PULMONARY FUNCTIONS IN THE RESIDENTS OF A GOLD TAILING TOWN AND ITS ASSOCIATION WITH CHRONIC EXPOSURE TO MINING DUST

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DOCTOR OF PHILOSOPHY IN PHYSIOLOGY
Under

Faculty of Medicine

By

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I, **Mrs. Usha G. Shenoy**, hereby declare that this thesis titled **"Pulmonary functions in the residents of a gold tailing town and its association with chronic exposure to mining dust"** is an original research work carried out by me for the award of **Doctor of Philosophy** in the subject Physiology.

This study was carried out under the guidance of Dr Karthiyanee Kutty, Professor, Department of Physiology, Sri Devaraj Urs Medical College, a Constituent Institute of Sri Devaraj Urs Academy of Higher Education and Research.

No part of this has formed the basis for the award for any degree of fellowship previously elsewhere.

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This is to certify that the Institutional Ethics Committee has examined and unanimously approved the study entitled **"Pulmonary functions in the residents of a gold tailing town and its association with chronic exposure to mining dust"** by **Mrs. Usha G Shenoy** under the guidance of Dr.Karthiyanee Kutty & Mrs. Usha G Shenoy conducted this study for the award of Ph.D degree by Sri Devaraj Urs Academy of Higher Education and Research.

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Mrs. USHA G. SHENOY

ABSTRACT

Gold mining is recognized as a major environmental polluter and here we investigated the pollution status of the ambient air in the mine tailing area and the state of the respiratory health of the population living.

Method: Air samples proximal to mine tailing and non-mine tailing areas were collected between June-August 2017 and analyzed using gravimetric method. ATS questionnaire was used to record the demographic details, duration of stay and the respiratory symptoms. Lung function parameters of FVC, FEV1, FEV1/FVC and PEFR were determined using computerized spirometer. The SpO2 and pulse rate were recorded using pulse oximeter. All the tests were performed on 400 exposed and 400 unexposed inhabitants of both genders between 18 and 60years, and lived in their respective areas for 3 years or more.

Results: Atmospheric air RSPM in the mining town were significantly higher with 1.491 $\pm$ 0.737 mg/m3 to 0.4800 $\pm$ 0.278 mg/m3 when compared to non-mine tailing area. The lung function parameters of FEV1, FVC, and PEFR and Spo2 showed a significant decrease (P<0.01) in the exposed population when compared with the unexposed population with a significant increase in FEV1/FVC and pulse rate in exposed population. (P<0.01) The prevalence of lung dysfunction was 63% in the exposed population with the majority showing restrictive type of lung disorder. Place of stay increased the odds risk by 1.45 times of developing lung dysfunction with smoking, gender or type of fuel not confounding the effect.

Conclusion: The PM concentration recorded in the mine tailing town was above "National air quality standard permissible limit" and three times higher than that of the non -mine tailing area. The prevalence of respiratory symptoms and abnormal lung function were higher with decrease in percentage saturation of oxygen and increase in pulse rate. Staying in the mine tailing carries the greatest risk of developing lung dysfunction.

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LIST OF ABBREVIATIONS

AMS	:	Alveolar macrophages
BTPS	:	Body Temperature and Pressure Saturated with vapour
CWP	:	Coal mine workers pneumoconiosis
DGMS	:	Directorate General of Mines Safety
mg/m^3	:	Milligram/Cubic Meter
FVC	:	Forced Vital Capacity
FEV1	:	Forced Expiratory Volume in First second
HAP	:	House hold air pollution
NIMH	:	National Institute of Miners Health
KGF	:	Kolar Gold Fields
PM	:	Particulate Matter
PFT	:	Pulmonary Function Test
PEFR	:	Peak Expiratory Flow Rate

RSPM	**:**	**Respirable Suspended Particulate Matter**
RNS	**:**	**Reactive nitrogen species**
ROS	**:**	**Reactive oxidative species**
SPO2	**:**	**Oxygen saturation**
SPM	**:**	**Suspended particulate matter**
TWA	**:**	**Time Weighted Average**
TSP	**:**	**Total suspended particulate**
UFPs	**:**	**Ultra fine particles**
WHO	**:**	**World Health Organization**

INTRODUCTION

The "World Health Organization (WHO)" has designated pollution from ambient air as a significant priority for public health. This decision was derived taking into account the total deaths and life years lost from disability from "Global Burden of Disease". More than 90% of the world lived in highly polluted air. This is the cause of deaths of approximately 7 million people globally every year. India has one of highest levels for air pollution in the world: increasing the burden of disease by a further 10%. This further worsens the already challenging health status of the country where communicable diseases remain common. Industrialization, mining and automobiles exhausts are major contributors to outdoor pollution. Burning of wastes from agriculture is more and more accepted as another source of pollution. India also has, within homes, household air pollution (HAP) that arises from the variety of fuels used in cooking. While governmental initiatives have been targeted to reduce HAP, economic factors and challenges have resulted in persistent mixed fuel usage. The lower socioeconomic strata are thus exposed to both outdoor and indoor air pollution; consequently, the urban poor are the worst affected. Epidemiological surveys show increase in adverse health effects that include mortality and hospital admissions rates for heart and respiratory diseases from air pollution **(1-3)**

The health effects of air pollution from short-term exposure is relatively meager, however the impact on the general population can be can be substantial given the pervasiveness of contaminants in the environment and less public awareness. In spite of extensive research on air pollution, there does not remain considerable uncertainty as to which population subgroups are more susceptible nor are there acceptable thresholds for harmful air pollutants.

Among all the human activities, mining is found to have negative impact on the quality of environment **(4)**. Impacts of mining range from physical/habitat destruction, destruction of natural ecosystems by removal of soil, vegetation buried under waste disposals with accompanying loss of bio-diversity resources and pollution of the environment (**5**, 6**)**. Therefore, the mining sites are a permanent toxicological problem for the adjacent ecosystems and particularly harmful to human health **(7)**. Like any productive activity, the exploitation of mineral resources produces negative impacts upon the three elements in the environment: water, atmosphere and soil **(8)**. Particulate Matter (PM) is a major air pollutant identified under the "Clean air act of 1970" for protecting the health of the local population. Particulate Matter are a mixture of solid particles and liquid droplets (or just suspended solid particles) in air.

NEED FOR THE STUDY

Gold mining is one of the worst environmental pollutants. Most mining projects are usually located in remote sites and companies have had to invest in considerable physical and social infrastructure. This leads to settlement of people and growth of communities in these locations. Though there are benefits they become victims of different types of pollution as they would not be under any protective guidelines or regular health assessments.

Karnataka has the distinction of being the principal gold producing state in the country **(9)**.

Kolar Gold Fields (KGF) often called 'little England', a town in Kolar District in the state of Karnataka where gold mining started in 1884**.** Many years of mining have led to dumping of 32 million tons of mine tailings in 15 dumplings over 8 kilometers **(10)**.

Mine tailings are crushed sand-like waste material which is generated by extraction and grinding of ground ore during mining. It can be blown by wind leading to increased content of particulate matter in air.

The earliest case of silicosis was reported from KGF in 1932, however it was not considered an occupational hazard until the first survey was done in KGF between 1940 and1946 where the prevalence was 43.7% **(11)**. This lead to the Mysore Silicosis rules and paved the way for legislations for occupation dust diseases in India. Dust sample analysis of the underground mines started in 1949 and records maintained till mine closure. Occupation based studies done have linked PM concentration to respiratory symptoms with altered lung functions (**12)**. In spite of all this, the available data on the occupational respiratory morbidity or other diseases from KGF seem limited **(13)**.

At this juncture, it must be highlighted that KGF is unique in that the families of miners lived in the same mining area benefiting from the developed infrastructure but without the miners health assessment or benefits. They are exposed to all the pollutants resulting from mining more so with their stay being in close proximity of the mine tailings. There is little published literature on the effects of pollutants on communities living. The closure of mines has left a devastated, degraded environment and struggling community living in poor hygienic conditions. Non-application of stringent closure guidelines worsened the situation.

The gold mines in KGF were closed in the year 2001, in the month of January. The PM concentration recorded then was above the permissible limit which was assumed to be due to the consequence of dust from mine tailings **(14)**. So an effort was made to record the role of mine tailings on quality of air, the respirable suspended particulate matter concentration and the prevalence of respiratory affliction in the residents here after almost two decades of closure of mines. This would help in better understanding of problem, plan strategies for prevention and further deterioration of health and closure guidelines of mines.

Plate 1: Mine tailing in Kolar Gold Fields

REVIEW OF LITERATURE

2.1 MINING

Mining is the world's second oldest and most important industry after agriculture and it has a crucial role in economic development **(15)**. Today, mining exists in most countries, and prerequisite for industrial development and production. The four major mineral mining commodities that produce most revenue are coal, copper, iron ore and gold **(16)**. It .includes exploration and extraction of minerals, including crushing, grinding, concentration or washing of the extracted material.

There are two kinds of mining the surface and underground mining. If the mineral deposit is above the earth surface it is called surface mining, while when it is deep below it is called underground mining.It is the most hazardous of professions and environmental pollutant.It has positive economic benefits and negative impacts **(17)**.

2.1.1 Environmental hazards of mining

The extraction of minerals and other geological materials of economic value from deposits on the earth is mining. It has severe effects on the area around it causing destruction of biodiversity, soil erosion and contamination that possibly be toxic and affect groundwater too. The toxic waste products can consist of elevated amounts of arsenic, cobalt, nickel, mercury, lead and zinc. Dust and carbon emission generated during mining and transport of ores affect the air around it and the population around **(18)**. Mining in the forest areas cause destruction of forest cover and natural habitats with alteration in ecosystems, and in farmlands it may destroy agriculture and graze lands. In urbanized environments mining may further produce noise, dust and visual pollution.

2.1.2 Phases of mining and its impact on the environment

Mining involves various process starting with exploration of ore to post closure period. The effect on environment depends on the different stages

1. Exploration

The location is identified, quality of mineral availability surveyed and the economic viability of the mining process is studied by a detailed evaluation programme. Here there is minimal or no threat to environment.

2. Development

As this term implies, there is need to develop a plan and execute groundwork before the actual mining starts. Sites for mining need to be prepared for the actual process & development of roads for accessibility. This involves irreversible environmental destruction and release of dust and particulate matter.

3. Active Mining

a) Open-pit mining

This type of mining is employed when mineral ore is found underground often deep and below the groundwater table. Here, vegetation needs to be removed, groundwater pumped out resulting absolute environmental destruction. After closure of mines, the groundwater accumulates to form pit lakes. The area becomes uninhabitable, land and water unusable and is most environmentally destructive.

b) Placer mining

Gold and gemstones are often mined this way. High streams of water are used to separate the precious minerals from the alluvial soil that results in production of large amounts of sediments. Surface soil and water for miles down are contaminated with remnants that are toxic and become unusable.

c) Underground mining

Underground channels made to connect the different areas under the ground are further strengthened with rocks and cement. This produces less environmental destruction but entails greater expenses.

d) Reworking of inactive or abandoned mines

Attempt to acquire metals by purification process from waste stack can lead to pollution but of far less degree.

4. Disposal of Waste Rock

Metallic ores are often buried deep and needs to be excavated. This involves removal of the surface soil or rocks. These wastes are called overburden or waste rocks and mining can generate huge volumes of them during excavation. They become toxic dumps found at mining sites as surface piles, back files or underground. Hence overburden disposal becomes a key factor for prevention of environmental degradation.

5. Ore Extraction

Ore is transported on roads to areas away from mining for extraction. This involves movement by heavy machines that produce huge dust emissions resulting in air pollution.

6. Beneficiation

This step involves separation of the relatively small quantities of metal from the non-metallic material of the ore. For example, the percentage of gold extracted can be very low even in good grade mines. Beneficiation includes various methods including leaching which is specially mentioned because it involves usage of cyanide that results in serious environment and public safety impacts. The remains after extraction of ore are called tailings.

7. Tailings Disposal

This is the most important challenge in any mining process. If not disposed scientifically it becomes a nidus for environmental pollution years after closure of mines. They can be disposed as tailing ponds if they are wet wastes. Dry ones can be used as a backfill to minimise environmental pollution. Mines close to water bodies try to use sub marine methods. The impact on water pollution extending far distances and further affecting food chain can be difficult to fanthom.

8. Site Reclamation and Closure

On closure of mines it seems natural for the site to be reclaimed and left in the same condition as prior to mining. But rarely occurs and they remain barren and toxic for years. Stringent guidelines for reclamation plan during proposed mining project clearance are often diluted (**19**).

2.1.3 Gold mining and pollution

Gold is a precious metal found in small quantities and its mining involves large areas thus having huge harmful effects. This also involves complex process including use of very toxic cyanide leaching process creating a non-reversible environmental poison that affects the food chain. Gold mining changes the landscape and geological stability surrounding ecosystem like land water and air. Because large amounts of water are used, the groundwater table is disturbed and further polluted by the by products which are produced. Soil and land composition and contents change and the toxic heavy metal contents and concentration persist for years. Plants grown here also reflect these content changes that then affect the consumers – man or animals. Its effect on ambient air can be immense with poisonous fumes, and dust from byproducts of active mining. Even with closure of mines, the effects continuous which destroys villages and relocation of communities. The effects of gold mining is highly ruinous and often called “dirty’’ gold the worst among metals.

2.2 PARTICULATE MATTER

Particulate matter refers to an air suspended mixture of solid, liquid particles which vary in size, composition, and origin. It is a mixture including numerous classes and subclasses of impure and poisonous entities. The size of particles is determines their behavior in the respiratory system. It divided based on of their aerodynamic diameter as follows:

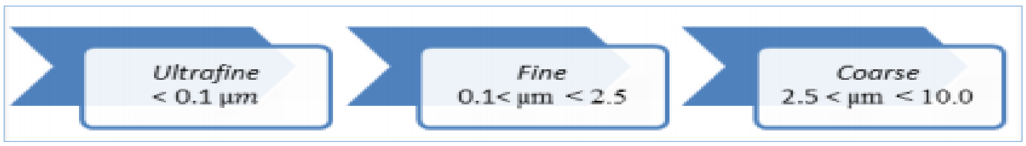

Plate 2: Classification of the particulate matter

2.2.1 Classification of particulate matter

Large particles:-are those particles with aerodynamic size above 10 μm. They are often trapped in the upper respiratory tract and do not enter the respiratory system, so they are not concerned in terms of health.

Coarse particles:-are those particles with aerodynamic diameter ranging from 2.5μm to 10 μm. They hang in the air over a long period of time, and are often naturally occurring and derived primarily from soil and other crustal materials. All particles that are inhalable come under the group of respirable suspended particulate matter RSPM.

Fine particles:- are those particles with aerodynamic diameter ranging from 0.1–2.5 μm **(20)**. They are derived chiefly from primary pollution which are caused directly by gases from combustion processes in transportation, manufacturing, power generation etc. Secondary pollution are the products formed by reactions between primary pollutants and the atmospheric components like soil dust, sea salts, pollens, spores and smoke are the sources of fine particles. The existence of PM 2.5μm affects air quality and visibility although it accounts for a quite small part of the atmosphere. When compared to coarse particle PM 10, PM 2.5 is characterized by smaller diameter, larger area, stronger activity, easier carrier of harmful substance like heavy metal and microbe, more time for suspension in the atmosphere and longer travelling distance. Therefore, PM2.5 has formidable effects on health and atmospheric quality.

Ultra-fine particles (UFPs) are particles less than 0.1 µm. They are the particles of nano scale size. UFPs can be carbon based or metallic based on their magnetic properties. They can be either naturally occurring or derived from manufacturing processes. They have relatively short time in the atmosphere because they readily accumulate or coagulate to form larger fine particles. Research shows because of their minute size they are able to penetrate the alveolar capillary membrane, cross it, circulate in blood and seen in remote organs. Hence they have several more aggressive health implications than those classes of larger particulates **(21)**.

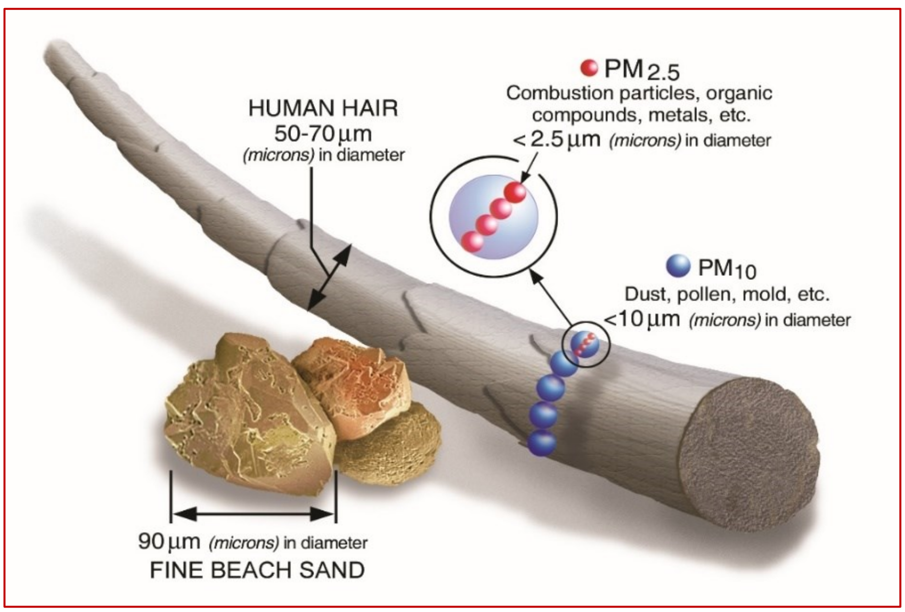

Plate 3: Particulate matter and size distribution

2.1.2 Particulate matter and health

Ambient air pollution causes forty two lakh deaths annually and increased hospital admissions, emergency room visits and premature deaths. According to "WHO" it accounts for 29% of all deaths and disease from lung cancer, 17% from acute infection of lower respiratory tract, 43% from lung obstructive disease, 25% from heart disease due to ischemia and 24% from stroke. There are many evidences indicating that diabetes and neurological development in the very young arise from air pollution **(22)**.

The occurrence of asthma and allergies are rising and there is proof to correlate them with rising levels of PM. Laboratory work has also confirmed that air pollution facilitates the access of allergens that are breathed in to the cells of the immune system and sensitization of the airway. **(23)**.

Health is affected differentially depending on content and magnitude of PM. The composition can vary with season & weather, vehicular traffic, mining and human activity. These major irritants damage respiratory tract that can result in immediate or chronic effects of lung disorder, more susceptible in the old and sick individuals. Further, the length of time, amount and type of PM people are subjected to contribute to the effect on health. Though the connection between PM concentration and pulmonary disease is well documented, its effect on the heart is now acknowledged.

2.2.3 Pathophysiology of respiratory system

The inhaled particles pass the proximal part of the respiratory tract and gets deposited in the bronchi or in the gas exchange region .Particles of size 3 μm are larger, hence less air borne and so do not follow the direction of air flow. They get impacted on the linings of the air ways- mainly the throat and larynx. Deposition of PM can also occur by gravitational pull.

This settling is directly linked to the particle size and this process is important in distal bronchial region and early gas exchange regions. Collision can occur between gas molecules and PM of micrometer size that pushes the particle in an irregular manner. This Brownian diffusion occurs with decrease particle size which is predominantly seen in the alveolar gas exchange region for PM<0.5 μm.

The PM getting into the respiratory system triggers the upper respiratory tract that is rich in sensory fibers and thus increase the cough reflex. The ciliated epithelium lines the tracheobronchial tree up to the respiratory bronchioles. The cilia stoke upwards trying to remove the impacted materials and sweep the bronchial secretions upwards to form phlegm and exacerbate cough. From the midway below the bronchioles are deficient in serous and mucous glands but increase smooth muscles that maintain the caliber of the conducting airways. Irritants can stimulate them to constrict and affect flow rates which may present as wheeze and present as asthma **(24)**.

Particles that enter the bronchi and alveoli come into contact with alveolar macrophages (AMs), the key cells that are activated in inflammation in the conducting tracts to clear bacteria or particles through phagocytosis. These activated AMs secrete a wide range of products including ROS, reactive nitrogen species (RNS), cytokines and proteases which can be dangerous to lung tissue. Cytokines and chemokines stimulate the inflammatory axis via recruitment and the inflammatory cells are activated. The ROS induced oxidative damage may be exacerbated by a decreased efficiency of antioxidant defense mechanism **(25-28)**.

The hazard of mine dump dust particles is involved by ROS formation, oxidative damage and inflammatory response that harm the respiratory system.

PM sizes below 10µm. are called RSPM are hazardous; they reach the gas alveoli exchange region or alveoli. RSPM reaching the alveoli activates macrophages which would induce phagocytosis. The contents released on phagocytosis further activate more macrophages. Depending on the load of foreign body reaching the alveoli, the cycle continues which can overwhelm the protective mechanism. The increased inflammatory products decrease clearance and affect the gas exchange mechanism and damage the alveoli. Not all particles can be degraded by the macrophages. Some remain in the alveoli, produce local damage to epithelial cells and promote fibrotic changes. The extremely minute nano sized particles can cross the intestinal lung tissue and create major changes, due to the degree of inflammation it can stimulate by increasing a larger surface to affect the pulmonary function tests**. (29**,**30)**

2.2.4 Studies on the respiratory system.

In Boston, where older men who were subjected to traffic pollution were studied for approximately fifteen years, their FEV1 and FVC fell which was beyond the normal age related decline. Black carbon- a traffic pollutant was also analyzed at regular intervals and higher concentration of PM exposure resulted in faster decline in lung function **(31)**.

In a ten year cohort among Swiss adults a 10 µg/m3 increase in PM10 produced a 3.4% decrease in FVC and 10.5 mL annual decline in FEV1 beyond the normal age-related decrease, indicating that even exposure to small increase PM levels lead to obvious lung function reduction in healthy adults **(32,33)**. Decreased PM concentration in air has improved respiratory function in both children and adults. The study on healthy children done in southern California showed improvement in FEV1 and FVC with improved air quality and decreased PM **(34)**. A study in Netherlands in children and adults showed 3% and 6% increase of FEV1 and FVC respectively **(35)**.

Children as a group are vulnerable to pollutants in air. Exposure during stages of development can affect lung growth and function. Fetal lung growth have been seem to be affected in mothers exposed to levels of PM that are considered steep. Asthmatic children between 6-11 years of mothers exposed to increase PM 10 in their first trimester of pregnancy showed decrease in PEFR **(36)**. Children of non-smoking mothers who were subjected to high PM values during pregnancy had a fall in FEV1 by an approximate of 90ml **(37)**. Castro et al. found that PEF in 118 schoolchildren in Rio de Janeiro fell by 0.34 L/min even when the increase in PM was as short as two days **(38)**. However a 3-year longitudinal study of 1150 Austrian schoolchildren, including healthy and asthmatic children did not demonstrate constant relationship between lung function and PM exposure **(39)**.

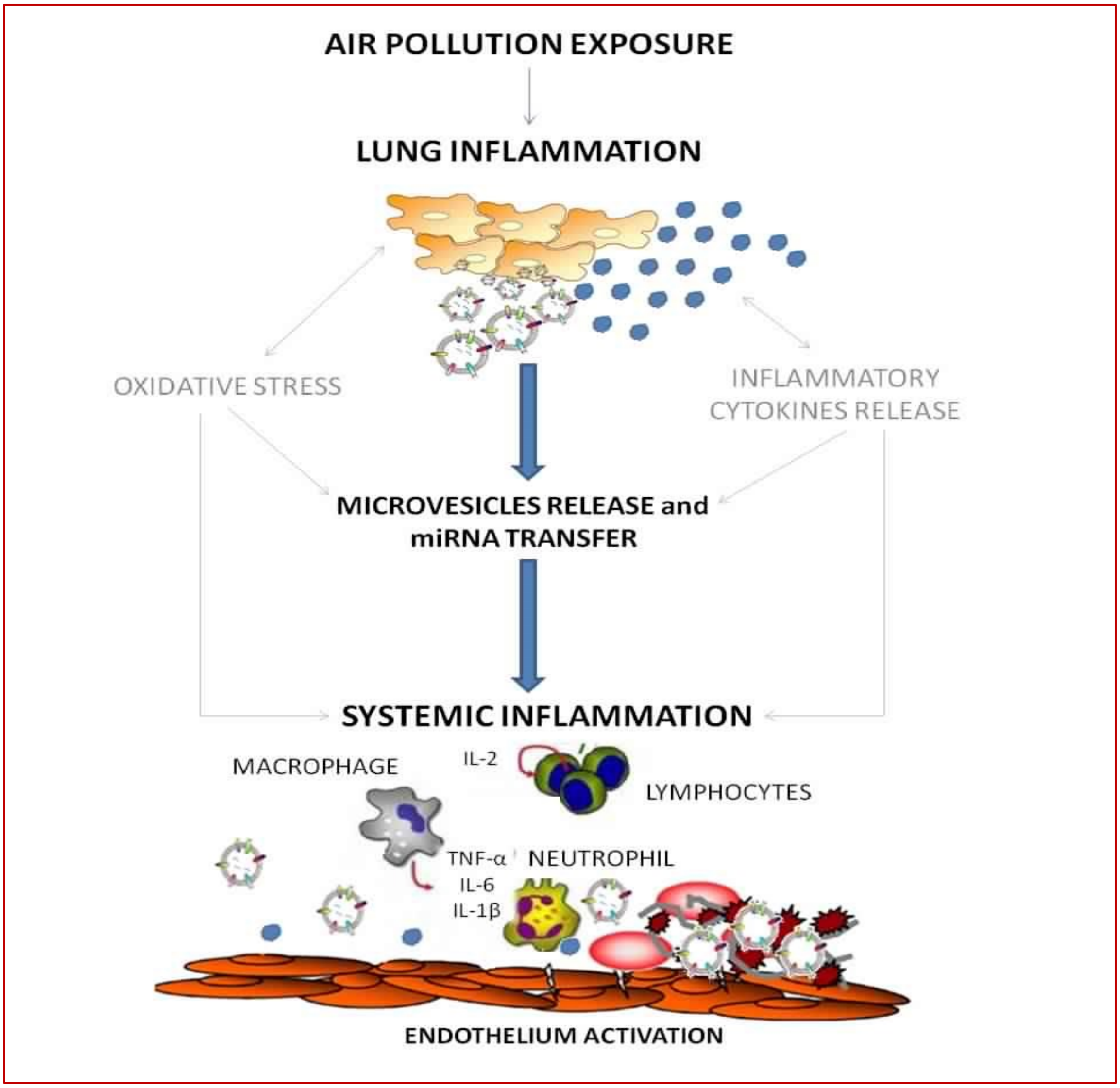

Plate 4.Mechanism of action of particulate matter on respiratory and cardiovascular system

2.2.5 Pathophysiology of cardiovascular system

Myocardial infarction, hypertension, atherosclerosis, arrhythmias and cardiac arrest are linked to rise in PM levels. The autonomic nervous system imbalance with a tilt towards the sympathetic component alters the heart rate variability. Changes in blood pressures during diastole and systole and coronary blood flow are other effects in the cardio-vascular system.

The particles that gets into the respiratory system are able to penetrate the alveoli to reach the blood stream and cause harmful effects to the cardiovascular system **(40)**.

The two pathways of action: Direct:- The inflammation from the oxygen species released locally from the endothelial cells lining the vascular system from PM deposits produces instability in the plaques to thrombus formation.. They can increase ischemia in diseased hearts. They are believed to have direct cardio toxic effects leading to decrease in heart function. Indirect:- when the origin of products of inflammation with release of oxygen species originates from the lungs. This stimulates a series of multiplying effects on inflammation to release of CRP,IL6,IL8 IL-1BETA even in individuals who have no health complaints resulting atherosclerosis progression, endothelial disturbance, accelerating clotting of blood and decrease myocardial blood supply. Further, they affect automatic cardiac control reflected as alterations in the chronotropic, bathomotropic or inotropic events of the heart **(41–48)**.

2.2.6 Studies on cardio-vascular system

"MONICA survey" carried out from1984 to 1985 recorded heart rate using ECG and demonstrated increase in heart rate with episodes of increase PM concentration in air (**49)**. A Study in Spain showed a raise of 10 μm. /m^3 in PM, altered the risk of mortality by 2.8% while from China the report was an increase of 28.8μm /m^3 raised the danger by 7% **(50,51)**. Particulate matter levels when raised reflected in number of ischemic complaints, even with a rise in PM <2.5 by 10 μm./m^{3} , especially in patients with established coronary compromise **(52)**.

2.3 REVIEW OF OTHER WORKS

2.3.1 Particulate Matter and Air Pollution

1. Shenoy UG. et al using gravimetric dust sampler showed area with mine tailings had more respirable dust concentration that was significant compared to non-mining area. It was concluded that periodic PM monitoring was required to assess air quality. Water sprinkling and covering of peripheral boundary by vegetation or artificial barrier can be employed to abate dispersion of PM. This may positively reflect on the health of the residents living nearby the mine tailing **(53)**.

2. Nkosi V. et al: International Study of Asthma and Allergies in Childhood (ISAAC) utilized self-administered questionnaire survey to identify asthmatic children, recorded a decrease in the FEV1 in them that linked to pollutants increase in air. The fixed-site monitoring station was used to measure the air samples. The findings demonstrated that spikes in pollutants worsens lung functions, increased symptoms and use of medication use even when the daily ambient pollutants concentration were all well below "South African Air Quality Standards"**(54)**.

3. Ntim M et al : Air samples form gold mines in Ghana had large amounts of PM10 and (TSP)total suspended particulate matter. They also observed all the lung volumes including peak expiratory flow rate were lower than the predicted value in the exposed group attributed to living in this dusty place **(55)**.

4. Wright CY et al studied the perception of health danger of five focus groups with sixty-two participants of different age groups and sex residing by gold mine dumps and tailing dams in Witwatersrand area of Gauteng South Africa. Local communities categorical believed that their environment had high dust concentrations from mine dumps and tailings dams. The ward committee members further expressed short term measures such as watering their yards and closing doors and windows were not effective. They indicated that a more permanent solution needs to be found, all stakeholders including government, mining houses and communities need to work together in solving the dust issue **(56)**.

5. Oguntoke et al in this study air dispersal of dust from gold mine tailing storage facilities impacts negatively on health, amenities and the surroundings of the Witwatersrand region, South Africa. A multivariate analytical method was adopted to measure the role of specific meteorological parameters on dust fall emissions, monitored at 22 sites in the central Witwatersrand area studied over 10years. The dust deposition rate varied between seasons, with spring months showing the highest levels and frequency. Atmospheric humidity had negative correlation with dust fall while wind speed showed positive correlations **(57)**.

6. The study by **Skoczynska A et al** studied pulmonary functions in the copper miners. Samples of mine air were determined for every month and also the timed weight average (TWA). This was below Maximum Allowable Concentration (MAC) but sometimes reached the maximum value. Pulmonary functions recorded by spirometer showed obstructive pattern with worsening effects on smokers above the age of 45years with peak expiratory flow rate which showed a significant decrease. Hence they concluded that Health Education Program, preliminary care with spirometry should be performed on smokers aged 45 years or older for early detection of lung abnormality and aid in quitting smoking. Welders who smoked should be referred for early clinical diagnostics **(58)**.

7. Gowda AJ et al studied the air sample of iron ore mines in Karnataka by Gravimetric method. The core zone concentrations was high while in buffer zone the concentrations were within the “National Ambient Air Quality Standards”. In summer the levels were very high and fell in the monsoons due to the differences in rainfall, humidity, temperature and wind **(59)**.

8. Onder M et al analyzed particulate matter by standard Gravimetric method in the underground mining area and the average respirable dust concentration was below the prescribed "Turkish standard" of 5 mg/m3. However, CWP (Coal mine workers pneumoconiosis) was mostly diagnosed in underground miners, elucidating that, to decrease the risk of CWP among workers, the permissible dust levels in Turkey coal mines should be reduced **(60)**.

9. Kim S et al studied the people living near abandoned mines and compared them with control groups. They observed that living near abandoned mines exposed them to metals and increased risk of ill health. The soil in the study area showed 2-10 times higher metal concentration and the cadmium levels in ground water, blood and urine samples of individuals were also higher. ($p<0.05$). Biological monitoring should be considered to check the possible health effects of residents living near abandoned mine **(61)**.

10. **Kneen MA et al** in their study found steady growth in housing developments edging closer towards the various tailings storage facilities by analysis of aerial and satellite images in conjunction with census data, indicating the combined number of households within mining buffer zones have increased by almost four times from 1952 to 2004. Hence there is increased in population exposed to harmful inhalable dust from the tailing storage facilities. Ideally, no further development of residential areas should be permitted within a certain perimeter. Similarly, relocation of the current residential population would be desirable, but is unlikely to be feasible within the economic and political landscape. Socio-economic pressure, fostered by the need for low-income homes close to work opportunities will continually cause pressure for further residential development. Hence increased emphasis on preventing wind erosion of mine dumps is important and cost-effective solution to this increasing hazard – which currently affects half a million residents of South Africa **(62)**.

11. Hamatui N et al in their cross sectional descriptive study used the ASTM D1739 method, a standardized self-administered questionnaire to collect details of symptoms of respiratory origin in an effort to connect it to levels of PM. Increased levels of PM concentration across all areas of Windhoek, reflected with increased occurrence for cough, difficulty in breathing and asthma with the odds of experiencing of phlegm and cough increased. Biomass fuel further worsened respiratory health **(63)**.

12. Bathmanabhan S et al in his paper discussed the diurnal, seasonal and the weekly cycles of the PM concentration and found maximum concentration in thethe peak traffic hour and low levels during the midafternoon and late night. The PM concentration was highest in the post monsoon season with levels above the "National ambient air quality standard" **(64)**.

13. Pandaa KK et al monitored air quality in Orissa for three seasons namely summer, post monsoon and winter during 2008-09.The Suspended Particulate Matter (SPM , >10 micron) and Respirable suspended Particulate Matter concentration exceeded the "National Ambient Air Quality standards" prescribed by Ministry of Environment and Forest (MoEF), Government of India at most of the locations. Data collected from the District Health Department indicated that incidence of Pulmonary Tuberculosis amongst residents of the study areas had increased between 1999 and 2008 during which the iron ore mining and road transportation was also rampant. Therefore, an effective Air Pollution Management Plan was formulated to decrease the effect of dust in the surrounding areas and implement pollution source inventories for future planning and monitoring. Strong implementation by statutory authority, capacity building for monitoring of PM 2.5, and provision of suitable personal protective equipment to concerned workers, were also considered. Pulmonary function tests for the people exposed to dusty atmosphere and conduct detailed health study of people residing in the vicinity of mining areas and industries was advised to create a baseline and to establish a link between PM concentration and human health **(65)**.

14.Sexana et al observed that health and environment is being continuously impaired by the amount of air pollutants in the atmosphere especially that of increasing amount of RSPM. It is found to even exceed The "National Ambient Air Quality Standards" in India. The reason for high levels are the emissions from auto vehicles, diesel generators , dust hanging in air from traffic, small scale industries, biomass burning, commercial and domestic use of fuels, etc. The outcome on health were worse in females compare to males **(66)**.

2.3.2 Pulmonary Function Tests

1. Paulin L et al discussed the detrimental role of PM on lung development and function in children and adults. The type of PM have differing health effects; yet not been clearly elucidated. Reducing PM concentrations would benefit a large population **(67)**.

2. Green DA et al demonstrated the individuals exposed to mixed mineral dust in childhood and early adult life had excess symptoms and reduced vital capacity without airflow obstruction compared with control subjects. They interpreted it as evidence of stunting of lung growth by exposure to respirable dust **(68)**.

3. Hnizdo E studied gold miners in south Africa and showed decreased lung function measurement of 35.5% for FVC, 29.8% for FEV1 with FEV1 being the strongest predictor of mortality from all causes. Smoking was a compelling contributor to lung dysfunction compared to dust exposure with blacks having higher predilection for lung impairment **(69)**.

4. Ehrlich RL et al In their project showed exposure-response relationships between respirable dust, respirable quartz and respiratory function loss in South African gold miners. They concluded that appreciable loss of lung function attributable to dust exposure in working South African gold miners, mediated via silicosis, pulmonary tuberculosis and/or an independent dust effect. Respirable dust was a slightly better predictor of lung function loss than respirable quartz **(70)**.

5. Choudhari SP et al in their paper revealed significant decline in FVC, FEV1 and MVV in goldsmith workers. They believed that the silica in gold extraction was responsible for pro fibrotic lung microenvironment **(71)**.

6. Raju AE et al studied the pulmonary function test on those exposed to coal dust and controls and it was found that all the PFT values were low in the exposed community and in smokers. Pollutants in air contributed to the respiratory dysfunction and smoking worsened the effects. Monitoring the exposures, conducting medical screening and surveillance, and encouragement of cessation of smoking were important in maintaining respiratory health **(72)**.

7. Qian QZ et al in their study concluded that the prevalence of abnormal pulmonary functions were higher in coal mixture workers, characterized by decreased FVC%, FEV1% and FEV1/FVC% and dysfunction in 35.1%.The dust-exposed duration would be a key factor for abnormal pulmonary function with an exposure dose and cumulative abnormal rate suggesting a threshold limit of 1000 mg/m^3 years for coal here **(73)**.

8. Gholami et al in their cross sectional study done on people working on different mining sectors determined the lung function and respiratory symptoms of workers exposed to mineral dust in the Eastern part of Iran. Finally, data was analyzed using Tukey's post hoc and chi-square tests. The exposed groups have significantly lower pulmonary function than the control group. Two out of four main pulmonary function variables – FVC and FEV1 showed reduce amounts in exposed groups **(74)**.

9. Borges R et al observed no significant relationship was present between respiratory symptoms and spirometry results in pyrochlore mine workers showing good working conditions which could prevent disease in this sector. The low toxic effects of of pyrochlore may be another factor **(75)**.

10. Johncy S et al In their study showed a significant drop in predicted values of FVC, FEV1, FEV1/FVC%, PEFR and FEF25-75% in construction workers, They concluded that airborne particulate materials in the construction site adversely affected the pulmonary function parameters and caused an obstructive pattern of lung dysfunction and was due to the dose effects of duration of exposure in construction site **(76)**.

11. **Christine O L et al** Observed that FEV1 in heavy and highway construction workers are lower than the predicted value with predilection for asthma, indicating a need for regular pulmonary function test assessment in the workers for better health. **(77)**.

12. Bakke B et al showed accumulative effects to nitrogen dioxide to be the main reason for lung dysfunction among tunnel construction workers. The decrease in FEV1 in non-smokers and smokers showed maximum association. They advised that respiratory devices be used to protect workers against dust and nitrogen dioxide exposure **(78)**.

13.Sumana P et al observed that lung function parameters- FVC, FEV1 and MVV were decreased in construction site workers .It was concluded that construction site workers should undergo pulmonary function tests from time to time to detect any changes so as to provide early treatment interventions **(79)**.

14. Jaffer M et al in their study observed that in steel factory workers, with a statistically significant decrease in FVC, FEV1, FEV1/FVC %, FEF25-75% and PEFR in cases compared to the controls. Among cases 30% of them were suffering from early small airway obstruction & mixed blockage, 76% of them were suffering from restrictive type of COPD severity that is combination of restrictive & obstructive patterns in their lungs. Reduction in their dynamic lung functions may be due to exposure to dust. Dynamic PFT evaluation with paucity of related symptoms of early lung dysfunction constitutes an important feasible and reproducible screening technique as a routine periodic assessment to uncover early lung dysfunction even in the asymptomatic state **(80)**.

15. Dangi BM et al Studied 100 male workers between 20- 50 years working in the cotton mill for more than one year were and compared with age and gender matched control group. There was no significant difference in FVC when compared to predicted percentage and with the control group. But FEV1, FEV1/FVC and PEFR were significantly decreased from predicted percentage and when compared to controls. Respiratory symptoms was significantly higher in cotton mill workers with highest numbers complaining of breathlessness. Duration of exposure of cotton mill workers directly affected the prevalence of respiratory symptoms and abnormal lung parameters. **(81)**.

16. **Fereidoun H et al** in their study showed about 19%reduction in vital capacity in Teheranian students with development of restrictive type when exposed to pollution for a greater length of time. This harms children's lung growth and function **(82)**.

17. Zwozdziak A et al Here increased PM levels is shown to decrease in lung function parameters with poor spirometry results in school children who were otherwise healthy. According to "WHO" there is no evidence of a threshold limit of PM or safe value of exposure below which there is no adverse influence on health. PM1 affects respiratory function parameters greatly when compared to PM2.5. The fraction PM that affects the quality of air in the school indoor areas is most likely the PM1 fraction and a better indicator of acute respiratory effects. PM1 mass concentrations are not routinely monitored but need to be with awareness of its danger on health than bigger size PM fractions. Effective quality program to analyze PM1 and PM 2.5 of air indoors is imperative to protect children **(83)**.

18. **Hanns K L, et al** studied the effect of dust exposure in work areas on spirometric results. Lung function decrease with time, that was worsened with habit of smoking and length of occupational dust exposure. FVC, FEV1 and MEF50 decreased yearly by 6.68 ml, 6.71ml and 16.16ml/s respectively. Smoking further significantly affected MEF50 decline. Strict implementation of limit values and cessation of smoking could prevent chronic occupational damage to the respiratory system **(84)**.

19. Sangeeta In her study recorded pulmonary function parameters of FVC, FEV1, FEF25-75 PEFR and MVV by using Medspiror, a dry type of spirometer and they were significantly changed. This fall in FVC and MVV indicated a restrictive impairment whereas decrease in FEV1, FEF25-75 and PEFR indicated an obstructive impairment. The observed changes in pulmonary function parameters may be because of mechanical irritation caused by dust and allergic reactions due to allergen present in dust itself and individual's susceptibility to dust depending on duration of exposure **(85)**.

2.3.3 Respiratory Symptoms

1. Nkosi V et al studied that communities in close proximity to mine tailings had an increase prevalence of wheeze -a symptom of asthma and rhino - conjunctivitis among adolescents. This resulted in the development of major cohort studies **(86).**

2. Bio FY et al tried to record the action of respirable dust on pulmonary function access the prevalence of respiratory dysfunction in the Ghanaian gold miners. They were not able to show any correlation between cumulative exposure and FEV1 predicted% in any group. They concluded that a mean respirable silica levels of 0.06mg/m^3 had no deleterious effect on FEV1 if the population had a minimal prevalence of tuberculosis, good housing and decreased smoking habit. They attributed smoking as the cause for chronic bronchitis in the miners of Ghanian gold mine **(87)**.

3. Nkosi et al investigated the link between closeness to mine dumps and prevalence of lung disease in people aged 55 years and older. Respiratory symptoms were assessed by using ATS DLD 78 questionnaire. Exposed population who lived within 2 kilometers of the mine dumps had a significantly higher prevalence of chronic respiratory symptoms than those who were unexposed who lived more than 5 kilometers away. Smoking habits, low level of education and domestic use of gas or paraffin were independent risk factors **(88)**.

4. Rusibamayila M et al showed high prevalence of respiratory symptoms despite personal respirable dust exposure for both underground and open pit operations below the threshold limit value. They recommend follow-up studies to establish a causal-effect relationship and to remove the Hawthorne effect. Similarly, they recommend that studies on ex-miners to be conducted to establish health effects emanating from hazards such as dust by controlling for the healthy worker effect. Further, they recommend that all heavy machine equipment be fitted with air conditioning systems to enable their operators to close cabin windows to decrease dust. Miners should be educated on the effect of cigarette smoking on the respiratory system and the need to abstain from this habit **(89)**.

5. **Ayaaba E, et al** in their study investigated respiratory disorders among gold miners in Ghana a sub-Saharan African country. Old age, lower educational back ground, marital status and consumption of alcohol significantly increased the development of respiratory symptoms. The prevalence of asthma, pneumonia, bronchitis and emphysema were 47.55%, 14.29%, 9.69% and 5.10% respectively. Cough was the most common respiratory symptom (35.4%) **(90)**.

6. Francies NDE et al studied the respiratory function related to wood dust exposure in carpenters in Douala. Lung function impairments was 24.2% in carpenters and 16.4% in the unexposed group with increased respiratory symptoms, predominantly cough. workers who smoked and of older age group showed more symptoms thus highlighting the necessity for work health surveillance **(91)**.

7. Tobin EA et al in his study a cross-sectional analytical survey involving 227 saw mill worker,. Structured questionnaire and spirometry were used for data collection. Dust monitoring in the study and comparison areas was done using gravimetric dust sampler. The average value for inhalable and total dust was higher in the study with a higher frequency of cough and phlegm in the exposed group, again stressing the need for strong implication for the improvement in dust control in wood industry **(92)**.

8.Shaikh S et al observed that the occurrence of symptoms in the lungs of brick kiln workers were same as those in different occupational where they were subjected to dust and smoke. The frequency was highest for cough among smokers, while wheeze on exposure to smoke was highest among non-smokers. The occurrence of respiratory symptoms was not influenced by the duration of service in occupation.. The frequency of respiratory symptoms and illnesses was observed in the brick kiln worker were high. Smoking, exposure to pollutants and age seem to compound the negative effects **(93)**.

9.Mahesh .PA et al 2011 In Mysore taluk eight villages were randomly selected based on the list of villages from census 2001. Trained field workers used the "Burden of obstructive diseases questionnaire" in a house-to-house survey and had 4333 participants. The prevalence of chronic cough was 2.5 per cent and that of chronic phlegm 1.2 percent which was lower than that observed in other studies. Heavy smoking was a key modifiable habit and efforts towards smoking cessation are important for good respiratory health in the community **(94)**.

10. Abbasi I .N. et al in their survey studied the respiratory symptoms by using the ATS questionnaire and a portable spirometer for lung functions ." The American thoracic society division of lung disease" questionnaire was modified to record the presence of respiratory symptoms. Respiratory symptoms of cough, wheeze, dyspnea and phlegm were significantly correlated with reduced lung function. These symptoms were important predictors of obstructive and restrictive lung function independent of risk of smoking. Validated respiratory questionnaire like ATS questionnaire is an effective tool in the diagnosis of respiratory symptoms. This then becomes a useful adjunct to spirometry in community setting of resource poor countries for screening of respiratory illness **(95)**.

11.Said A M et al: Male bakery workers in the age group of 14-56years,workingat least for 10 hours per day for six of the seven days in a week for total working years ranged between 2 and 30 years had elevated complaints of symptoms. This led them to conclude that the high wheat flour concentration in the bakery resulted in increased occurrence of respiratory symptoms, decrease lung function parameters and development of interstitial pulmonary disease. Smoking augments the wheat flour induced lung disease **(96)**.

12. Demeke D et al in their study showed that airborne dusts were of particular concern to health, as they resulted in development of occupational lung diseases. The study was therefore undertaken to assess the symptoms and functional effects of flour dust on the respiratory system on millworkers. The decrease in the percentage predicted of the functional parameters in the mill-workers when compared to healthy control group was significant except in FEV1/FVC. Large percentage of workers developed restrictive type of lung disorder while few developed obstructive type of lung disease. Hence, the prevalence of obstructive and restrictive lung diseases was higher in exposed group than in controls. The reason for this increased prevalence of restrictive lung impairment in exposed group may be caused by flour dust that acted on lymphoid and connective tissue of terminal bronchioles and interstitial inflammatory cells. Percentage of respiratory symptoms was higher among exposed workers as compared to control groups and the difference was more vivid for dry cough **(97)**.

13. Jamali T et al tried to associate spirometric lung patterns with respiratory symptoms and validated the ATS for lung function assessment among the textile workers. Chronic respiratory symptoms including cough, wheeze and shortness of breath decreased lung function significantly and this trend was found consistently for all lung function indices of

FVC, FEV1 and FEV1/FVC. The study also illustrated respiratory symptoms can be a good predictors of impaired lung function and the questionnaire (ATS) can be used as an effective tool to screen the respiratory symptoms in epidemiological studies **(98)**.

2.3.4 Peak Expiratory Flow Rate

1. Shenoy UG et al studied the lung function of 400 residents exposed to mine tailings and compared it with 400 residents from Kolar who were not exposed to mine tailings using spirometer and the percentage of SPO2 determined using a pulse oximeter The PM concentration was steeper in the samples of air from the mine tailing region with the PEFR values on the lower side, decrease SPO_2 and increased in pulse rate **(99)**.

2. Panwar1 B R et al tried to connect the relationship of RSPM, PEFR and vascular pressure. High amounts RSPM decreased PEFR. They noticed that a 50% reduction in PEFR reflected rise in BP recorded **(100)**.

3. Kabamba N L et al: The influence of occupational dust-exposure on the respiratory health of Congolese coltan miners was assessed. In total, 441 Congolese workers volunteered for the study, including 199 informal coltan miners and 242 office workers (controls). Information on respiratory complaints was collected using two standardized questionnaires. Physical examination and lung function test (Peak Flow meter) were performed. All respiratory complaints and disorders were more prevalent in informal coltan miners than in controls. Markedly lower mean PEFR was observed in coltan miners. Informal coltan mining and almost all respiratory complaints were observed to be linked except wheezing at effort and cough at night. An inverse association was observed between PEFR and PM2.5 exposure, between PEFR and volatile organic compounds exposure, and also between PEFR and current smoking. This study recorded increase prevalence of respiratory complaints in

Congolese informal coltan miners, suggesting the necessity to implement efficient occupational safety measures and regulate this informal mining business **(101)**.

4. Majgi SM et al in their paper observed 128 workers were asked questions about their respiratory symptoms and knowledge of protection from occupational hazards, and their peak expiratory flow rate and oxygen saturation were measured. Only 31.25% workers had appropriate PEFR. The oxygen saturation was more than 95% for all the workers studied. 30% of the workers suffered from cough and 30% from breathlessness. They were unaware of measures to be taken to protect themselves or usage of protective masks **(102)**.

5. Nku.CO et al. Two groups of subjects comprising dust exposed (test) and control groups were studied. Both groups comprised of women who worked and lived in Nigeria in Calabar metropolis. The respirable dust amounts in the test and control sites was measured using a gravimetric method and showed no significant difference between the two. The presenting symptoms of cough, catarrh and sneezing were higher in the study group-the street sweepers. The apparent lowering of all respiratory function indices among sweepers within two years of exposure suggested the probability of development of serious respiratory function impairment with chronic exposure. Therefore, it is necessary to introduce wearing of facemasks, watering of streets and provision of other protective devices in street sweeping to decrease the dust inhalation by the street sweepers **(103)**.

6. Shoba B V et al compared the peak expiratory flow rate among power loom and non-power loom workers in rural area in Salem district and showed decreased PEFR values in power loom workers. Finally, they concluded that hazardous effects of working in power loom workers on lungs could be reduced by adopting protective measures, decrease exposure to work by shift method, proper ventilation, using mask during working time and routine physical examination on a yearly basis **(104)**.

7. Neelem SN et al in their study linked exposure to biofuel and different types of fuel smoke to PEFR among rural Indian women. It was a community based cross-sectional study of 760 non-smoking women who cooked using one of four types of fuel: biofuel, kerosene, liquefied petroleum gas (LPG) or a combination of two or more fuels. A PEFR <80% of predicted was considered abnormal. Exposure index was the most important factor that resulted in abnormal PEFR in those using biofuels and LPG. Strangely, no association was found between abnormal PEFR and index of exposure, for which no reason was given. Mixed fuels had the worst effect on PEFR.**(105)**.

8. Singh V et al PEFR was done on students recruited based on their stay in campus or outside. The RSPM was measured through the personal sampler APM 800 (Environtech, India) used for exposure assessment studies. Children who stayed outside the campus and commuted to college had lower PEFR values. This significant difference in PEFR variability between the two groups can be attributed to increased personal levels of pollutants recorded from daily travel exposure on daily basis to nitric oxide and RSPM or episodic to very increased levels of pollutants at traffic lights **(106)**.

9. Dhokane N et al Many human biological systems, including airway caliber, shows a cyclical rhythmical changes. The cause of this rhythm in the airways are passively affected by the rhythm of related endogenous systems or because they respond directly to cyclically varying exogenous stimuli. The peak expiratory flow rate (PEFR) is an accepted marker of pulmonary function, primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the subject. Here, the PEFR recorded in the morning and evening on young healthy adults showed significant difference. This was important in understanding the behavior of airways in producing changes in PEFR. They concluded that a diurnal variation pattern of PEFR exists in healthy population and this knowledge is important for any meaningful interpretation of its recordings used to screen the population for asthma **(107)**.

10. Rajnarayan R. et al studied the effect of occupational exposure, age, gender and smoking on PEFR of quartz stone grinders. A predesigned questionnaire was used to collect details required including that of respiratory symptoms .PEFR was also recorded they have been able to demonstrate that age ≥ 35 years, female, those having duration of exposure ≥ 2 years and those having respiratory morbidity had significant reduction in peak expiratory flow rate **(108)**.

2.4 AMERICAN THORACIC QUESTIONNAIRE

Questionnaires are commonly used subjective instrument of measurement in epidemiology. The standardization of the questionnaires aims to limit bias by maximizing validity and reliability, and comparability. The standardized American Thoracic Society Questionnaire was devised in the early 1950s in Great Britain after the realization that the clinical assessment of subjects in epidemiologic studies was plagued by uncontrollable biases **(109, 110)**. After several years of developmental work, the Medical research council (MRC) approved a standard questionnaire in 1960 **(111)**. This questionnaire was reviewed for publication by the ATS in 1969 **(112)**. It underwent modest revision between 1960 and 1976, and a slightly modified version was approved again in 1976 by the MRC on a worldwide basis. The ATS-DLD-78 is recommended to be used for epidemiologic study of all respondents of 13 or more years of age. This questionnaire consists of two components the 1st component containing a minimal set of questions to be asked in every survey. The second set of questions which is optional questions that are left up to the discretion of the individual investigator to consider for inclusion at the end of the respective part of the questionnaire. This questionnaire can be in cop orated in any new study designed to assess the prevalence of the chronic respiratory symptoms and disease. The new version of ATS-DLD78 is extensively tested and reviewed by a large body of experts **(113)**. This questionnaire contains sufficient information to compare between self-completed and interviewer administered questionnaire. The investigator in his wisdom will determine the method of assessment and inclusivity of supplementary questions.

2.5 SPIROMETRY

Spirometry is mandatory for accurate and repeatable measurement of respiratory function. It is helpful in making a diagnosis in people suffering from complaints that may be arising from respiratory system and for screening in occupational environments **(114)**.It assesses lung function by measuring the volume of air that the patient can expel from the lungs after a maximal inspiration. The indices derived from this forced exhaled maneuver has become the most accurate and reliable way of supporting a diagnosis of pulmonary function. These values are compared with predicted normal cut offs determined based of age, height, sex and race, On these guidelines the mild, moderate, and severe disease levels are assessed.

Since its introduction in clinical practice, measurements of lung volumes and related indices have become key in the objective study of most respiratory diseases. Of various parameters, forced expiratory volume in one second (FEV1) is strongly recommended as an index of choice for the following reasons:

1) It is reproducible, in most instances with a well-defined range of variation accounting for age, sex and ethnic group.

2) It has a strong prognostic value in disease like chronic obstructive pulmonary disease **(115, 116)**. Actually, spirometry measurement is one of the indicators " global health" , that can predict all-cause mortality **(117, 118)**, also in long-term **(119)**.

3) Serial measurements are used as follow up of normal decline with age, state of obstructive and restrictive diseases and the response to treatments. Also, the importance in epidemiological studies cannot be overemphasized.

2.5.1 Types of Spirometers

1. Bellows or rolling seal spirometers are large and not very portable, and are used predominantly in lung function laboratories. They require regular calibration with a 3-liter syringe and are very accurate.

2. Electronic desktop spirometers are compact, portable, and usually quick and easy to use. They have a real-time visual display and paper or computer printout. They maintain accuracy over years and are ideal for primary care.

3. Hand-held spirometers

It provides a numerical record of blows but no printout. It may be necessary to look up predicted values in tables, but some include these in their built-in software. Recent models allow pre-programming of patient details so that the spirometer also gives percent predicted values. These are good for simple screening and are accurate for diagnosis if the more expensive desktop form is impractical or too expensive. Many spirometers provide two forms of traces. One is the standard plot of volume exhaled against time. The other plots the flow

(L/sec) on the vertical axis and volume (L) on the other axis. This flow–volume tracing is most helpful in diagnosing airway obstruction.

Pulmonary Volumes and Capacities

A simple method for studying pulmonary ventilation is to record the volume movement of air in the lungs, a process called spirometry.

2.5.2 Pulmonary function tests

Below figure lists four pulmonary lung volumes that, when added together, equal the maximum volume to which the lungs can be expanded. The significance of each of the volume is as follows.

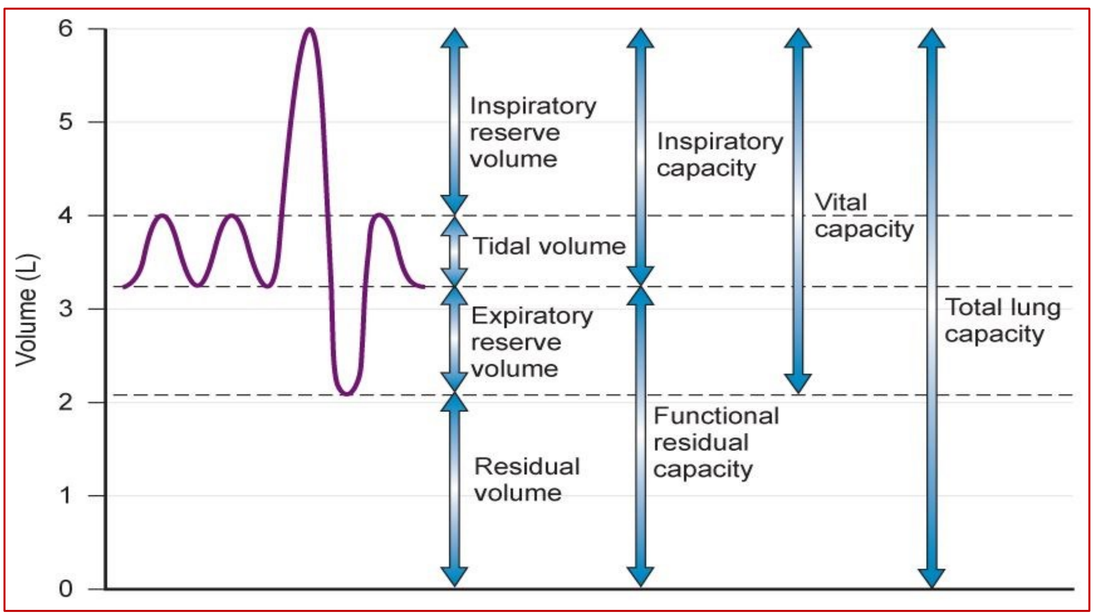

Plate 5: Spirogram

Lung volumes

1. **The tidal volume: -**The volume of air inspired or expired with each normal breath; it amounts to about 500 milliliters in the adult male.

2. **The inspiratory reserve volume:-** The extra volume of air that is inspired over and above the normal tidal volume when the person inspires with full force; it is usually equal to about 3000 milliliters.
3. **The expiratory reserve volume:-**The maximum extra volume of air that is expired by forceful expiration after normal tidal expiration; this normally amounts to about 1100 milliliters.
4. **The residual volume:** The volume of air that remains in the lungs after the most forceful expiration; this volume averages about 1200 milliliters.

Lung Capacities

1. **The inspiratory capacity: -** It equals to the tidal volume plus the inspiratory reserve volume. This is the amount of air is about 3500 milliliters a person can breathe in, beginning at the normal expiratory level and distending the lungs to the maximum amount
2. **The functional residual capacity**: - It equals the expiratory reserve volume plus the Residual volume. This is the amount of air that remains in the lungs at the end of normal expiration is about 2300 milliliters.
3. **The vital capacity: -** It is equal to the inspiratory reserve volume plus the tidal volume plus the expiratory reserve volume. This is the maximum amount of air a person can expired from the lungs with maximum effort after maximum inspiration is about 4600 milliliters.
4. **The total lung capacity:-**It is the maximum volume to which the lungs can be expanded with the greatest possible effort (about 5800 milliliters) it equals to the vital capacity plus the residual volume. All pulmonary volumes and capacities are about 20

to 25 per cent less in women than in men, and they are greater in large and athletic people than in small and asthenic people.

Classification of ventilatory abnormality in spirometry (120,121)

PARAMETER	Normal	Obstructive	Restrictive	Mixed
FEV1	Above 80% Predicted	Reduced	Normal or Mildly Reduced	Reduced
FVC	Above 80% Predicted	Reduced or normal	Reduced	Reduced
FEV1/FVC%	Above 70	Reduced	Normal or Increased	Reduced

FEV1 :- The volume of air forcibly blown out in first second after full inspiration. The average value for healthy people depends mainly on sex and age. Values between 80% and 120% of the average value are considered normal.

FVC :- The amount of air forcibly exhaled after taking the deepest breath possible.

FEV1/FVC:-The ratio of FEV1 to FVC.

Peak expiratory flow rate:- The maximal expiratory flow rate that can sustained for at least 10 milliseconds during forced expiration starting from total lung capacity. Peak flow is largely reflects the function of airways with bigger caliber. It greatly depends on expiratory muscle strength and the patient's effort and co-ordination. It is highly effort dependent and hence many clinicians use PEFR in addition to FVC and FEV_1.

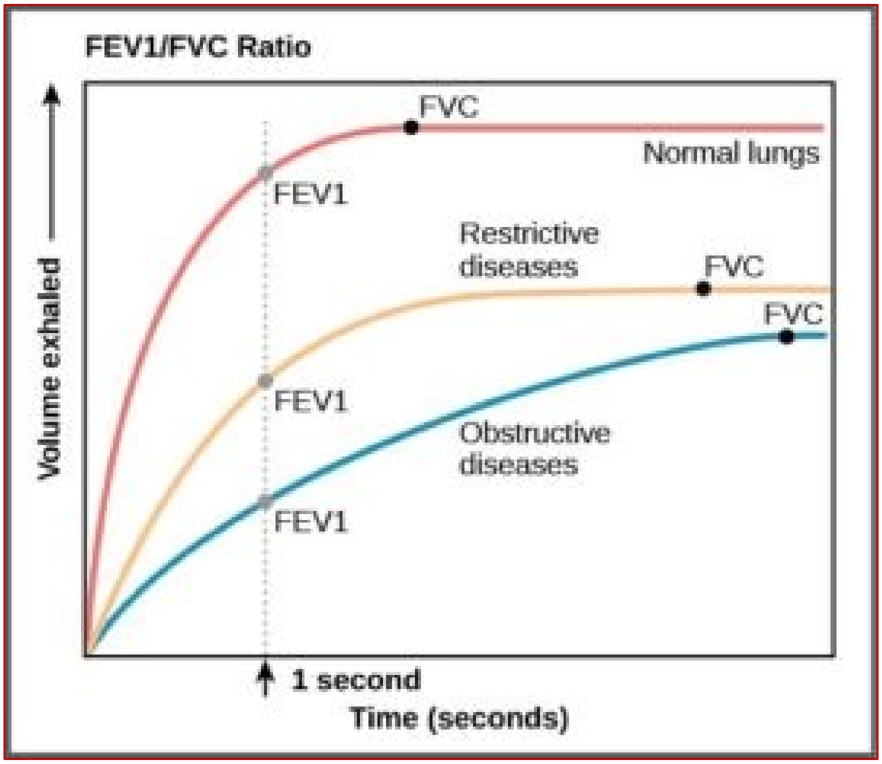

Plate 6 : Flow volume loop

2.6 AIR SAMPLING

Air sampling is capturing the contaminants from a known volume of air, measuring the amount of contaminants captured, and giving its concentration **(122)**. Of the different methods for taking air samples the most widely used and preferred method gravimetric sampling.

Air Sampling Techniques

Basically there are six air sampling methods which are:

1. Filter Sampling Inhalable (Total) Dust
2. Sorbent Sampling
3. Sampling Respirable Dust
4. Bag Sampling

5. Filter Sampling Respirable (Alternative Method)
6. Impinger/Bubble Sampling

2.6.1 Gravimetric sampling

In this method of sample air is passed through a filter, or other sampling collector is weighed to determine the amount the particulate matter gathered. It is a non-specific technique. All material on the filter is included, although some of them may not be the contaminant of interest. While most contaminants are determined by other methods that give quantifies the substances in the given sample of air, materials such as wood dust, coal dust, etc. are still measured by gravimetric method.

PM10 and PM2.5 Samplers of High volume type

For PM10 assessment, traditional gable roof of the high volume sampler is replaced by an impactor design size-select inlet. For the impaction design the air sample entering the symmetrical hood is deflected upward into a buffer chamber. The buffer chamber is evacuated at a rate of 68 m^3 per hour via multiple circular nozzles. The entering particulate matters get accelerated as they pass through the nozzle to an impaction chamber; this process helps the particulate matter to gain some momentum and thus particulate matters having diameter larger then inlet 10µm gets impacted in the impaction chamber. Small particulate matters rise through the impactor chamber at speeds slow enough to minimize re-entrainment of the already impacted particles and then pass through multiple bent tubes to high volume sampler's filter where they are collected.

The second size select design of PM10 measurement is 'cyclone inlet'. Here omnidirectional cyclone is used for fractionation in the inlet allowing particulate matters to enter from all angles of approach. In the inlet, an angular velocity component is added to the sample air and the particulate matters contained in it by evenly spaced vanes. Larger particulate matter removal occurs in the inner collection tube. This tube incorporates a perfect absorber which is usually an oiled surface to eliminate bouncing of particulate matters. The sample flow then enters the intermediate tube where the direction of the particulate matter is altered. An additional turn is added to change the flow to a downward direction to allow the remaining particulate matters to deposit on a filter for further analysis. Like the impaction inlet control of air velocities in cyclonic inlet, it is important that correct particulate size cut point be used and also correct design volumetric flow through the inlet be maintained.

Plate 7: Gravimetric sampling

3. RESEARCH QUESTION

1. Does mine tailing contribute to increase particulate matter concentration in the area?

2. Is the pulmonary function reduced in the residents of mine tailing?

3.1 AIM

To determine the respiratory disease burden in the residents of Kolar Gold Fields (KGF)

3.2 OBJECTIVES

1. To determine and compare the respirable dust concentration in the mine tailing area and non-mine tailing area.

2. To assess the prevalence of chronic respiratory symptoms of the residents of the mine tailing and compare it with residents of non -mine tailing using ATS DLD -78 questionnaire.

3. To compare the FVC, FEV1, FEV1/FVC and PEFR of the residents of the mine tailing and compare it with residents of non- mine tailing using spirometer.

4. To compare the oxygen saturation and pulse rate in the residents of the mine tailing and compare it with residents of non- mine tailing of using pulse oximeter.

MATERIALS AND METHODS

4.1 INTRODUCTION

4.1.1 Study design

A cross sectional study

4.1.2 Source of data

Mine tailing area- Study Area

This study was undertaken in mining town of Kolar Gold Fields (KGF) in Kolar district. Kolar district is situated in southern part of Karnataka state at a distance of about 70 Kilometer from Bengaluru. It is spread over an area of 58.12 sq. km. with a population of 1, 63,643. Champion reef, Coromandel, Ooragum and Marrikuppum were chosen based on the size of the mine tailing and proximity of residents to mine tailings.

Non mine tailing area -Comparison area

Gandhi Nagar was selected as the non-mine tailing area which is situated in Kolar town 30 Kilometer away from KGF and with the same demographic status.

4.1.3 Sample size estimation

$n = Z\alpha^2 x PQ/d^2 n = 384$

Prevalence of the population 50%

Confidence interval is at 95%

Absolute precision is at 5%

$d=0.05$

$Q=1-P$

Considering the prevalence for the chronic bronchitis of 50% in the adults with 95% confidence interval and with ± 5 % precision, the sample size was calculated and rounded to 400.

4.1.4 Selection of subjects

Exposed population - Study group: 400 participants of both genders who were selected based on inclusion and exclusion criteria from the mine tailing area referred to as exposed population.

Unexposed population -Comparison group - 400 participants of both genders were selected based on inclusion and exclusion criteria from the non-mine tailing town referred to as unexposed population.

4.1.5 Inclusion and exclusion criteria

Inclusion criteria:

Exposed population/ Unexposed Population

1. Sex: Both the genders
2. Age: 18 to 60 years
3. Duration of stay: 3 and more years

Exclusion criteria-

1. Miners.
2. Based on history and clinical examination subjects with
   - Neuromuscular disorders like myasthenia gravis
   - Kyphoscoliosis
   - Peripheral nerve disorder

4.1.6 Ethical clearance

From the institutional ethical committee was obtained for the start of study. DMC/KLR/UDOME/IEC/37/2014-15

4.1.7 Informed consent

Information regarding the study including the necessity for participation was explained to each participant in their language of understanding. All participants were informed that they have full right to refuse or discontinue participating at any point of the study. Before performing the actual procedure, verbal and written consent were secured.

Plate 8: Mine tailing Ooragum and Champion reef

4.2 METHODOLOGY

A total of 12 dust samples were collected from the 4 mine tailing areas - Champion Reef, Marikuppum, Ooragum and Coromandel based on the proximity of the mine tailing and 7 dust samples were collected from non-mining area during the month of June-August 2017. Samples were analyzed in the registered office of National Health of Miners Health KGF.

4.2.1. Respirable suspended particulate matter estimation (RSPM estimation)

The respirable dust was collected by using respirable dust sampler Side Kick Ex51 having 37 mm filter cassette holder which holds Polyvinyl Chloride (PVC) filter of 37mm diameter, having a pore size of 5.0µm. Pre calibration of Side Kick 51Ex personal respirable dust sampler was carried out by using DRYCAL DCLITE BIOS calibrator in NIMH (National Institute of Miners Health) laboratory. During the field study pre & post calibration of samplers were done with the help of rotameter to maintain a constant flow rate of 2.2 L/min. Both Aluminium cyclones & plastic cyclones were used for collection of respirable fraction of dust below 4µm in diameter by using its respective cassette holders as per the requirement while using Side Kick 51Ex as respirable dust samplers. Sampling head holders were used to keep the cassette, cyclone, and coupler together to facilitate the entry of air to enter only from the cyclone inlet. Digital single pan analytical balance (Shimadzu having range of 0.001 mg to 5200 mg) was used for pre and post weighing of the PVC filters. The respirable dust sampler Sidekick Ex51 when used as an area dust sampler has a correlation factor of 1.13 with gravimetric dust sampler Mine research establishment GDS MRE 113A dust samples. Hence the dust concentration result obtained for area respirable dust samples, by using Side Kick Ex51, is divided by 1.13 to get the equivalent MRE respirable dust concentration in mg/m^3 in case of area samples. For area dust sampling Side Kick-51Ex was placed in the periphery of 5 to 15 m of the dust generating source in the mine tailing area. After sampling for 8 hrs. The Side Kick 51Ex was re-checked for its constant flow rate of 2.2 l/m with the help of Rotameter and entered in the recording sheet. The constant flow rate of 2.2 l/min was noted in the data sheet. The collected samples were carefully preserved and taken to the laboratory for further analysis by weighing the filters, calculating the dust concentration **(122)**.

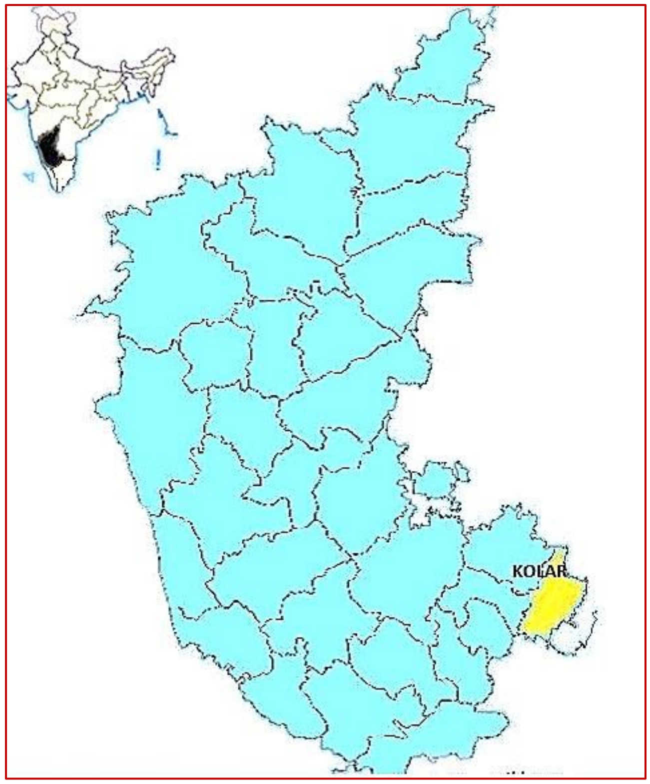

Plate 9: Map of Karnataka showing Kolar district

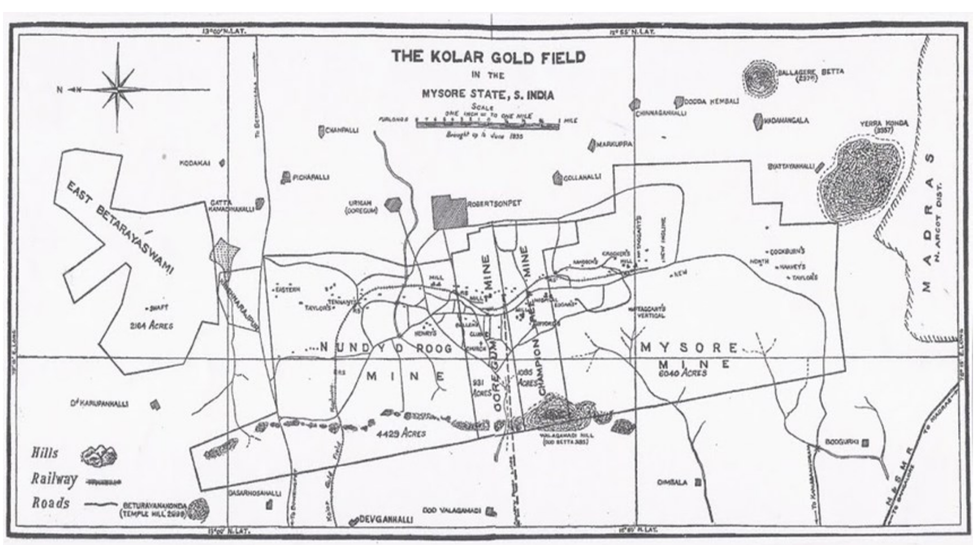

Plate 10: Map of Kolar Gold Fields

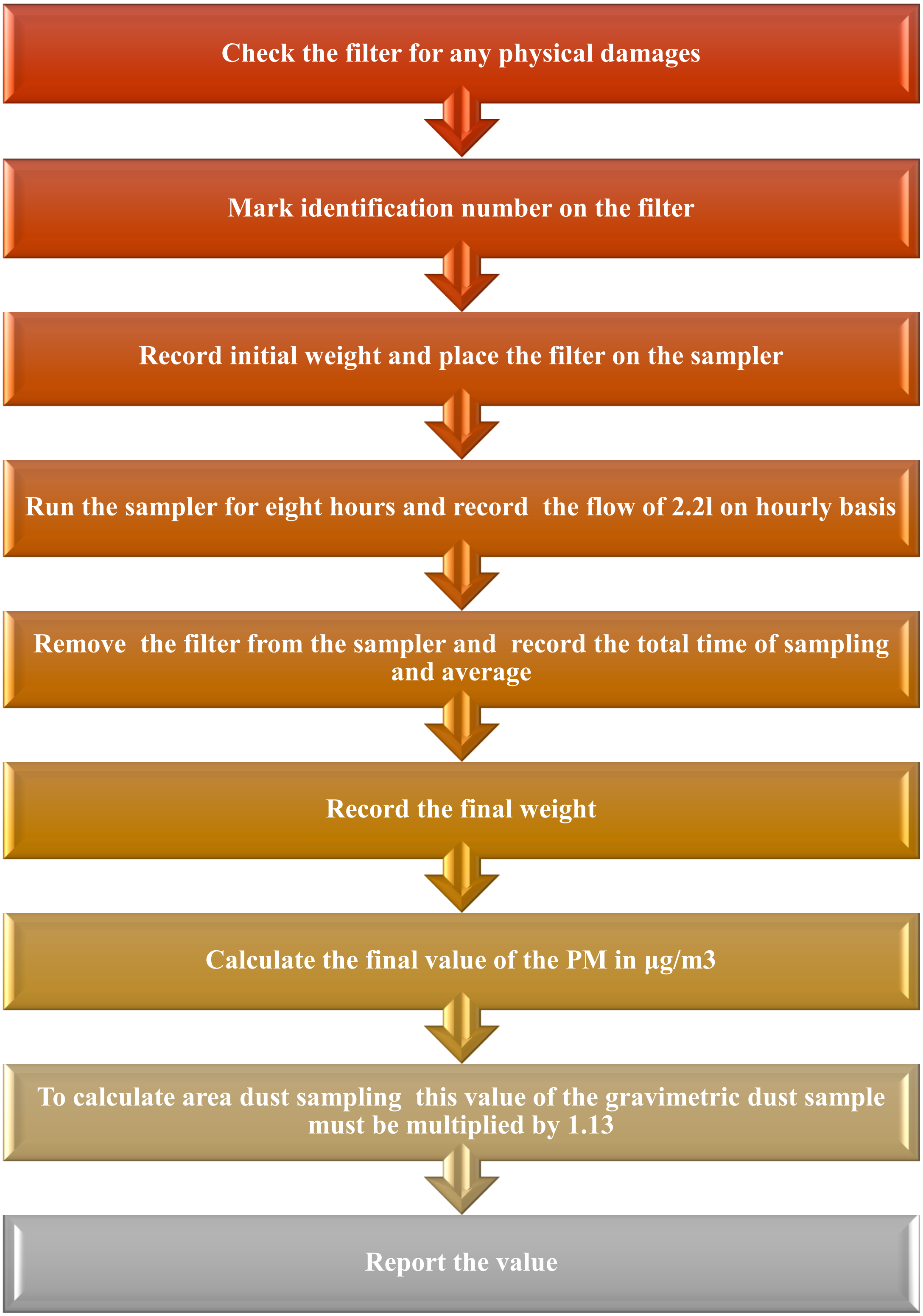

Plate: 11 Procedure for air sample measurement for RSPM.

Plate: 12 Dust sample analysis

4.2.2. Anthropometric measurements

Height: Height was measured using a stadiometer fixed to the wall. It was measured without shoes to the nearest centimeter.

Weight: Weight was measured using digital weighing scale. The subject was made to stand barefoot on the center of the weighing scale, kept on the flat platform, with minimal clothing without touching anything else and measured to the nearest kilogram **(123)**.

4.2.3 Demographic profile and the respiratory symptoms

ATS American thoracic society questionnaire (ATS DLD -78) was used. The ATS DLD -78 was designed to assess the prevalence of chronic respiratory symptoms and disease which is a modified version of BMRC (British Medical Research Council) questionnaire (**124)**.

4.2.4. Pulmonary function tests

Spirometry is essential for health surveillance of workers in order to diagnose lung dysfunction **(125)**.Spirometry was performed after demonstrating the procedure to the participants. The subjects were asked to take deep inspiration from the external air followed by forceful expiration into the mouthpiece of the Clarity Spirotech in standing posture. It was ensured that the mouthpiece was inserted without any leakage of air or obstruction by the lips or teeth and forced expiration continued to completion without a pause. The subjects inspired rapidly again to maximum capacity. The subjects were asked to repeat the procedure three times and the best one was taken. All the lung volumes and capacities obtained (FVC, FEV1, PEFR and FEV1/FVC ratio, were expressed with correction for Body Temperature at the Ambient Pressure, Saturated with Water vapor (BTPS)**(126) .**Data of the subjects which did not match the acceptability and reproducibility criteria of ATS was discarded. The acceptability criteria of ATS includes satisfactory start of the test (extrapolated volume of less than 5% of FVC or 0.15 L, whichever is greater), was considered. The reproducibility criteria is that the difference among two largest FVC and FEV1 values should not exceed 0.2 L **(127)**.

The computerized spirometer provided values with the graph for FVC, FEV1 and PEFR. All displaceable volumes were reported in liters.

Classification of ventilatory abnormality in spirometre (120,121)

PARAMETER	**Normal**	**Obstructive**	**Restrictive**	**Mixed**
FEV1	Above 80% Predicted	Reduced	Normal or Mildly Reduced	Reduced
FVC	Above 80% Predicted	Reduced or normal	Reduced	Reduced
FEV1/FVC	Above 0.7	Reduced	Normal or Increased	Reduced

Plate 13: Recording pulmonary function test

4.2.5. Oxygen saturation (SpO2) and Pulse rate

Blood SpO2 and pulse rate were recorded using pulse oximeter (Romsons imported and marketed by Rennex Medical, New Delhi, India). Pulse oximeter uses a light sensor containing two sources of light (red and infrared) that are absorbed by hemoglobin and transmitted through tissues to a photo detector. The amount of light transmitted through the tissue is then converted to a digital value representing the percentage of hemoglobin saturation. Hence, the sensor device is placed around the pulsating arteriolar bed of finger (e.g., left or right index), and the SpO2 and pulse rate were also recorded **(128)**.

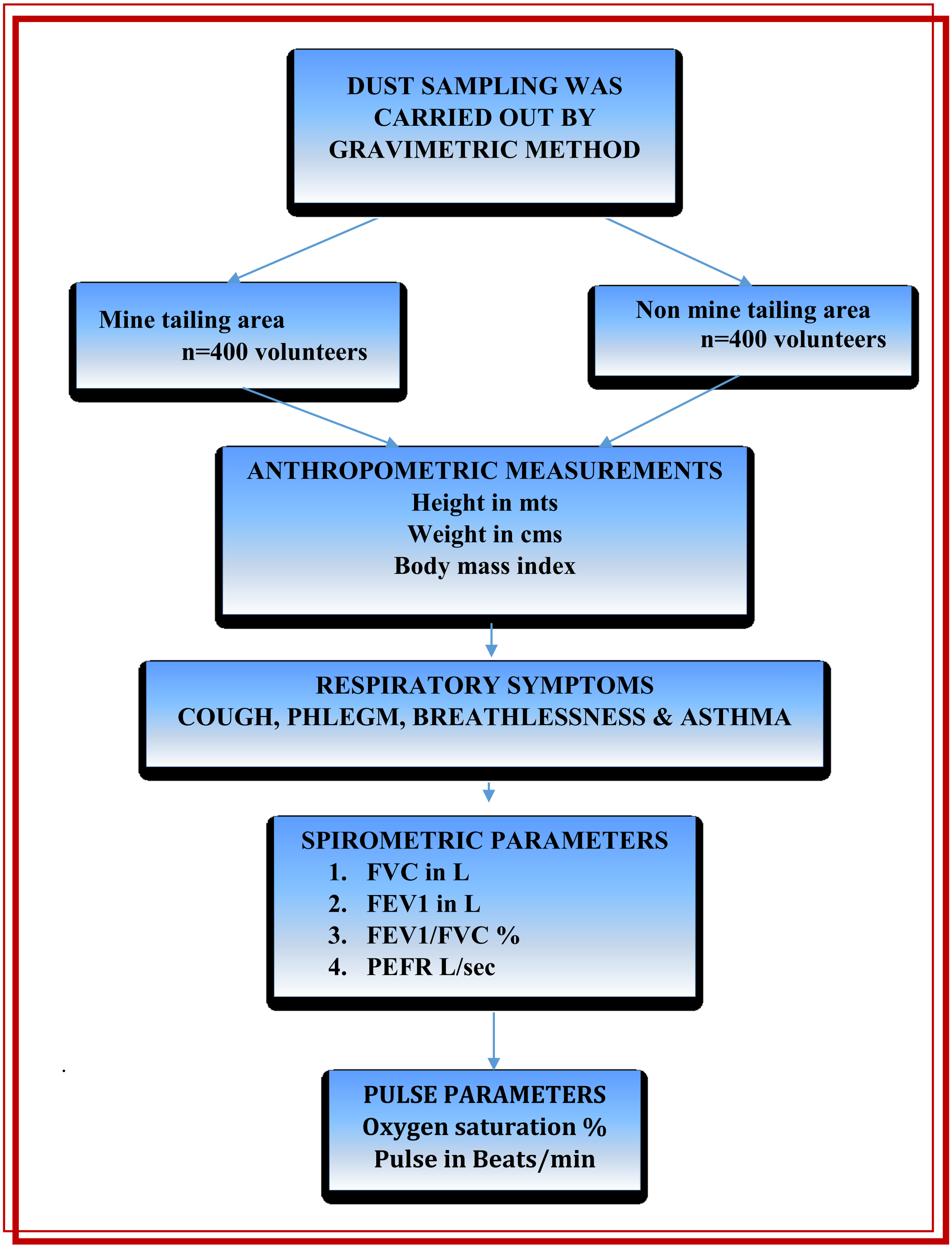

Plate: 14: Steps For Collection Of Data

4.2.6. Data Interpretation and Statistical Analysis

- Statistical Package for Social Science (SPSS) version 20 was used to analyze data
- Microsoft Excel 2007 to arrange and organize the data.
- Descriptive statistics was used to summarize demographic description and anthropometric measurements of subjects.
- Chi-square test was used to analyze and estimate the prevalence of respiratory system symptoms.
- Independent sample t-test was used to compare the mean values of FVC, FEV1, FEV1/FVC ratio and PEFR of exposed and non-exposed population.

RESULTS AND ANALYSIS

In the present study 400 subjects from the mine tailing area (exposed population) and 400 subjects from the non-mine tailing area (unexposed population) were selected based on the inclusion and exclusion criteria. After informed consent demographic details were recorded and analysis for respiratory symptoms was done using the ATS DLD-78 Questionnaire.

Recording of pulmonary functions were done using computerised spirometer. Oxygen saturation and pulse rate were recorded using pulse oximeter. Air samples of the mine tailing area and the non-mine tailing area were measured using Gravimetric sampler.

Data Interpretation and Statistical Analysis

The data was suitably arranged into tables for discussion under different headings. (SPSS) version 20 was used to analyze data. Descriptive statistics was used to summarize demographic description and anthropometric measurements of subjects. Results on continuous measurements are presented as mean ± standard deviation and the results on the categorical measurements are presented as numbers%. Chi-square test were used to analyze and estimate the prevalence of respiratory system symptoms. Significance were assessed at 5% level of significance.

To compare the differences between the mean spirometric values, FVC,FEV1,FEV1/FVC and PEFR, air samples , oxygen saturation and pulse rate of the exposed and the unexposed population using independent student ‘t’ test **(129).**

The level of significance was fixed at p=0.05. Multiple logistic regression was carried out to assess odds ratio of various potential risk factors like place, fuel, smoking habits, gender and age. Conclusion was drawn based on the outcome of this statistical treatment.

Table 1: Comparison of respirable dust concentration of the mine tailing and the non - mine tailing area

Sl no	**Variable**	**Mine Tailing area Mean ± SD**	**Non Mine tailing area Mean ± SD**	***t* value**	**P value**
1	Area dust mg/m3	1.491 ± 0.737	0.4800 ± 0.278	-3.455	<0.003

Independent t test

Table.1 shows the mean respirable area dust concentration was significantly higher in mine tailing area when compared to non-mine tailing area.

Table 2: Demographic profile of the exposed and unexposed population

Sl no	Parameters	Sub division	Exposed Population n=(400) n (%)	Unexposed Population n=(400) n (%)
1	Age	<40yrs	180 (45)	164 (41)
		>40yrs	220 (55)	236 (59)
2	Gender	Males	143(35.8)	183(45.8)
		Females	257(64.3)	217(54.3)
3	Religion	Hindu	260 (65)	378(94.5)
		Christians	92 (23)	11 (2.8)
		Muslims	48 (12)	11 (2.8)
4	Marital Status	Single	34 (8.5)	63 (15.8)
		Married	358(89.5)	314 (78.5)
		Widow	08 (2)	23 (5.8)
5	Education	Illiterate	53(13.3)	108(27)
		Primary	96(24)	128(32)
		Secondary	168(42)	83 (20.8)
		University	83(20.8)	81 (20.2)
6	Occupation	Retired	12(3)	16 (4.1)
		Housewife	173(43.3)	107 (26.8)
		Agriculturist	50 (12.5)	50 (12.5)
		Unskilled laborers	32(8)	42 (10.5)
		Skilled laborers	88(22)	136 (34)
		Business	29(7.25)	49(12.3)
		Government service	11(2.8)	0
		Others	05(1.3)	0
7	Income	1000-10,000	184 (46)	237 (57.8)
		10,000-20,000	93 (23.3)	77 (19.3)
		20,000-30,000	41 (10.3)	40 (10)
		30,000 and above	2 (0.5)	22 (5.5)

Table. 2 shows the demographic profile of 400 subjects from the exposed and the unexposed population. 220(55%) among exposed group and 236(59%) among unexposed group belonged to age group more than 40 years, 257(64.3%) among exposed and 217(54.3%) among unexposed were female participants,

260(65%) among exposed and 378(94.5%) among unexposed group belonged to Hindu religion. 358(89.5%) among exposed and 314(78.5%) among unexposed were married. 168(42%) among exposed and 83(20.8%) among unexposed had completed secondary education. 88(22%) among exposed and 136(34%) among unexposed were skilled workers.

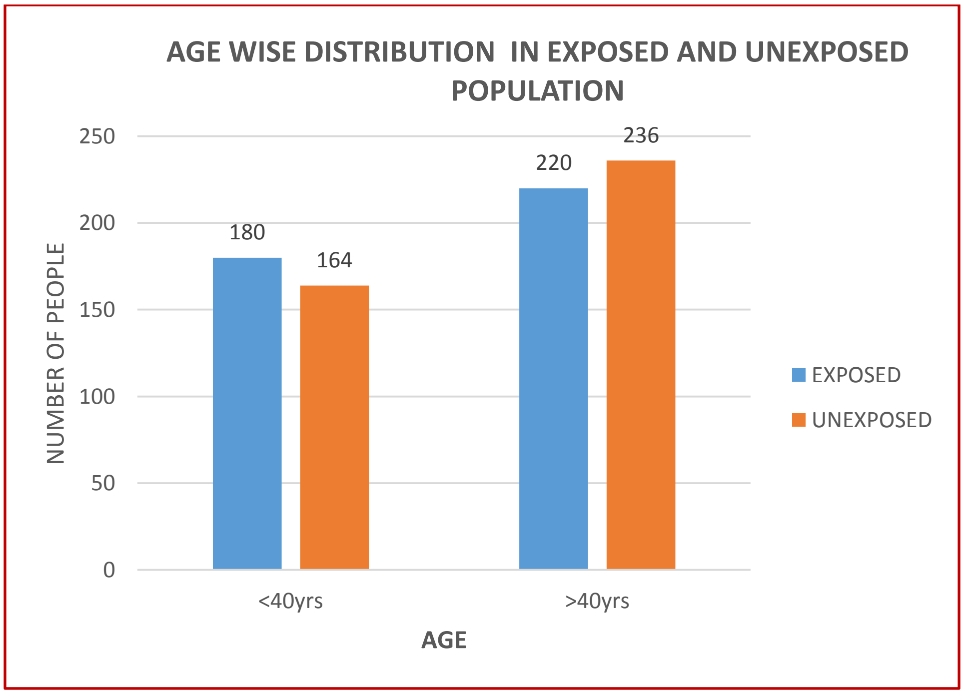

FIG. 1 Age wise distribution in the exposed and unexposed population

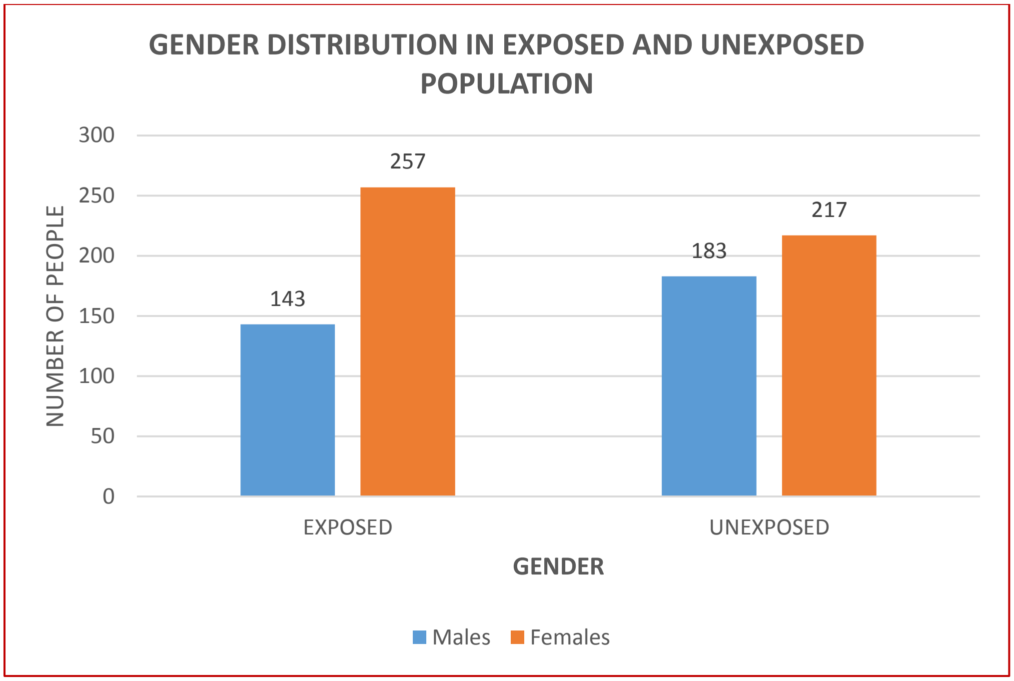

FIG.2 Gender distribution of the exposed and unexposed population

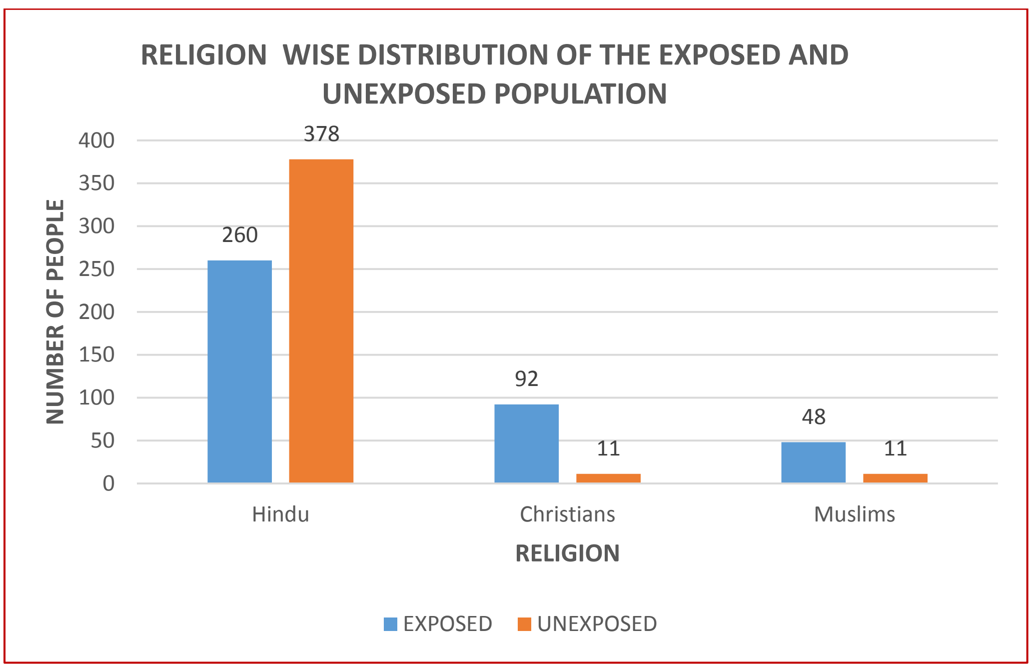

FIG.: 3 Religion wise distribution of the exposed and unexposed population

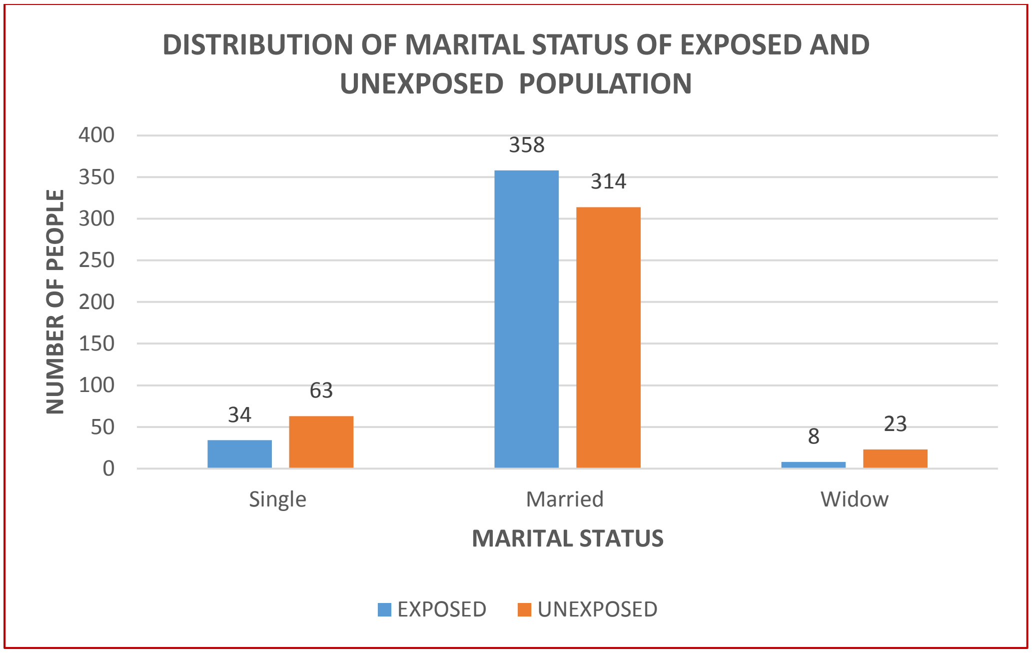

FIG. 4 Distribution of the marital status of exposed and unexposed population

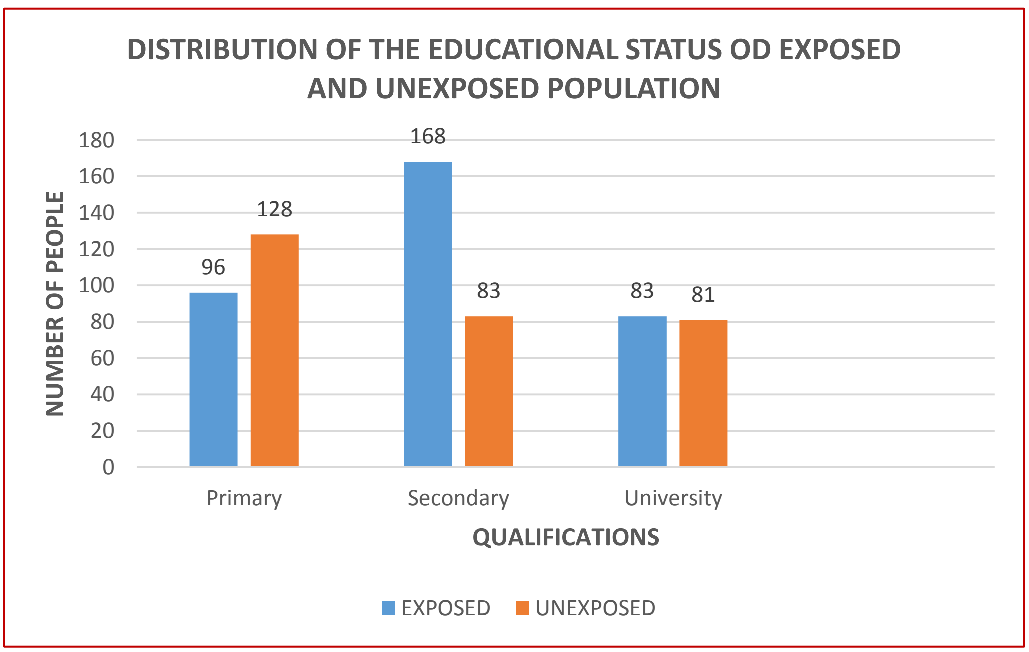

FIG. 5 Distribution of the educational status of the exposed and unexposed population

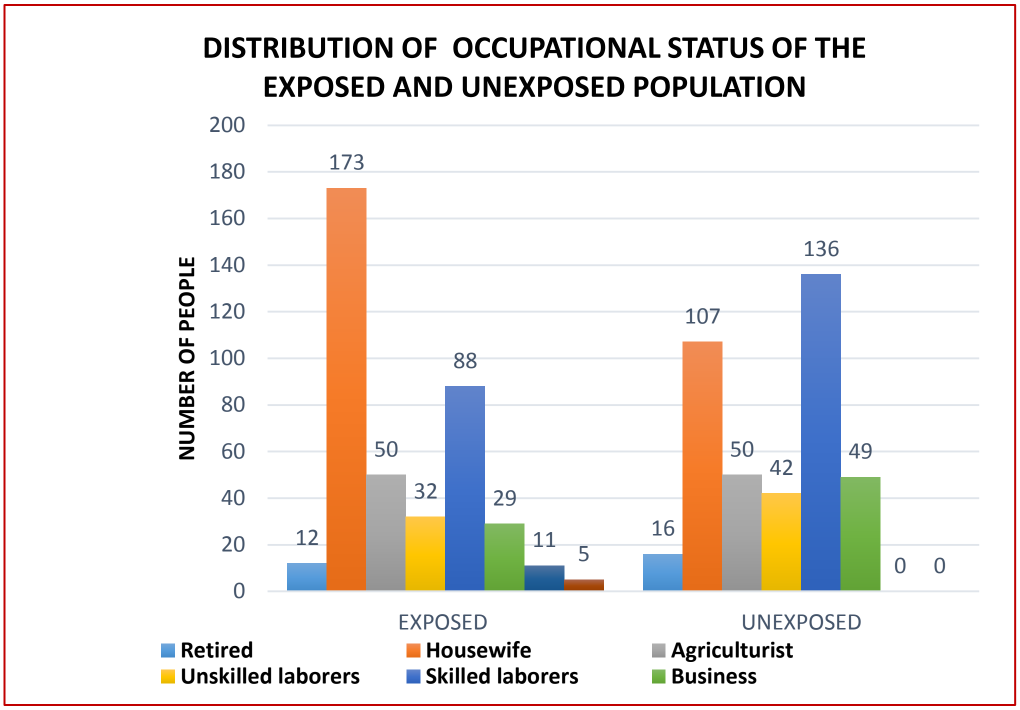

FIG. 6 Distribution of occupational status of the exposed and unexposed population

Table 3: Comparison of Age, BMI and duration of stay in the exposed and unexposed population

Variables	Exposed Mean $\pm$SD	Unexposed Mean $\pm$SD	*t* value	P value
Age (years)	42.23 $\pm$ 110.47	41.67$\pm$ 11.43	-3.937	0.466
BMI (kg/m^{2})	25.38 $\pm$ 5.46	25.29 $\pm$5.29	-0.275	0.784
Duration of stay (Years)	39.91 $\pm$ 12.25	38.36$\pm$ 11.20	-1.868	0.062

Independent t test

Table. 3 shows that P value did not show any significant difference for age, BMI and duration of stay indicating that the data was matched

Table 4: Perception regarding air pollution and the effect of mine tailing on the health of exposed and unexposed population

Sl no	Questions	Comment	Exposed n=(400) n (%)	Unexposed n=(400) n (%)	χ^2	P value
1	Do you think your surrounding is polluted	Yes	267 (50.3)	264 (49.7)	0.050	0.822
		No	133 (49.4)	136 (50.6)		
2	Do you think that the mine tailings has ill effect on your health	Yes	206(46.9)	233 (53.1)	3.680	0.06
		No	194 (53.7)	167 (46.3)		

Chi-square test

Table. 4 shows that the P value did not show any significant difference in the perception regarding air pollution in their surrounding or on the ill effects of mine tailings on their health.

Table 5: Comparison of the fuel used by the exposed and unexposed population.

Sl no	Variable Type of the fuel used	Exposed n=(400) n (%)	Unexposed n=(400) n (%)
1	Liquid Petroleum Gas	294 (73.50)	343 (85.75)
2	Kerosene	66 (16.50)	29 (7.25)
3	Wood	40 (10)	28 (7)

Table. 5 shows that prevalence of the usage of LPG is more in both exposed and unexposed with 294(73.5%) and 342(85.7%) when compared to kerosene and wood.

Table 6: Comparison of the respiratory symptoms in the study areas

Sl no	Respiratory symptoms	Response	Exposed n=(400) n (%)	Unexposed n=(400) n (%)	χ^2	P value
1	Cough	Yes	153(38.25)	132(33)	2.634	0.121
		No	247(61.75)	268(67)		
2	Phlegm	Yes	123(30.75)	90(22.5)	6.968	0.008
		No	277(69.25)	310(77.5)		
3	Breathlessness	Yes	132(32.8)	86(21.75)	12.512	0.001
		No	268(67.2)	314(78.25)		
4	Asthma	Yes	89 (22.2)	31(7.8)	32.920	0.001
		No	311(77.8)	369(92.2)		

Chi-square test

Table. 6 Pearson's chi square test was carried out to compare the prevalence of respiratory symptoms of the exposed population to the unexposed population. Cough with a prevalence of 38.25% in exposed population when compared to 33% in unexposed population was not statistically significant (χ^2 =2.634, P=0.121) . Phlegm with a prevalence of 30.75% in exposed population compared to 22.5% in unexposed population was significantly higher (χ^2 =6.968, P=0.008). Breathlessness with prevalence of 32.8% in exposed population compared to 21.75% in unexposed population was significantly higher (χ^2 =12.512, P=0.001).Asthma with prevalence of 22.2% in exposed population compared to 7.8% in unexposed population was significantly higher (χ^2 =32.920, P=0.001)

Table 7: Comparison of the pulmonary function test in the exposed and unexposed population

Sl no	Lung function	Exposed Mean ±SD	Unexposed Mean ±SD	*t* value	P value
1	FEV1(L)	1.335±0.546	1.733± 0.576	0.868	0.001
2	FVC (L)	1.427±0.577	1.855± 0.661	7.162	0.001
3	FEV1/FVC	0.964 ±0.034	0.933±0.088	6.482	0.001
4	PEFR L/Sec	2.746 ± 1.286	3.739± 1.474	83.519	0.001

Independent t test

Table .7 shows that the pulmonary function test parameters were significantly lower in exposed population compared to unexposed population except in FEV1/FVC.

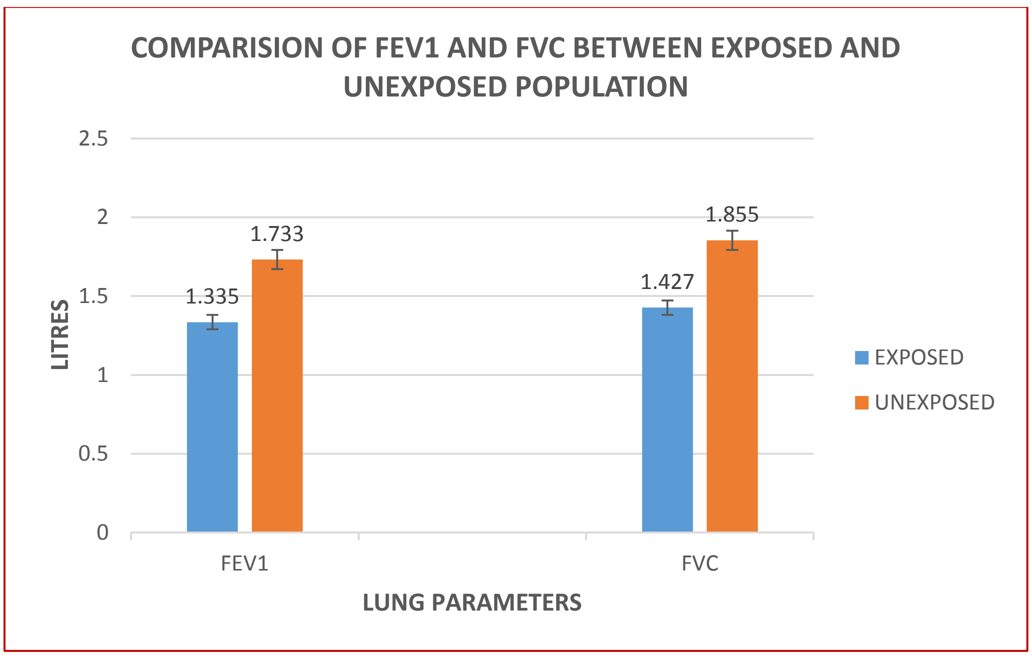

FIG.7 Comparison of the FEV1 and FVC between exposed and unexposed population

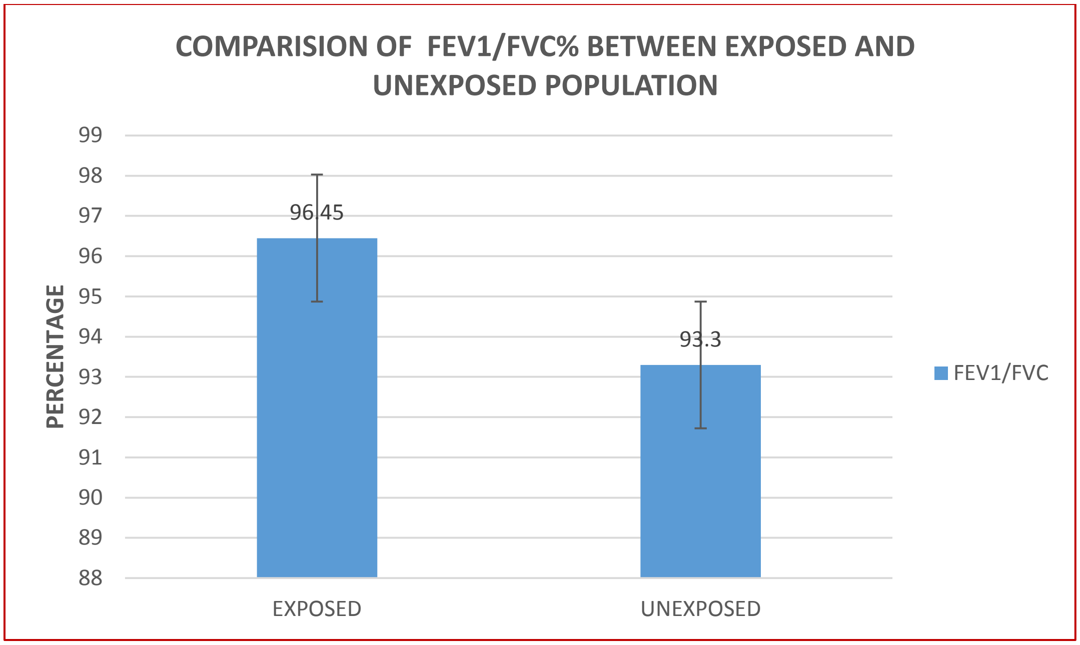

FIG. 8 Comparison of the FEV1/FVC% between the exposed and unexposed population

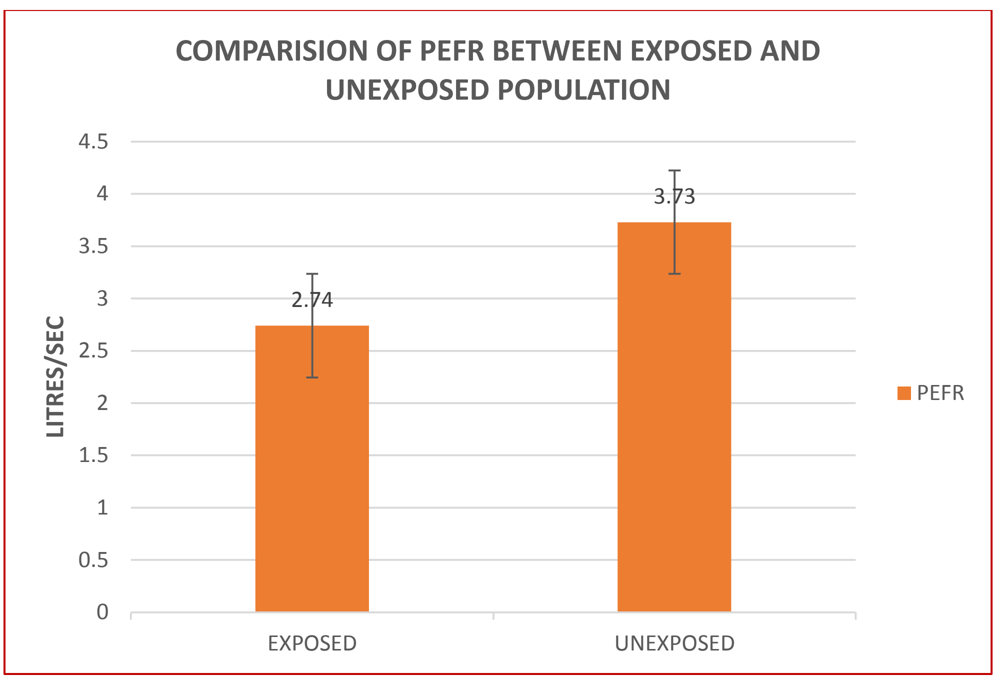

FIG. 9 Comparison of The PEFR Between the exposed and unexposed population

Table 8: Comparison of the pulmonary function test parameters in predicted percentage in the exposed and unexposed population

Sl no	Parameters	Exposed Mean ± SD	Unexposed Mean± SD	t value	P – value
1	% FVC	59.52± 21.54	69.43 ± 22.69	6.335	0.001
2	% FEV1	68.91 ± 24.45	79.32 ± 21.91	6.339	0.001
3	% PEFR	44.27± 22.20	56.48 ± 38.76	5.465	0.001
4	% FEV1/FVC	96.457±3.465	93.304± 8.847	6.482	0.001

Independent t test

Table. 8 shows that the pulmonary function test parameters in predicted percentage were significantly lower in exposed population compared to unexposed population except in the % FEV1/FVC which was significantly higher.

Table 9: Distribution of the abnormal pulmonary function in exposed and unexposed population.

Sl no	PFT Impression	Exposed n=(400) n (%)	Unexposed n=(400) n (%)
1	Normal	145 (36.25)	214 (53.50)
2	Abnormal	255 (63.75)	186 (46.50)

Table. 9 shows that the prevalence of abnormal lung function test in exposed population (63.75%) is higher compared to unexposed population (46.50%).

Table 10: Comparison of oxygen saturation and pulse rate between unexposed and exposed population.

Sl no	Variables	Exposed n=400 Mean ± SD	Unexposed n=400 Mean ±SD	t value	P value
1	SPO2 (%)	96.52± 3.52	97.54± 1.13	-5.51	0.001
2	Pulse rate (bts/min)	85.55±13.45	82.07±12.02	3.857	0.001

Independent t test

Table. 10 shows that SPO2 (%) was significantly lower in the exposed population compared to unexposed population and the pulse rate are significantly higher in the exposed population.

Table 11: Association of risk factors between exposed and unexposed population as assessed by multiple logistic regression

		Total	Compromised	Crude odds ratio (CI)	P value	Adjusted odds ratio(CI)	P value
Place	**Kolar**	400	183 (45.8%)	1.39 (1.22-1.53)	<0.001	1.45 (1.27-1.67)	<0.001
	KGF	400	254(63.5%)				
Age	**<40 years**	341	185 (54.3)	1.01 (0.89-1.15)	0.855	0.96 (0.85-1.08)	0.500
	>40 years	459	252 (54.9)				
Gender	**Male**	325	166(51.1%)	1.12 (0.98-1.28)	0.100	1.1 (0.97-1.25)	0.158
	Female	475	271 (57.1%)				
Smoker	**NO**	664	361 (54.4%)	1.03 (0.87-1.21)	0.744	1.15 (0.99-1.35	0.068
	YES	136	076 (55.9%)				
Fuel	**LPG**	636	353 (55.5%)	0.92 (0.78-1.08	0.308	0.83 (0.71-0.98)	0.27
	Others	083	083 (51.6%)				

Table. 11 shows that multiple logistic regression carried out to assess the odds ratio of potential risk factors like place, fuel, smoking habits, gender and age. The odds ratio showed that staying in KGF had a 1.45 times risk of developing compromised pulmonary function.[O.R- 1.45 (C.I 95% 1.27-1.67) *P*< 0.001]

DISCUSSION

Air pollution is among the serious environmental hazards that lead to non-infectious respiratory & heart diseases including cancer. Ambient quality of air, world-wide continues to deteriorate affecting mainly countries that are developing, affecting people are from the middle and lower socioeconomic strata and the population that are very young or old in age spectrum **(130)**. Growth of industries are one of the worst environmental pollutant.

The gold mines of KGF have been closed for almost 2 decades with very little published data on the effects of the remains of mines on the residents here. Here the study aimed to assess how the mine dumps affected the quality of air especially the respirable fraction (RSPM) and whether it affected the pulmonary system. This kind of study would also create awareness about the quality of air in their area and how they may be affected by it.

6.1 AIR SAMPLING

Gold mining was the core of the economy here until the mines closed. Mine closure was accompanied by a lack of rehabilitation and reclamation treatment of mine dumps and tailings dam resulting in environmental and human impacts, including those related to dust emissions. Wind-blown dust consists mainly of larger particles considered more a nuisance and does not affect health; however the smaller particles of RSPM have severe health impacts. In the published data of 2001 regarding effect of mine tailing in KGF on environmental pollution, it was seen that there was increased concentrations of PM though the actual concentration were not mentioned and reported that and pollution was worsen by the weather conditions **(13).**Further in 2009, the RSPM concentration was further increased with seasonal variations **(14)**.

One of the objectives of our study was to assess the RSPM concentration in the mine tailing area and to study if they influenced air quality even after almost 2 decades after no fresh tailings. This was studied using gravimetric method with the help "National institute of miner's health- NIMH". The RSPM analysis was 1.491± 0.737 in mine tailing area and 0.480± 0.278 in non -mine tailing area (Table 1) which was significant in areas with tailings. This seemed obvious as at the time of closure of KGF mines, nearly 33 million tons of mine tailings were dumped across 8 kilometers with sparse vegetation cover. Exposure to wind generates mineral dust increased PM concentration and becomes a persistent environmental hazard for the residents **(62).** In our study the exposed population lived within 500 meters of mine tailing exposing them to concentrations that was well above the guidance value of 60μm.

6.2 AWARENESS AND PERCEPTION REGARDING AIR POLLUTION

To prevent pollution or diseases, it is essential to create awareness and educate regarding the same **(131)**. Individual and collective perception regarding the quality of environment around them is imperative to bring about behavioral changes and accept intervention strategies **(132)**. Educational level, economic status and culture further influence the perception of risk **(133)**. So, we studied the awareness and perception of pollution in air in the groups. Both groups believed their residential areas were polluted. However, only 46.9% of the residents of the mine tailing town thought that mine tailing affected their health compared to 53.1% in the other group (Table 4).This came as a surprise as 42% of the residents in the mine tailing area compared 20% in the non-mine tailing area was educated with a minimum qualification of secondary school certificate. This difference of perception may be because they have always been exposed to pollution resulting from mining and mine tailings.

6.3 RESPIRATORY SYMPTOMS

Respiratory symptoms are the most common presentation to a clinician. Symptoms of cough, phlegm, and breathlessness are important indicators of respiratory morbidity. Use of validated questionnaire can help in the screening of the same in population studies.

The prevalence of respiratory symptoms in the exposed and the unexposed population for cough, phlegm, and breathlessness were 38.25% Vs 33%, 30.75% Vs 22.5% and 32.8% Vs 21.75% respectively which were significantly higher in the exposed population when compared to unexposed population except for cough (Table 6). The prevalence of chronic cough and phlegm have not been well documented in India but reported prevalence were between 2.4-5.6% in rural areas and varied from 1.7 to 5.45% in different centers of urban part of India **(134)**. In a cross sectional survey done in Mysore taluk on 4333 population the reported prevalence of chronic cough and phlegm was 2.5% and 1.2% respectively **(94)**. The increase in symptoms in the exposed population of our study may be attributed to the increase in exposure to particulate matter concentration in the mine tailing area. PM gets trapped by the mucus in the nasopharyngeal tract and cleared by sneeze or nasal drip. Those that enter the passages and often get cleared by cough, increase macrophage activity and phlegm formation.

In a similar study done in Ghana, it was demonstrated that air quality was affected by gold mines resulting in increased respiratory complaints with a prevalence of 21.2% in chronic bronchitis and 31.3% in breathlessness **(55)**. Among elderly living in proximity to the mine tailings, there was significant higher prevalence of respiratory symptoms compared to the unexposed population **(88)**. Increase in PM concentration from traffic of vehicles had more respiratory complaints in people monitored using respiratory questionnaire with the prevalence for cough 43%, breathlessness 25% & asthma 11.2% which were comparable to our study **(63)**. Pollutants from combustion (PM2.5) led to increased complaints of cough, wheeze and shortness of breath in children **(135,136)**.

Studies were mostly done to understand the degree of hazard in the employees in various industries of occupational nature. Cement factory workers had prevalence for cough 30% and phlegm 25% which were similar to our study even though ours was a population based study. This shows that though our population were only residents, the affect was high, a reflection of the pollutant content in the air from mine tailings. The frequency of shortness of breath was 38% in our study compared to 8% in their study **(137)**. Studies done in industries of textile, wood, stone works and miners have shown increase work related respiratory symptoms of which cough showed highest prevalence **(138, 139)**. They were same as the study conducted by Milanowski et al among furniture factory workers in Poland, Lublin Region which showed a higher prevalence of work-related respiratory symptoms in wood workers than in controls **(140)**. Nagoda et al. found that complaints of respiratory symptoms such as cough, phlegm production, rhinitis, wheezing, chest pain, and breathlessness were higher in the exposed textile workers compared to unexposed workers. Workers in cotton industry had a greater frequency of symptoms with lower FVC, FEV1, and PEFR than unexposed workers **(141)**.

6.4 LUNG FUNCTION PARAMETERS

Respiratory symptoms are indictors of respiratory morbidity but diagnosis of the same will be done only on assessment of functional state of respiratory system. This can be done by spirometry, a simple tool to access lung functions that permits a precise and reproducible assessment of functional state of respiratory system. The commonest parameters studied are

FVC, FEV1, FEV1/FVC and PEFR. FVC is a measurement of lung volume rather than rate. Measurements of FVC combined with FEV1 are more authentic in diagnosing respiratory insufficiencies. FVC and FEV1 declines with age as a part of normal aging process but an enhanced or accelerated decline occurs in lung disorders when working in dusty work areas or even air pollutants **(79)**.

FVC, FEV1 and PEFR in our study were notably lower in the exposed population when compared to unexposed population as seen in Table.7 The exposed population lived in close proximity to the mine tailings for an average of 39 years exposing themselves to the high concentration of RSPM that was significantly greater and three times more than the levels of non-mine tailing area. In Ghana, when the residents in the area of gold mining were studied, they recorded significant decrease in pulmonary function parameters **(55)**. In a large scale cross sectional study done in Switzerland (SAPALDIA) where 9651 adults took part in the study, they demonstrated detrimental effect on FEVI, FVC with a 9% decrease in FEV1 yearly and increase prevalence of respiratory symptoms with an annual increment of 10mg/m^3 in PM10. The effect of was higher for FVC estimates than for FEV1 suggestive of a restrictive pattern **(32)**. Studies have not been able to explicitly demonstrate whether air pollution results in obstructive or restrictive disorders **(58)**.

Increased prevalence of heart and pulmonary diseases (using questionnaire) was observed in the old in South Africa who lived in close proximity to mining dumps. The other important risk factors were age, occupational exposure, history to dust/chemical fumes and type of fuel used for heating/ cooking in the home **(142)**.

Most of the studies done were to assess the occupational risk of workers to different PM exposure. There were decrease lung functions with increased exposure with cumulative effects. In cross sectional studies among copper miners, increase work place exposure was associated with decline in FEV1 and FVC (**58, 72)**. Sumana et al in their study in cement factory workers showed the performance on pulmonary function tests was poor in workers in construction industry compared to healthy controls. **(79).** Dust particles of <10microns pose a health hazard to such workers as it easily gains entry into the lower respiratory tract leading to disability among workers. Qian QZ et al recorded higher abnormal pulmonary function in coal mixture workers, characterized by decreased FVC%, FEV1%, FEV1/FVC% and suggested that dust-exposed duration as aa critical risk factor that affects pulmonary function. The lung functional indices (FEV1%, FEV1/FVC%, and FVC%) in coal mixture workers were significantly lower than those in the control group, showing that the pulmonary function indices in the exposed group had decreased significantly, and serious pulmonary function damage was observed. **(73)**. Studies conducted in Poland on occupational exposure to wood dust showed impaired FVC and FEV1 with no changes in FEV1/FVC ratio indicating restrictive pattern but no traces of obstruction. **(143)**. People who worked with cotton had a more frequency of symptoms with lower FVC, FEV1, and PEFR than unexposed workers **(141)**.

Respiratory dysfunction was 62% in the exposed population to 46% in the unexposed population with the majority suggestive of restrictive pattern (Table 9). The plausible explanation for this increased prevalence of lung dysfunction in exposed group would be because mine tailing dust reacts with lymphoid and connective tissue of the terminal bronchioles and interstitial inflammatory cells. Most inhaled dust is filtered out by the upper airways or cleared by the ciliated epithelium of large airways. If these defenses are overwhelmed by fine dust (less than 10 μm in diameter), however, the lung reacts with an alveolar and interstitial inflammation causing restrictive lung disease **(144).**

There has been some debate about using observed values, predicted % or even percentile values in lung parameters in comparison research studies. Age, height, sex and race influence these parameters. Predicted % are corrected for these values and would be of better use in comparing groups.**(145)**. The "American Thoracic Society/European Respiratory Society" suggested using a percentile-based approach to define an abnormal test. However, Pakhale Setal showed that the results of the per cent predicted and percentile-based approaches for pulmonary function test interpretation were same for most parameters in lung function, so the two methods are interchangeably for spirometry **(146)**.

All spirometric parameters differed with significance when observed values were used to compare both the groups (Table7).So, predicted % for the same parameters were compared between exposed and unexposed population. FVC%, FEV1% and PEFR% and were significantly lower while that of FEV1/FVC% was significantly higher in exposed population as shown in (Table 8) which was the same as to what we have got using observed values.

6.5 PEAK EXPIRATORY FLOW RATE

PEFR is changes with age, sex, height, weight, body surface area, environment and ethnic differences **(147)**. It is also very useful in the assessment of severity of airway obstruction **(148)**.The exposed resident population recorded significant lower PEFR values when compared to those from unexposed group as represented in table 7. The most likely explanation for this could be that most of the exposed group participants were born here and having a life time exposure. Peak flow rate mainly reflects the caliber of the bronchi and larger bronchioles which are subject to reflex bronchoconstriction causing narrowing of airways and increasing the resistance in air ways leading to decrease PEFR. Our study findings were the same as that of Gupta. P et al (1999) who reported that various kinds of dusts decreased PEFR**(149)**. Air pollutants irritate the respiratory passages, increase inflammation of bronchial walls and increase secretion of mucus. This leads to narrowing of the conducting systems resulting in increasing the resistance in the airways.

6.6 OXYGEN SATURATION AND PULSE RATE.

The link between particulate matter quantity and cardiorespiratory morbidity have to an extent made clear with scientific research. Two of the parameters studied here are oxygen saturation and pulse rate using pulse oximeter. Though the values recorded were within normal range, a significant decrease in oxygen saturation with higher in pulse rate were observed in the exposed group (Table 10). The underlying mechanism though is not well established, a plausible explanation for decrease in oxygen saturation is that, the increase in air pollutants result in oxidative species, leading to oxidative stress leading to lung damage and inflammation causing decrease in pulmonary function and oxygen supply. In 1985, a connection between pollutant levels in air and pulse rate has been recorded, where air pollution by increasing plasma viscosity increased the pulse rate **(150).** In the MONICA Augsburg cohort study, it was observed that spikes in air pollution with concentrations of sulphur- oxide, carbon- monoxide and TSPM were reflected by increase in heart rate consistently (**49**).Another reason can be because of alteration in autonomic function from the inflammation arising form heart and lungs. Moreover, the levels of PM concentration beyond which it affects cardiorespiratory mechanism is yet to guided. Strangely, cardiorespiratory morbidity continues to jump even in countries with stringent safety guidelines, again the dilemma of safe levels. **(151)**.

So far, it was clear that the exposed population had significantly higher lung dysfunction. Major factors that influence this further would be smoking, age and sex. So, multiple logistic regressions were carried out to assess their strength of influence in the development of lung dysfunction. Uni-variate analysis for place of stay identified that staying in KGF -mine tailing area raised the risk significantly by 1.39 (1.2-1.53) and on adjusting the odds ratio, it was significant with odds of 1.45 (1.27-1.67). The confounding factors analyzed for influence indicated that the factor that increased the risk of lung dysfunction in our study happens to be the place of stay that is mine tailing area in this case. In fact, it was the only factor with age and gender not influencing the findings.

SUMMARY

Air pollution has been increasing recognized as one of the most important risk factor in the development of non- communicable disease posing a heavy economic burden on countries. It is known to affect major organ systems like respiratory, cardiovascular and central nervous system. With deteriorating air quality, the quality of life also deteriorates. India ranks among the countries that have highest air pollution which has been recognized by our government and the "National clean air program" has been launched. With mining recognized as among the worst environmental pollutants, it seem logical to study the respiratory diseases burden of the population living in closed mining areas and near the mining tailing. It further tried to assess the air quality by estimating RSPM concentration using gravimetric method in the mine tailing area and non-mine tailing area from where the comparison group was selected.

After institutional ethical clearance and informed consent, 400 participants of both genders, between the ages of 18-60years with a minimum duration of stay of 3 years or more in their respective areas were selected from the mine tailing and non-mining tailing area each, and grouped as exposed and unexposed population. Personal interview was conducted and ATS DLD - 78 questionnaire used to document demographic details, respiratory symptoms, perception regarding pollution in their area and whether they perceived that mining tailing had ill effects on health. After recording the height and weight, computerized spirometer was conducted to record lung parameters of FEV1, FVC, FEV1/FVC and PEFR. Pulse oximeter was used to record percentage oxygen saturation and pulse rate.

All the data recorded were analyzed using (SPSS) version 20. Descriptive statistics was used summarize demographic details, Chi-square test to compare prevalence of respiratory

symptoms, independent t tests for lung parameters, oxygen saturation and pulse rate. Multiple regression analysis was used to calculate the odds ratio of potential risk factors for developing lung abnormality.

The results showed that the important parameters of age, gender and duration of stay were comparable showing that the 2 groups were matched. The RSPM concentration was 1.49 ± 0.737 mg/m^3 in mine tailing area compared to 0.480 ± 0.278 mg/m^3, which was significantly higher and well above the air quality standards. Participants of both groups thought their surroundings were polluted and higher percentage of unexposed population thought the mine tailing had ill effects on health. Respiratory symptoms of phlegm, breathlessness and asthma were significantly higher in the exposed population while lung parameters of FEV1, FVC and PEFR were significantly lower than the unexposed group with FEV1/FVC% was significantly higher in the exposed group. Percentage oxygen saturation was significantly lower and pulse rate significantly higher in the exposed group. Exposed population had a risk of 1.45 for decline in lung function than those of unexposed population.

The increased RSPM concentration in the mine tailing area may be due the windblown PM from the tailing to air which continue to pollute it even 17 years after closure of mines. The increased RSPM may be responsible for the presentation of increase respiratory symptoms by exacerbation of natural protective mechanisms. Long term exposure to PM can produce local inflammatory responses and depending on the load of exposure overwhelm the activation of macrophages, release of cytokines and stimulate fibrotic changes. All this can account for decrease in lung parameters and percentage oxygen saturation with a predilection toward restrictive pattern of disease. There is increasing evidence that air pollution can affect the cardiovascular system when UFPM cross the alveolar membrane and stimulate release of cytokines and ROS in the cells and produce autonomic imbalance. One of the earliest sign of this is increase in pulse rate and may be seen as a red flag.

It needs to be highlighted that this study has been able demonstrate mining can be one of the worst long standing pollutants of the environment resulting in what may be even irreversible damage. The resulting air pollution is associated with a huge burden of respiratory morbidity worsen by lower socio economic status and unawareness of pollution status. Perception regarding air pollution in their area of stay and cause of it would be the key to improving quality of life, fight for the right to clean air and take safety measures.

Further, strict implementation closure plans of mines including reversing environmental degradation becomes a priority. The biggest challenge faced would be maintenance of community health in the promise of economic development. So it is imperative that every mining company should have a clearly defined mine closure plans at the start of mining activity to which they should be legally adhering. These plans should not only address the environmental impacts but also the health and social status of the population following mine closure. Since development and manifestation of the health effects of mining among the population take several years and often goes unrecognized, a well-defined rehabilitation scheme by the government for regular periodic screening, counseling and health education related to such diseases should be implemented.

RECOMMENDATIONS

Based on the findings of our study.   The following recommendations are suggested for better and improved health of the people staying in the exposed region.

- Increase the awareness regarding air pollution among the community and methods to prevent further pollution.
- Watering or spraying the areas near the tailing during the windy seasons to reduce the dust.
- Educating the population regarding safety measures employable to prevent further deterioration of respiratory morbidity.
- Periodic health checkup for the exposed population.
- Periodic air sampling to forewarn the community to employ safety measures when air pollution is above safety guidelines.
- The mine closure plan in all mining projects should be stringently adhered to.
- Long term environmental and human rehabilitation programmes should be implemented.

STRENGTHS OF THE STUDY

- The study was conducted in a residential population that is exposed to considerable environmental air pollution but was not studied earlier.
- The study was conducted using an adequate sample size.
- Respiratory symptoms were assessed using a standard tool of American Thoracic Society - Division of Lung Diseases (ATS- DLD) an effective tool for screening respiratory illness. It was a useful add-on to spirometry.
- The study was done by a single researcher and chance for inter-observer bias was reduced.
- RSPM was assessed in the mine tailing and non-mine tailing regions.

LIMITATIONS OF THE STUDY

- Only RSPM was done using gravimetric method. Analysis of other air pollutants was not done.
- Bronchodilator reversibility test was not performed in spirometry
- Lung diffusion test was not conducted

ACHIEVEMENTS

1. Organized a State level CME titled **“Air quality measures and respiratory health effects”** on 27th August 2016.

2. Oral presentation titled **“Pulmonary function tests in the residents of the gold mining town and their association with chronic exposure to mining dust -** a pilot study in the above CME..

3. Oral Presentation titled “**The Influence of Central Obesity Assessed By Conicity Index on Lung Age In Young Adults”** at International conference on environment and occupational health- ENVOCCON 2016 organized by department of Physiology at Sree Balaji Medical College and Hospital Chennai in September 2016.

4. Participated in the National Women Science Congress conference and presented a paper (oral) on “**Pulmonary function and respiratory symptoms of the women exposed to mine tailings”** held at JSS College for women from 9th to 11th November 2018 at Mysuru and won the best paper award.

5. Presented a poster titled “**Effect of Mine tailing on the respiratory symptoms and functions in the residents of the gold tailing town in South India**.” at the 64th Annual National Conference of Physiologists and Pharmacologists of India held at Manipal on 29th and 30th of November 2018.

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PAPER SEND FOR PUBLICATION

"**Pulmonary function and respiratory symptoms of the women exposed to mine tailings"**

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ANNEXURE I
INFORMATION SHEET

Title of the study: Pulmonary functions in the residents of a gold tailing town and its association with chronic exposure to mining dust.

Investigator's statement:

Introduction – My name is **Mrs. USHA G. SHENOY** Assistant Professor in the department of Physiology, Sri Devaraj Urs Medical College, Kolar. We are carrying out a study on the assessment of environmental pollutants and its effects of respiratory function due to the dust emerging from the mine tailing among the people of KGF in comparison with the people of non-mine tailing region The study has been reviewed by the local ethical review board and has been started only after their formal approval.

Consent for the Study-At Kolar Gold Fields (KGF), Karnataka, tones of mill tailings were generated during mining of gold ore. Gold mining facilities also produce large quantities of effluent from the cyanidation process, which can contain free cyanide and a variety of metal-cyanide complexes. The mine tailings are also blown with wind leading to increased concentration of dust in air. This can possibly cause respiratory diseases. In this regard, I will ask you some questions about your household and the members staying at your household. You do not have to answer any questions that you do not want to answer and you may end this interview at any time you want to. However, your honest answer to these questions will help us better understand the health status of this area. We would greatly appreciate your help in responding to this survey. The survey will take about half an hour to ask the questions. Participation in this study doesn't involve any cost for you. This study is not only beneficial to you but also to the community in large.

All the information collected from you will be strictly confidential and will not be disclosed to any outsider unless compelled by law. This information collected will be used only for research.

I kindly request you to give consent for giving information and also for spirometry to identify airway obstruction. There is no compulsion to participate in this study. You will be no way affected if you don't wish to participate in this study. You are required to sign only if you voluntarily agree to participate in this study. Further, you are at a liberty to withdraw from the study at any time, if you wish to do so. Be assured that your withdrawal will not affect your treatment by the concerned physician in any way. It is up to you to decide whether to participate. This document will be stored in the safe locker in the department of Physiology in the college and a copy is given to you for information.

For any further clarification you are free to contact the principal investigator,

Mrs. **USHA G SHENOY**; Mobile No: 9880633910

ANNEXURE II
INFORMED CONSENT

Sl. no:

Title of the study: “pulmonary functions in the residents of a gold tailing town and its association with chronic exposure to mining dust.

I, the undersigned, agree to participate in this study and to undergo spirometry and disclosure of my personal information as outlined in this consent form.

I have been read out/ explained in my local language i.e. in _____________ and understand the purpose of this study and the confidential nature of the information that will be collected and disclosed during the study. I have had the opportunity to ask questions regarding the various aspects of this study and my questions have been answered to my satisfaction. The information collected will be used only for research.

I understand that I remain free to withdraw from this study at any time. Participation in this study does not involve any extra cost to me.

Subject’s name and signature /thumb impression

Date:

If the respondent does not agree to sign or give his/her Left Thumb impression, signature of interviewer certifying that informed consent has been given verbally by the respondent

Name and signature of witness

1. Date:

2. Date:

Name and signature of interviewer:

Date:

Name and signature of Principal Investigator

ANNEXURE III

Contact No. Date:

ಮಾಹಿತಿ ಪತ್ರ

ನಾವು ಶ್ರೀ ದೇವರಾಜ್ ಅರಸ್ ವೈದ್ಯಕೀಯ ಕಾಲೇಜಿನಿಂದ ಬಂದಿದ್ದೇವೆ. ನಮ್ಮ ಕಾಲೇಜು ವತಿಯಿಂದ **ಕೋಲಾರ ಚಿನ್ನದ ಗಣಿ ಪ್ರದೇಶದಲ್ಲಿ** ಅಧ್ಯಯನ ಮಾಡುತ್ತಿದ್ದೇವೆ.

ಅಧ್ಯಯನದ ಶೀರ್ಷಿಕೆ : "**ಕೋಲಾರ ಚಿನ್ನದ ಗಣಿ ಪ್ರದೇಶದಲ್ಲಿ ಶ್ವಾಸಕೋಶದ ಖಾಯಿಲೆ; ತೊಂದರೆಯ ಅರಿವು ಮತ್ತು ಪರಿಸರದ ಮಲಿನತೆಯ ಸಂಶೋಧನೆ**"

ನಾನು................................ ಈ ಅಧ್ಯಯನದ ಪ್ರಮುಖ ಸಂಶೋಧಕಿ. ನಿಮ್ಮನ್ನು ಈ ಮೇಲ್ಕಂಡ ಅಧ್ಯಯನಕ್ಕೆ ಸ್ವಾಗತಿಸುತ್ತೇನೆ. ಈಗ ನೀಡುವ ಮಾಹಿತಿಯು ನಿಮಗೆ ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ಅಥವಾ ಭಾಗವಹಿಸದೆ ಇರಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ. ನಿಮ್ಮಲ್ಲಿರುವ ಸಂಶಯ ಅಥವಾ ತಪ್ಪು ಕಲ್ಪನೆಯ ಬಗ್ಗೆ ನೀವು ನನ್ನನ್ನು ಕೇಳಬಹುದು. ಚಿನ್ನದ ಗಣಿಯು ನಮ್ಮ ಆರ್ಥಿಕ ಬೆಳವಣಿಗೆಗೆ ಎಷ್ಟು ಸಹಾಯಕಾರಿಯೋ ಅಷ್ಟೇ ಅಪಾಯಕಾರಿಯು ಹೌದು. ಗಣಿ ಕೈಗಾರಿಕೆ ಇಂದ ಹಲವಾರು ಹಾನಿಕಾರಕ ವಸ್ತುಗಳು ಬಿಡುಗಡೆ ಆಗುವ ಕಾರಣ ಆರೋಗ್ಯಕ್ಕೆ ಧಕ್ಕೆ ಉಂಟು ಮಾಡುತ್ತದೆ. ಅದರಲ್ಲು ಶ್ವಾಸಕೋಶಕ್ಕೆ ಭಾರಿ ಹಾನಿ ಉಂಟು ಮಾಡಿ, ಉಸಿರಾಟದ ತೊಂದರೆಗೆ ಒಳಪಡಿಸುತ್ತದೆ.ಈ ಪ್ರದೇಶದಲ್ಲಿ ಗಣಿಗಾರಿಕೆ ನಿಲ್ಲಿಸಿದ್ದರೂ ಸಹ ಇಲ್ಲಿಯ ಪರಿಸರದಲ್ಲಿ ಹಲವಾರು ಹಾನಿಕಾರಕ ಅಂಶಗಳು ಹೆಚ್ಚಿನ ಪ್ರಮಾಣದಲ್ಲಿ ಇರಬಹುದು.ಇದರಿಂದ ಆರೋಗ್ಯಕ್ಕೂ ಧಕ್ಕೆ ಉಂಟು ಮಾಡುತ್ತಿರಬಹುದು.ನಿಮ್ಮಲ್ಲಿ ಈ ಖಾಯಿಲೆಯನ್ನು ಗುರುತಿಸಲು ನಾವು ಕೆಲವು ಪ್ರಶ್ನೆಗಳನ್ನು ಹಾಗು ಕೆಲವು ಪರೀಕ್ಷೆ ಮಾಡಲು ಇಚ್ಚಿಸುತ್ತೇವೆ

ನೀವು ಕೊಡುವ ಮಾಹಿತಿಯು ಗೌಪ್ಯವಾಗಿ ಇಡಲಾಗುತ್ತದೆ. ಅದನ್ನು ಕೇವಲ ಸಂಶೋಧನೆಗೆ ಉಪಯೋಗಿಸುತೇವೆ. ನಿಮ್ಮ ಹೆಸರು, ವಿಳಾಸ ಮತ್ತು ಇತರೆ ಸ್ವಂತ ವಿಚಾರಗಳನ್ನು ಉಪಯೋಗಿಸದೆ ಕೇವಲ ಒಂದು ಸಂಖ್ಯೆ ಇಡಲಾಗುವುದು. ನೀವು ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಬೇಕೆಂಬ ಬಲವಂತವಿಲ್ಲ. ಇದು ನಿಮ್ಮ ಸ್ವ-ಇಚ್ಛೆ. ಭಾಗವಹಿಸಲು ಯಾವುದೇ ವೆಚ್ಚ ತಗಲುವುದಿಲ್ಲ. ನಿಮ್ಮ ಶ್ವಾಸಕೋಶದ ಕಾರ್ಯ ವೈಖರಿಯನ್ನು ಪರೀಕ್ಷೆ ಮಾಡಲು ಹಣ ಪಾವತಿಸಬೇಕಿಲ್ಲ. ನಿಮ್ಮ ಶ್ವಾಸಕೋಶದ ಕಾರ್ಯ ವೈಖರಿಯನ್ನು ಪರೀಕ್ಷೆ ಮಾಡಿಸುತ್ತೇವೆ ಹಾಗು ಅದರ ಫಲಿತಾಂಶವನ್ನು ನಿಮಗೆ ತಿಳಿಸುತ್ತೇವೆ. ನೀವು ಈಗ ಒಪ್ಪಿಕೊಂಡು, ನಂತರ ಬೇಕಿದ್ದಲ್ಲಿ ನಿರಾಕರಿಸಬಹುದು. ನಾವು ನಿಮಗೆ ಕೇಳುವ ಪ್ರಶ್ನೆಗಳಲ್ಲಿ, ಯಾವುದನ್ನಾದರೂ ನೀವು ಉತ್ತರಿಸಲು ನಿರಾಕರಿಸಬಹುದು. ಹೀಗೆ ಮಾಡುವುದರಿಂದ ನಿಮಗೆ ಯಾವುದೇ ತೂಂದರೆ ಇರುವುದಿಲ್ಲ.

ಮತ್ತೇನಾದರು ಸಂಶಯವಿದ್ದರೆ ಸಂಶೋಧಕರನ್ನು ಸಂಪರ್ಕಿಸಿ. ಈ ಅಧ್ಯಯನದ ಪ್ರಮುಖ ಸಂಶೋಧಕರು ಶ್ರೀಮತಿ.ಉಷಾ.ಜಿ. ಶಣೈ**.** ಮೊಬೈಲ್ ಸಂಖ್ಯೆ **: 9880633910.**

ಈ ಪತ್ರವನ್ನು ಸಹಿ ಮಾಡಿದರೆ, ನಾವು ನಿಮ್ಮಿಂದ ಏನನ್ನು ಬಯಸುತ್ತಿದ್ದೇವೆ ಎಂಬುದು ನಿಮಗೆ ಅರ್ಥವಾಗಿ, ಈ ಅಧ್ಯಯನದಲ್ಲಿ ನೀವು ಪಾಲ್ಗೊಂಡಂತೆ ಆಗುತ್ತದೆ.

ANNEXURE IV

ಒಪ್ಪಿಗೆ ಪತ್ರ

ಅನುಕ್ರಮ ಸಂಖ್ಯೆ :

ಅಧ್ಯಯನದ ಶೀರ್ಷಿಕೆ: **"ಕೋಲಾರ ಚಿನ್ನದ ಗಣಿ ಪ್ರದೇಶದಲ್ಲಿ ಶ್ವಾಸಕೋಶದ ಖಾಯಿಲೆ; ತೊಂದರೆಯ ಅರಿವು ಮತ್ತು ಪರಿಸರದ ಮಲಿನತೆಯ ಸಂಶೋಧನೆ"**

ಮುಖ್ಯ ಸಂಶೋಧಕರ ಹೆಸರು: **ಶ್ರೀಮತಿ.ಉಷಾ.ಜಿ. ಶಣೈ.**

ಭಾಗವಹಿಸುವವರ ಹೆಸರು:

ಈ ಅಧ್ಯಯನದ ಪೂರ್ತಿ ವಿವರವನ್ನು ಹಾಗು ಅದರ ಉದ್ದೇಶವನ್ನು ನನಗೆ ಅರ್ಥ ಆಗುವ ಹಾಗೆ ತಿಳಿಸಿಕೊಟ್ಟಿದ್ದಾರೆ. ಈ ಅಧ್ಯಯನದ ಬಗ್ಗೆ ಬೇರೆ ಬೇರೆ ಪ್ರಶ್ನೆ ಕೇಳಲು ಅವಕಾಶ ದೊರೆತಿದೆ ಹಾಗೇ ನನ್ನ ಪ್ರಶ್ನಗಳಿಗೆ ನನಗೆ ತೃಪ್ತಿಕರವಾದ ಉತ್ತರಗಳು ದೊರೆತಿದೆ.

ನನ್ನಿಂದ ಓದಲ್ಪಟ್ಟ ಅಥವಾ ನನಗೆ ಓದಿದ ಅಧ್ಯಯನದ ಉದ್ದೇಶ ನನಗೆ ಅರ್ಥವಾಗಿದ್ದು, ನನ್ನಿಂದ ಸಂಗ್ರಹಿಸಲ್ಪಟ್ಟ ಮಾಹಿತಿಯನ್ನು ಕೇವಲ ಅಧ್ಯಯನಕ್ಕಾಗಿ ಬಳಸಲಾಗುವುದು. ಹಾಗು ಮಾಹಿತಿಯನ್ನು ಗೌಪ್ಯವಾಗಿ ಇರಿಸಲಾಗುವುದು. ನನ್ನ ಗುರುತನ್ನು ಬಹಿರಂಗ ಪಡಿಸುವುದಿಲ್ಲ. ನನಗೆ ಅಧ್ಯಯನದಲ್ಲಿ ಯಾವುದೇ ವೆಚ್ಚೆ ತಗಲುವುದಿಲ್ಲ ಮತ್ತು ಶ್ವಾಸಕೋಶದ ಕಾರ್ಯ ವೈಖರಿಯನ್ನು ಪರೀಕ್ಷೆ ಮಾಡಲು ಯಾವುದೇ ರೀತಿಯ ಹಣವನ್ನು ಪಾವತಿಸಿರುವುದಿಲ್ಲ.

ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ಅಧಿಕ್ರತವಾಗಿ ಮಾಹಿತಿ ಸಂಗ್ರಹಿಸಲು, ಶ್ವಾಸಕೋಶದ ಕಾರ್ಯ ವೈಖರಿಯನ್ನು ಪರೀಕ್ಷಿಸಲು ಮತ್ತು ನನ್ನ ಸ್ವಂತ ಮಾಹಿತಿಯನ್ನು ಗೌಪ್ಯವಾಗಿರಿಸಲು ನನ್ನ ಸ್ವ-ಇಚ್ಛೆಯಿಂದ ಒಪ್ಪಿ ಸಹಿ ಹಾಕಿರುತ್ತೇನೆ. (ಯಾವುದೇ ಸ್ಪಷ್ಟೀಕರಣಕ್ಕಾಗಿ ನೀವು ಮುಖ್ಯ ಪರಿವೀಕ್ಷಕರನ್ನು ಸಂಪರ್ಕಿಸಬಹುದು)

ಭಾಗವಹಿಸುವವರ ಹೆಸರು ಮತ್ತು ಸಹಿ: ದಿನಾಂಕ:

ಸಾಕ್ಷಿದಾರರ ಹೆಸರು ಮತ್ತು ಸಹಿ ದಿನಾಂಕ:

1.

2.

ಸಂದರ್ಶಕರ ಹೆಸರು ಮತ್ತು ಸಹಿ: ದಿನಾಂಕ:

ಮುಖ್ಯ ಸಂಶೋಧಕರ ಸಹಿ :

ANNEXURE V

THE AMERICAN THORACIC QUESTIONNAIRE

PULMONARY FUNCTIONS IN THE RESIDENTS OF GOLD MINING TOWN AND ITS ASSOCIATION WITH CHRONIC EXPOSURE TO MINING DUST

A) DEMOGRAPHIC STATUS

1.Name:

2. Age:

3. Sex: - 1. Male 2. Female

4. Religion:- 1. Hindu 2. Musilm 3.Christain 4.others

6. Marital status: - 1. Single 2.Married 3.Widow

7. Education: 1. Illiterate 2. Primary 3. Secondary 4. University

8. Occupation:- 1. Retired 2.Housewife 3.Agricultrust 4. Unskilled labourers 5.Skilled labourers 6.Business 7.Worker in government service 8.others.

9. Per capita Income:-

B) ENVIRONMENTAL DETAIL

11. How long have you been staying in this house?

Enumerate to list the areas in which the subject lived near the mine tailing

1.Marrikuppam

2. Coromendal

3. Champion reefs

4. School of mines

5. Others specify

ADDRESS

12. C) **AWARENESS**

a).Do you think your surrounding is polluted?

1 YES 0 NO

If yes, what makes you think so?

Mine Tailings 1 **Other causes 0**

If the reply is Mine Tailing, then go question b

b) Do you think it has an ill effect on your health?

YES NO 0

13.TYPE OF THE HOUSE AND COOKING.

a. Type of house: Pukka/kutcha/semi-pukka 1 ☐ 2 ☐ 3 ☐

b. No. of rooms: 1 ☐ 2 ☐ 3 ☐ 3and more

c. Separate kitchen: YES 1 NO 0

d. Type of cooking fuel used: 1.LPG 2.Kerosene 3.Wood 4.Others

e. Do your kitchen has windows /opening 1 Yes 0 No

f.. Since how many years are you cooking? Years

g How many hours do you daily spend in the kitchen **?** Hours

h .Do you have pets like dogs /cats/birds ? 1 Yes 1 0 No

D) RESPIRATORY SYMPTOMS

14. COUGH

a) Do you usually have a cough**? (**Count a cough with first smoke or on first going out of doors exclude clearing of throat)(If no skip to question 14 C)

b) Do you usually cough as much as 4-6times a day,4 or more days of the week?

1 Yes 0. No

c) Do you usually cough at all on getting up, first thing in the morning?

1. Yes 0.No

d) Do you usually cough at all during the rest of the day or at night ?

1. Yes 0 No

If yes to any of above (a, b, c or d) answer the following

If no to all, check does not apply and skip to next page.

e) Do you usually cough like this on most days for 3

Consecutive months or more during the year

1. Yes 0. No

f) For how many years have you had this cough ?

1. Yes 0.No

15. PHLEGM

a)Do you usually bring up phlegm from your chest? 1.Yes 0. No

(Count phlegm with a first smoke or first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm. IF yes answer the following if No go to the next question 16.

b).Do you usually bring up phlegm like this twice a day, 4 or more days a week

1.Yes 0.No

c) Do you usually bring up phlegm while getting up in the morning?

1.Yes 0. No

d) Do you usually bring up phlegm at all during the rest of the day or at night? at the rest of the day or night

1.Yes 0..No

If yes to any of above (a, b, c or d) answer the following

If no to all, check does not apply and skip to next page

e)Do you bring up phlegm like this on most days for 3 Concecutive months or more during the year?

1. Yes 0. .No

f) For how many years you had trouble with phlegm

1. Yes 0. .No

16. BREATHLESSNESS

a) Do you have shortness of breath? 1. Yes 0 No

<u>IF YES answer the following if NO go to the next question 17</u>

b) Do you walk slower than people of your age 1. Yes 0 No

c) Do you have to stop for your breath when walking at your pace 1. Yes 0 No

d) Do you have stop for breath after walking for few min on level ground? 1. Yes 0 .No

e) do you feel too breathlessness to leave the house. 1. Yes 0 .No

17. ASTHMA

a)Do you have Asthma? 1. Yes 0.No

<u>IF YES answer the following if NO go to the next question 1</u>

b) Do you still have it? 1. Yes 0 .No

c) Was it confirmed by a doctor 1. Yes 0 .N

d) At what age did it start? ………. years

e) If you no longer have it at what age did it stop 1. Yes 0 .No

18 SMOKING

Do you smoke 1. Yes 0 .No

<u>If yes answer the following if NO go to the next question 21</u>

a) What form of tobacco did/do you predominately smoke ?

1. Cigarette

2. Bidi

3. Others

b) How many cigarette, or beedis you usually smoke in a day? Yrs

c) How long have you been smoking Yrs month

d) Have you smoked before 1.Yes 0 No.

e) How many cigarettes did you smoke per day now? numbers

19. F) FAMILY HISTORY

Did or do your father or mother suffer from of the lung disease .

Father Yes 1 No 0

Mother Yes 1 No 0

PHYSICAL EXAMINATION

Oxygen saturation--

Pulse rate –

Signature of the Investigator

Date:

CONCLUSION

The study aimed to determine the respiratory disease burden of the population living in the mine tailing area and assess the air quality of the same area. The study has been able to demonstrate that mining can be a major environmental disaster especially on air. The byproduct of mining, the mine tailings remain on site and continue to disastrously affect the quality of air almost two decades after the closure of mines. As per the notification of "Central Pollution Board", the "National Ambient Air Quality" standards values for PM10 is 60 to 100 microgram in industrial, residential, rural and other areas, and that of PM 2.5 being 40 to 60 microgram depending on whether it was an annual or 24 hour analysis. **(152)** The recorded PM concentration in the mine tailing area was above this with values of 1.49 $\pm$ 0.80mg/m3, which was way above the notified values even years after closure of mines.

The population staying in the vicinity of the mine tailing has been exposed to polluted air, many of them through life. They showed significant increase in respiratory symptoms of phlegm, breathlessness and asthma while lung parameters of FVC, FEV1 and PEFR, and percentage saturation of oxygen were significantly decreased when compared to the unexposed group who did not stay near the vicinity of mine tailings. The prevalence of abnormal lung function was as high as 67% in the exposed population. Though this is a cross sectional study and the cause –effect cannot be justified here, the most plausible reasoning for the abnormalities recorded may be because of exposure to high PM which may have been even higher during active mining. This has been further demonstrated by multiple regression analysis where place of stay – KGF, the mine tailing area was the single and only risk factor for the development of abnormal lung function while other confounding factors of age, gender, type of fuel used and smoking did not appear to increase the risk. The pulse rate in the exposed population was also found to be significantly higher. This may be explained by the fact that air pollution is also known to affect the cardiovascular system including autonomic imbalance.

Hence, it can be concluded that gold mining is an environmental disaster even years after its closure, contributing to suspended particles in air, affecting the respiratory health of the residents including percentage oxygen saturation and pulse rate – a cardiovascular effect.