and let stand at room temperature for 30 minutes or in water bath at 37°C for 10 minutes. After cooling, the colour developed was read in a colorimeter using green filter.

$$\text{Plasma total protein (g/100ml)} = \frac{\text{Test} - \text{Blank}}{\text{Standard} - \text{Blank}} \times 0.5 \times 15$$

$$\text{Plasma Albumin (g/100ml)} = \frac{\text{Test} - \text{Blank}}{\text{Standard} - \text{Blank}} \times 0.5 \times 12$$

Globulin = Total Protein - Albumin

APPENDIX VI

SEPARATION OF SERUM PROTEINS BY AGAR GEL ELECTROPHORESIS (Gowenlock *et al.*, 1996)

Principle

Electrophoresis is the movement of small charged particles, through an electrolyte subjected to an electric field. The different charged ions move in opposite directions, the positively charged ions migrating to the cathode and the negatively charged ions move towards anode. The rate of migration depends on the number of charges it carries. When serum is subjected to electrophoresis on agar gel media, the complex mixture of plasma proteins can be separated into a number of fractions. The mobility and sharpness of separation depends upon the extent to which each fraction is homogenous in its mobility.

The albumin moves rapidly towards the cathode. It is followed by $\alpha 1$, $\alpha 2$, β and γ globulins.

Procedure

Preparation of the gel

1.0g of agar was dissolved in 100 ml of distilled water by heating in a bacteriological steamer for half an hour, with shaking every ten minutes.

Preparation of the slide

Placed glass microscopic slide on a previously levelled sheet of glass plate. Using a warm fast delivery pipette, layered 2.0 ml of molten agar on each slide. Allowed to set and stored in a moist chamber at room temperature.

Electrophoresis on Agar gel

A barbitone buffer of pH 8.6, 60 mmol/L, ionic strength 0.05 Mol/L (1.84g diethyl barbituric acid and 10.3 g Sodium diethyl barbiturate/litre) was used.

A slot of 5 mm depth was cut across the middle of agar laid slide and inserted 2 to 3ml of serum into this from a fine capillary pasteur pipette. Inverted the slide and laid across wicks of Whatman 3mm paper in horizontal type of electrophoresis tank. Using a constant current of 7mA per slide, the electrophoresis was run for 60 minutes until the bromophenol blue marker showed that the albumin band has moved 25 to 30 mm. Switched off the current, removed the slide and placed in cold dilute acid ethanol (ethanol, water, acetic acid, 70/25/5 v/v) for 30 minutes. Then dehydrated by immersing in acetone-water, (90/10 v/v) for 4 hours and finally dried in an incubator at 37°C.

Staining The Gel

For staining, amido schwarz 10 B has been exclusively used. Dissolved 5.0 g of amido schwarz 10 B in a litre of water containing 50 g Mercuric chloride and 50 ml glacial acetic acid. Filtered before using. Immersed the slides for 30 minutes, then washed by immersing three times in fresh portions of acetic acid (20ml/l in water) for 5 minutes. Rinsed for 10 minutes in water and dried at 37°C.

Scanning The Gel

The slide was cleared by placing in xylene and the bands were scanned by using a densitometer. The intensities of each band was found out, from which the percentage of each fraction present in serum proteins was found out.

APPENDIX VII

ESTIMATION OF LACTATE DEHYDROGENASE (Bergmeyer and Bernts ,1974)

Principle

Lactate dehydrogenase (LDH) is an enzyme, which catalyzes the reversible conversion of pyruvate to lactate. Pyruvate is reduced by incubation with serum containing LDH in the presence of coenzyme $NADH_2$. The reaction is stopped by adding dinitrophenyl hydrazine solution, which reacts with remaining pyruvate to give brown colour hydrazone at alkaline condition. This was read at 510 nm using a green filter in a colorimeter.

Reagents

1. Phosphate Buffer (pH 7.4) : 11.0 g of anhydrous Disodium hydrogen phosphate and 2.7 g of anhydrous Potassium dihydrogen phosphate per litre.
2. Stock Sodium pyruvate (37.5 mM) : Dissolved 41.5 mg of Sodium pyruvate in 10.0ml of phosphate buffer. Fresh solutions were made daily.
3. Working stock : Diluted stock pyruvate solution 1 in 50 with phosphate buffer.
4. Reduced Nicotinamide adenine dinucleotide ($NADH_2$)
   10 mg $NADH_2$ in 1.0 ml of phosphate buffer. Fresh solution for each batch of tests.
5. 2,4 Dinitrophenyl hydrazine (DNPH) (2mM)
   Dissolved 400 mg of DNPH in 85 ml of concentrated hydrochloric acid. Made upto 1.0 litre with distilled water and stored in a dark bottle.
6. 0.4 N Sodium hydroxide: Dissolved 1.6 gm of Sodium hydroxide in 50 ml of distilled water and made upto 100 ml with the same.

Procedure

Mixed 1.0 ml of buffered substrate with 0.1 ml of serum. Placed the mixture in a water bath at 25°C. After few minutes, started the reaction by adding 0.1 ml of $NADH_2$ solution. Incubated for exactly 15 minutes. Removed the tube from the water bath and immediately added 1.0 ml of 2,4 DNPH solution and mixed.

Control : 1.0 ml of substrate, 0.2 ml of buffer and 1.0 ml of DNPH.

Blank : 1.2 ml of buffer and 1.0 ml of DNPH

Allowed the tubes to stand at room temperature for 20 minutes. Then added 10.0 ml of 0.4 N Sodium hydroxide to each tube and mixed. After 10 minutes, the colour developed was read at 510 nm.

The control tube contains 0.75 μ mole of pyruvate

$$\text{The amount of pyruvate which has reacted is} = \frac{C - T}{C - B} \times 0.75\ \mu\text{ mole}$$

This is for the effect of the enzyme in 0.1 ml of serum acting for 15 minutes.

$$\text{The pyruvate reacting per minute/litre of serum (IU)} = \frac{C - T}{C - B} \times 0.75 \times \frac{1}{15} \times \frac{1000}{0.1}$$

$$\text{Serum Lactate dehydrogenase (IU/ L)} = \frac{C - T}{C - B} \times 500$$

APPENDIX VIII

SEPARATION OF THE ISOZYMES OF LACTATE DEHYDROGENASE IN SERUM (Dietz and Lubrano, 1967)

Principle

The different isozymes of LDH have different net charges and therefore can be separated into fractions in an electric field. The supporting medium used is polyacrylamide gel. When the mixture of isozymes are subjected to an appropriate electric current, they move with velocities that vary based on the molecular weight as well as their charges and separate out into fractions.

Reagents

1. Buffered TEMED: 24.0 ml of 1N HCl, 18.1 g of Tris (Tris hydroxy methyl aminomethane) and 0.12 ml of N N N' N' tetra ethyl methyl ethylene diamine (TEMED) were dissolved in distilled water and made upto 100 ml. The solution was filtered and kept in brown bottle at 4°C.
2. Acrylamide solution: 28.0 g of acrylamide and 0.735 of methylene bis acrylamide were dissolved in 100 ml of water and filtered. The solution was kept at 4°C in a brown bottle.
3. Ammonium persulphate: 140 mg of ammonium persulphate was dissolved in 100 ml of distilled water and stored at 4°C.
4. Electrophoretic buffer (pH 8.2 - 8.4): 6 g of Tris and 28.8 g of glycine were dissolved in water, made upto 1000 ml and stored at 4°C.
5. Tracking solution: 5 mg of bromophenol blue was dissolved in 100 ml of distilled water.
6. 40% Sucrose solution

Staining solution

Lithium lactate (1 M)	1.0 ml
Nicotinamide adenine dinucleotide (10 mg/ml)	1.0 ml
Sodium chloride (0.1M)	1.0 ml

Magnesium chloride (0.1M)	1.0 ml
Phosphate buffer (0.5M) (pH 7.4)	2.5 ml
Nitroblue tetrazolium (1 mg/ml) (NBT)	2.5 ml
Phenazine methosulphate (PMS) (1 mg/ml)	0.25 ml

All the above solutions were mixed in the given proportion and kept in the dark, as it is light sensitive. The staining solution should be prepared just before use.

Procedure

Reagents 1,2 and 3 were brought to room temperature before preparation of the gel. To obtain 7% gel, 1.0 ml of reagent 1, 1.0 ml of reagent 2, 3.9 ml of diluted water and 2.0 ml of reagent 3 were mixed. Care was taken to avoid entrapment of air bubbles. Glass tubes of 63 mm length and 5 mm diameter were carefully inserted into the rubber grommets. The mixed solution was carefully added to a height of 4 mm by means of a fine capillary tube. After the solution was gelled, which normally takes about 20-30 minutes, the water was decanted. Fresh serum sample was suitably diluted with 40% sucrose solution. 0.01 ml of the diluted sample was layered by means of a micropipette over the gel. The tubes were then fitted to the upper tank of the electrophoretic apparatus. The lower ends of the gel tubes were dipped in the buffer present in the lower tank to establish current conductivity. A few ml of bromophenol blue solution was added to the upper tank buffer solution and filled up the air gaps of gel tubes with this solution.

The upper and lower tanks were filled up with the buffer of pH 8.4. The upper tank was fixed to the apparatus. Then the power was switched on. The current was regulated to 2 - 5 milliamperes per tube. The current was switched off when the marker dye migrated to the bottom of the disc. Usually it takes about 30 - 60 minutes.

The gel was then removed from the tubes by means of the needle and was transferred to petridishes containing staining solution. The stained gels were removed and washed with distilled water and stored in 7% acetic acid.

Scanning of the gel

The intensity of the stained isozymes were scanned in a densitometer.

APPENDIX IX
BIOASSAY OF HISTAMINE
(Parikh *et al.*, 1987)

Priniciple

The isolated ileum of guinea pig is the most sensitive and accurate test object for the assay of histamine. A piece of terminal ileum is put up in an isolated bath in Tyrode solution containing 10^{-7} g/ml atropine sulphate. This eliminates contractile responses of the ileum due to cholinergic agents. Contractions of the ileum to histamine are usually completed in ½ minute or less. Hence contractions for exactly ½ minutes are regularly obtained at intervals of one to one and a half minutes. A matching assay is carried out with standards and the results are expressed in terms of micrograms per milliliter of the solution.

Procedure

Preparation of the blood sample

From the selected 13 ginning factory women labourers and 10 control participants, 10 ml of blood was collected from the antecubital vein and transferred to heparinized tubes. Processing of blood samples was carried out in two stages.

1. Extraction of histamine from blood

10 ml of blood was run into 15 ml of 10% trichloro acetic acid (TCA). After standing for one hour or more, the extract was filtered through paper and the precipitate was washed four times with 5 ml of TCA. The filtrate was dried by evaporation in a water bath. The residue was extracted three times in distilled water (2+2+2 ml) and then neutralized with bromothymol blue (0.1 gram dissolved in 3.2 ml of 0.05 N Sodium hydroxide and made upto 250 ml using distilled water) so as to obtain the same volume as that of blood.

2. Biological Assay

The second step was a biological assay on sensitized and drug - treated (with antagonists of interfering substances other than histamine) guinea pig ileum in a thermostatic, aerated (95%, oxygen, 5% carbondioxide), isolated organ bath.

Intestine of a 24 hour fasted medium sized guinea pig was removed after killing the animal by a blow on the head. The removed intestine was kept in aerated Tyrode's solution prior to use and stored at 4°C. Terminal 3 cm of ileum (after identifying the ileo caecal junction) was mounted in an organ bath. Temperature of the bath was kept constant at 37°C. The responses were taken on a fixed time schedule ie., ½ minute was allowed for response after adding histamine or test solution, ½ minute for washing and half minute for rest. Histamine value of the test solution was detected by matching the curves of the standard histamine response and the test solution response.

APPENDIX X

MEASUREMENT OF RESPIRABLE COTTON DUST USING RESPIRABLE DUST MONITOR

(Tamil Nadu Pollution Control Board,Coimbatore)
(Bhagia *et al.*, 1992)

Principle

High volume air samplers are used to pump large volumes of air upto 2000 m^3 at a rate of about 1.7 m^3/minute. The filters used usually consist of glass fibres and have a collection efficiency of more than 99% for particles with 0.8 μ diameter. Particles with diameters exceeding 100μ remain on the filter surface whereas particles with 0.1μ diameter are collected on the glass fibres in the filters. For efficient collection of particles, very small diameter fibres containing filters are used.

Instrument Calibration

The actual airflow rate of instrument was determined by means of the standard calibration kit.

Preparation of Filters

Pre- Weighing

1. The glass fibre filters were numbered on the back side for identification.
2. Weighed up to 0.01 mg accuracy.
3. Placed in clean, pyrogen free petridishes.
4. Sterilized by autoclaving at 15 pounds pressure (121°C) for 15 minutes
5. Dessicated for minimum of 12 hours.
6. Again weighed and recorded the difference ie the amount of moisture.
7. The above process was repeated until the filter showed no moisture.

Sampling Procedure

1. Filters were installed in samples with numbered side towards the screen support.

2. Pump motor was started and recorded the starting time

3. At the end of the sampling, the stopping time was recorded

4. Filters were removed carefully from samples and folded for identification.

Weighing Procedure

1. The collected samples were dessicated for minimum of 12 hours.
2. Again filters were weighed upto an accuracy of 0.01 mg
3. Weight of the filters with dust was recorded
4. Filters were kept aseptically for endotoxin measurement.

Calculation Of Volume Of Air Sampled (Air Quantity)

1. The length of the sampling time in minutes was determined from starting to stopping time
2. The sampling time in minutes was multiplied by flow rate (litres/minute) of the instrument, and divided by 1000. This gave the air quantity in cubic meters.

Calculation Of Dust Concentration

$$\text{Respirable dust concentration } (mg/m^3) = \frac{\text{Final weight of the filter paper} - \text{Initial weight of the filter paper}}{\text{Air Quantity}}$$

APPENDIX XI

ESTIMATION OF ENDOTOXIN FROM RESPIRABLE DUST SAMPLES (Rylander and Morey, 1982)

Principle

Endotoxin estimation was carried out from respirable dust. The Limulus Amoebocyte Assay(Rylander and Morey, 1982) was adopted in the present experiment. Endotoxin in low concentration causes gelation of a protein containing fluid derived from the circulating blood cells (Amebocytes) of horse shoe crab, *Limulus polyphemus.* Method of estimation of endotoxin was based on this phenomenon and was capable of detecting $5x10^{-4}$ μg of endotoxin per millilitre of whole blood.

All the reagents used for estimation of endotoxin were obtained from sigma chemicals, USA.

A. Preparation of endotoxin free equipments and glasswares

Since extremely minute quantities of endotoxin could cause *E. toxate* (Sigma) to gel, all the equipment, glasswares, screwcaps, linears, stoppers etc that came in contact with *E. toxate* were made free of endotoxin by the following methods:

1. All the required glasswares were dipped in dichromic acid solution overnight to avoid false results. As far as possible, all the glass wares, equipment and materials used were taken new
2. The overnight soaked glasswares were washed with warm running tap water and all the glasswares and equipment were then dipped in 1% solution of *E.toxaclean* (Sigma) again overnight
3. All the glasswares and equipment were rinsed ten times with warm running tap water, followed by five times with triple distilled water and finally once with pyrogen free water

4. All the glasswares and equipment were dried in oven at 100°C . Pipettes were placed in stainless steel pipette cans with tips downwards. Other glasswares were covered with aluminium foil and kept in appropriate containers
5. Covered materials were autoclaved at 121°C for one and a half hour followed by heating in hot air oven at 175°C for 3 hours

B. Preparation of working solution of *E. toxate* (dry concentrate)

Working solution of *E.toxate* was prepared after removing the aluminium seal and stopper from vial of *E. toxate.* 2.5 ml of endotoxin free water was added and swirled to dissolve and restoppered again. This was kept in deep freeze for 10 minutes and then centrifuged at 1000-2000 g for 15 minutes. The supernatant fluid was carefully pipetted into pyrogen free screw cap test tube.

If the working solution was found contaminated by showing turbidity or gel, it was immediately discarded. Only clear solution was taken for the test and experiments were carried out on the same day only.

C. Endotoxin Standard

Endotoxin reference (LPS (L-3255) of *Shigella flexners)* of Sigma was taken as endotoxin standard.

For standardization, the tests were carried out at different pH, temperature, incubation time and with varied concentration of standard endotoxin.

D. Standard reaction mixture

It comprised of

1. **Test sample**: Contained equal amount of aliquots ie 0.1 ml of sample to be tested and 0.1 ml of *E. toxate* (working solution) in a 10x75 mm pyrogen free aluminium foil.

2. **Positive control**: Equal amount of aliquots ie. 0.1ml of endotoxin reference and 0.1 ml of *E. toxate* solution were pipetted into a 10x75 mm pyrogen free test tube covered with pyrogen free aluminium foil.

3. **Negative control**: 0.1 ml of E. toxate was taken into a 10x75 mm pyrogen free test tube and covered with pyrogen free aluminium foil.

All the tubes were incubated at 37°C in a water bath for optimal time

Observation of Tests

1. Positive results

The criteria for the positive results were set as mentioned below :

3+ - A solid gel formed within 1-2 hours

2+ - A weak gel or soft gel formed within 1- 2 hours.

1+ - No gel but increase in viscosity, opacity or starchy granules which adhered to the wall of the tube when tilted and returned upright, within 18 hours or less.

2. Negative results

Assay was scored negative in the absence of any of the above signs.Sometimes flocculation was observed, but it was accepted as negative results.

Observation of Control

1. Positive control tube: Gelation should occur. If a negative result was obtained, endotoxin reference solution and/or *E.toxate* was replaced.

2. Negative control tube: Gelation should not occur. If a test showed positive result, either the *E.toxate* or the glasswares had been contaminated and the tests was repeated with new reagents and/or glassware.

After standardization, estimation of endotoxin from respirable dust samples was carried out. The amount of respirable dust in various areas of the ginning factory was determined and the filter was shaken in 10 ml of endotoxin free water which was kept for ½ an hour. The pH of the extracts was checked and adjusted if necessary, with endotoxin free 0.1 N HCl or 0.1 N NaOH . Then the extracts were centrifuged at 1000-2000 g for 15 minutes and serial dilutions were prepared with endotoxin free water.

Equal aliquots (0.1ml) of *E.toxate* and dilutions of dust extract were measured in glass tubes (10x75 mm) and covered with pyrogen free aluminium foil. Incubated in a water bath at 37°C for 1 hour, observed at 5 minutes interval. The tubes were inverted for observation of result. The stable clot was compared with similar clot formation in a dilution series of known amounts of endotoxin reference (Sigma)

Taking into consideration, amounts of air drawn through the filter, the results could be expressed as μg of endotoxin /m^3 of air.

With each experiment, a positive control with endotoxin reference and negative control with *E. toxate* were run simultaneously.

APPENDIX XII

COMPOSITION OF MACCONKEY AGAR MEDIUM

(Samuel,1992)

Bacto peptone	17.0 g
Protease peptone	3.0 g
Bacto lactose	10.0 g
Bacto Bile salt No.3	1.5 g
Sodium chloride	5.0 g
Bacto Agar	13.5 g
Bacto neutral red	0.03 g
Bacto crystal violet	0.001g

MacConkey's Agar is a differential medium and it was rehydrated by suspending 50 g in 1000 ml of distilled water. Dissolved completely by heating in steamer. pH was adjusted to 7.1. Sterilized by autoclaving at 15 pounds pressure (121°C) for 15 minutes. About 15 ml of aliquots were poured aseptically into each sterile petridishes.

These plates were exposed for 1 minute in various sections of the ginning factory (gin house, gutter, sorting section) and control area and incubated at 35°C for 48 hours.