Assessment and characterization of airborne dust in coal surface mine

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ASSESSMENT AND CHARACTERIZATION OF AIRBORNE DUST IN COAL SURFACE MINE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

in

MINING ENGINEERING

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May 2016

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UNDER THE GUIDANCE OF

MR. VIVEK KUMAR HIMANSHU

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Mr. Vivek Kumar Himanshu May 2016

Assistant Professor

SUPERVISOR'S CERTIFICATE

This is to certify that the thesis entitled, "Assessment and characterization of airborne dust in coal surface mine" submitted by Mr. Prashant Kumar, 112MN0435 and Mr. Aswini Kumar Padhi, 112MN0439, in partial fulfillment of the requirement for the award of Bachelor of Technology Degree in Mining Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any university/Institute for the award of any Degree or Diploma.

Mr. Vivek Kumar Himanshu

Assistant Professor

Department of Mining Engineering

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Rourkela 769008

Date:

Dedication

I dedicated my work to my family, friends and best wishers

Signature

Declaration of Originality

We hereby declare that this thesis entitled *Assessment and characterization of airborne dust in coal surface mine* presents our original work carried out as an undergraduate student of NIT Rourkela and, to the best of our knowledge, contains no material previously published or written by another person, nor any material presented by us for the award of any degree or diploma of NIT Rourkela or any other institution. Any contribution made to this research by others, with whom we have worked at NIT Rourkela or elsewhere, is explicitly acknowledged in the thesis. Works of other authors cited in this dissertation have been duly acknowledged under the sections "Reference" or "Bibliography". We have also submitted our original research records to the scrutiny committee for evaluation of our thesis.

We are fully aware that in case of any non-compliance detected in future, the Senate of NIT Rourkela may withdraw the degree awarded to me on the basis of the present thesis.

May, 2016
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ABSTRACT

Now a day's dust pollution is the major environmental issue inside an opencast mine, which has various effects on human life. There are a number of fugitive sources, and activities which cause dust pollution inside an opencast mine e.g. Drilling, transportation, blasting, crushing, conveying, overburden face, haul road etc. Among these dust, there are some toxic and carcinogenic dust which are when exposed to the workers that lead to different serious health effects like silicosis and lungs cancer. So measurement of these dust concentration is necessary to know the impact of various mining activity on the surrounding environment.

From the above view, this current project mainly focuses on the dust sampling by using high volume dust sampler i.e. Envirotech APM 460 NL and Envirotech APM 550, measuring the personal dust exposure of different workmen at different mining sites by using Personal Dust Sampler (Model Arelco Ineris CIP 10), and characterization of the dust collected from the filter paper by using FTIR (Fourier Transform Infra-Red spectroscopy). For this purpose Lajkura Opencast Project was chosen which produces 30 MT of coal per year for convenience, because as it is a large opencast mine so better knowledge can be gained from this mine regarding the concentration and effects of the dust. The dust sampling and monitoring was conducted during the month of March 2016 to get a good assess of dust. From the measurement through Envirotech APM 460NL the dust concentration was found out to be 1074µg/m^3 and 984 µg/m^3, and through Envirotech APM 550 dust concentration is found out to be 196 µg/m^3. Personal dust exposure is also measured and the measured concentration was found to vary between 0.8mg/m^3 to 1.3 mg/m^3. From the characterization of the dust sample the compound that we found are Silica, Sulphates, Sulfoxide, and Carboxylates etc.

Keywords: Dust, APM, FTIR, exposure

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List of Abbreviations

Abbreviation	Explanation
PM	Particulate matter
APM	Ambient particulate matter
SPM	Suspended particulate matter
RSPM	Respirable suspended particulate matter
TSP	Total suspended particle
DGMS	Directorate general of mines safety
FTIR	Fourier transform infrared spectroscopy
NAAQS	National ambient air quality
CPCB	Central pollution control board
CHP	Coal handling plant
ARD	Airborne respirable dust

Chapter 1
Introduction

1. INTRODUCTION

Mining is a significant practice for industrial and economic development of any country. The development of infrastructure and core sector is immediately linked with multiplied creation of minerals, like coal for energy sector, iron ore for steel sector, limestone for cement for housing and infrastructure development. With extended industrialization, urbanization and other developmental pursuits; there is a higher want for improved creation of minerals. The emphasis therefore is now on opencast mining which is adopted for fast and monetary extraction with bigger percentage of healing compared to underground mining; in fact bulk of the minerals got in India now comes from opencast mines. Various important minerals like dolomite, limestone, iron ore, bauxite, silica, granite, and magnetite and many others, are acquired exclusively through opencast mining. Most of the mining operations produces dust due its working procedures, which includes drilling hauling, blasting, loading, dispatching, etc. Dust from mines becomes serious hazard to miner's health and may cause diseases (respiratory) e.g. pneumoconiosis, silicosis. Dust can be divided into different categories like SPM, TSP, PM_{10} and $PM_{2.5}$ based on the particle size, which is generally measures as in terms of weight of particles per meter cube. It is well known that dust production is related to every mining activity, for every operation dust generation is associated.

When it comes to comparison between dust generation from opencast and underground mine then it is well understood that opencast operations is more associated with generation of dust. Various mining operations like blasting, drilling loading, transportation, conveying, crushing, haul road and overburden face generates large quantities of fugitive dust. In view of this, identification dust emission sources and decision of emission cost of more than a few routine of the mine site is relevant to a particular matter to determine impact of mining activities on surrounding air excellent. When it comes to silica it is potential of carcinogen and its publicity to the employees may be harmful to their health which may result in development of silicosis and lung melanoma. Therefore, determination of silica content within the respirable air is main to determine its impact on miner's health.

Emission of dust and prediction of dispersion is difficult process as there are various factors which are responsible for emission and dispersion. For safety purpose and workable

environment to a miner, it is required to carry out the dust monitoring on regularly basis and follow the guidelines of DGMS.

1.1 OBJECTIVES

The purpose of the project is to determine the dust concentration at mine sites of a coal mine and assess all the data collected either by monitoring or by safety office of the mine. For this purpose lajkura opencast project has been selected for the project work. After dust monitoring for characterization we chose the FTIR spectroscopy for the characterization part by which we found the different compound exist in the mine air dust.

- To monitor dust at different locations of Lajkura opencast project.
- Assessment of personal dust exposure by using personal dust sampler.
- To characterize the dust by using FTIR.

1.2 METHODOLOGY ADOPTED:

Through the project we have adopted a particular path for completion of the following project. Figure 1.1 shows the methodology adopted to complete this project

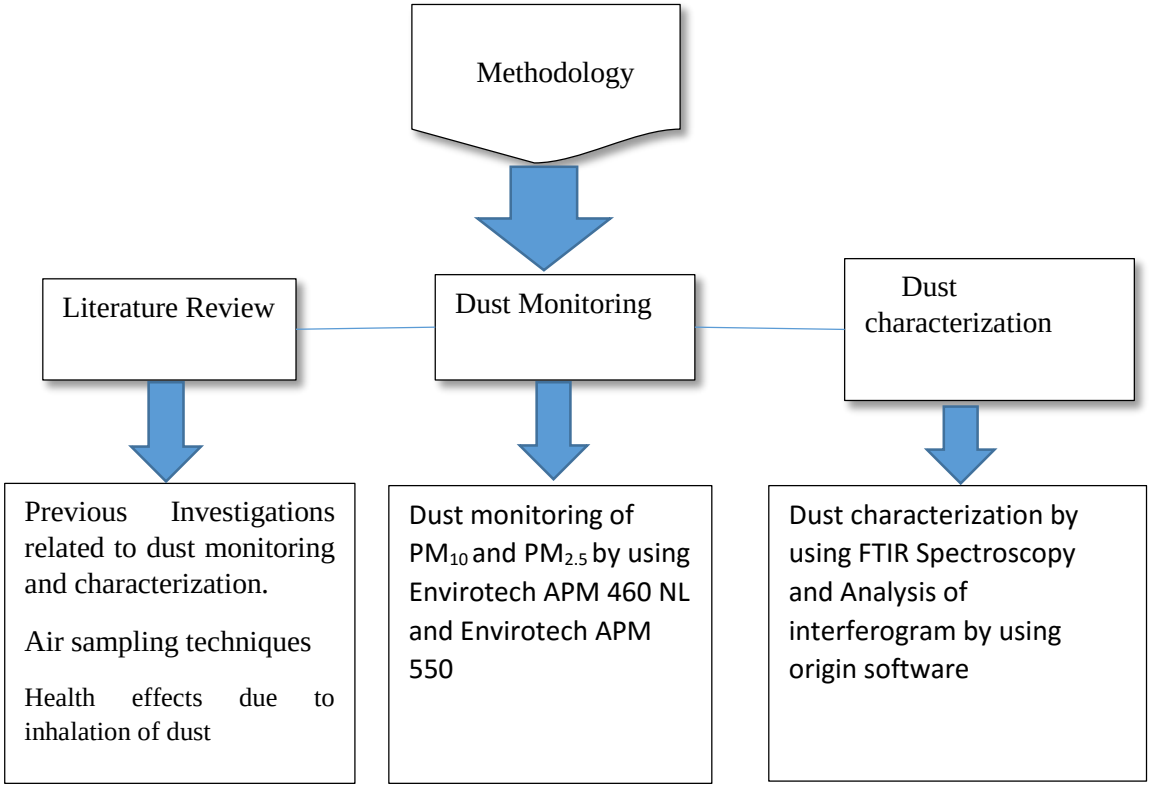

Fig: 1.1 Methodology adopted

Chapter 2

Literature Review

2. LITERATURE REVIEW

The following researches has been done in the field of assessment, monitoring and characterization by different scholars.

Stein and corn (1975) watched that to give an unmistakable picture on the physical method for the size divisions, additional describing parameters in perspective of thickness, particulate matter size by optical microscopy, unpredictable and expected reach and specific surface locale ought to be given.

They accumulated air tests from underground coal mines from Pittsburg wrinkle, lower Freeport likewise, bring down kittaning wrinkles and with the use of even elutriator and assembled more than 8" X 10" film channel (Millipore SCW P00010). Each illustration was segregated into four differing size segments by bahco dissimilar classifier. By then distinctive examinations were driven by them to figure the above parameters for each size bits. By then the qualification in parameters for the size parts were destitute down and discussed. Along these lines, it is made possible to relate the coming and sincerity of respirable lung sicknesses with the physical and manufactured properties of different size divisions of the ARD (Airborne respirable dust). [1]

Kumari et al. (1995) the study gives an amazing highlight on determination of quartz present in the airborne respirable dust (ARD) known not silicosis and tumor. FT-IR spectrometer was being used as a piece of direct on channel system for quartz determination in ARD with quartz doublet top at 800 and 700 cm-1. For taking air tests from different territories of mine own dust samplers were used and accumulated over GLA - 5000 PVC layer channels.

Certain dust making sources were picked where dust samplers may be set and it was even associated with different pros involved with the developments. The examination in different coal and metal mines showed that quartz content in respirable dust is <1% which is not precisely the supported MEL (Greatest presentation limit) 3mg/m3 except for 2-3 territories in Longwall and stronghold top. It was watched that entering, haulage, crusher house are guideline high danger zone of silicosis and was over the long haul assumed that wet exhausting and moreover improved ventilation is intense to control airborne dust and what's more transmission of quartz. Consistent turn of experts is an outright need in regions like crusher

destinations where, even after gathering of dust disguise measures, dust is not reduced quite far. [2]

Chaulya (1999) for a period of 1 year, did a study for assessment of air quality in Lakhanpur range. He found that the yearly ordinary of centralizations of TSP and PM10 were higher than beyond what many would consider possible given by NAAQS. He took the help of straight backslide examination to predict the groupings of one sort of particulate matter by knowing the level of the other, for surface coal mines with same as conditions. Checking stations were set to evaluate air quality and plan any control measures. Analysing and examination were done twice month to month for neighbourhood areas (support zone) and six times month to month for current domains (focus zone/mining locale) in the midst of the year from September 1998 to August 1999. He suggested that fruitful control measures at the CHP, evacuation region and Overburden dumps should be progressed to direct the TSP radiation at source. Groupings of carbon monoxide (CO) likewise, lead (Pb) were underneath recognizable cut-off indicates or insignificant concurring the bi-month to month watching report for the area in the midst of the study time. [3]

Krupa and Legge (1999) inspected the use of isolates samplers for vaporous air poisons. They evaluated the specificity and linearity of the response of reserved samplers; results procured by such a technique were at initially differentiated and cross-related and help establish dynamic samplers or constant screens for precision. It was found that the consistent effects in any relationships of data from latent looking at versus dynamic watching, particularly uncovered airs and related natural methodology of the northern degrees. They found that the differences between the two structures can be exceedingly basic in the midst of the winter months. A couple of defilements, for instance, NH3 ought to be changed over to a second compound (NO2) at some point as of late estimation. This can incite specific troubles on area with instrument execution. Finally they construed that though inactive samplers are outstandingly appealing from budgetary and logistic perspectives, they should be co-arranged with inert samplers, with interminable screens at testing zones. [4]

Ghose and Majee (2001) watched that in India, real coal generation is from opencast mines, contributing more than 70% of total coal creation and it similarly has a high share in air sullying. To keep a track upon the adjacent atmosphere influence, an outline was coordinated by them taking surges data which was utilized to find the dust time on account of various mining works out. They saw that the air poisons starting from mines and their general changes

in its sum had high defilement potential and more unmistakable negative impact on human prosperity. They have given an impressive measure of control measures to deal with this situation and even chalked out 'afforestation and persevering capacity of trees' against the dust particulate matter. They underlined the need of utilization of different chemicals to minimize the air pollutions beginning from Pull Street and communicated that a tainting free environment can be expert by executing proper lessening measures". [5]

Chakraborty et al. (2001) made test formulae with the objective to figure radiation rate of various opencast mining works out. They picked 7 coal mines and 3 iron mineral mines with the considered geological region, working procedure, openness and resource availability. 12 Exact condition for Suspended particulate matter were delivered for some opencast mining practices like infiltrating, coal stacking ,coal dealing with plant , pull road , workshop , et cetera yet the formula was for the general mine for NOx and SO_2 estimation. To check the boundless congruity of the definite formulas, they picked Rajpura opencast coal mine. A better than average precision was exhibited between the registered regard and field measured worth which varied from 77.2% to 80.4%. They assumed that Suspended particulate matter is the essential constituent of releases while spreads as a result of NOx and SO2 are irrelevant. They revealed that the outcomes of this study is of mind blowing importance for mine natural planners and specialists working in the field of air quality seeing to screen air quality and its impact from pollutions making wanders . [6]

Reddy and Ruj (2002) did the incorporating air quality examination in the Raniganj – Asansol range considering sulfur dioxide, oxides of nitrogen and suspended particulate matter (SPM) at four stations particularly – Raniganj young women school (RGC), Searsol raj optional school (SRS) Raniganj, B.B school (BBC) Asansol and B.C school (BCC) Asansol; where a total of 429 tests each were taken from RGC and SRS and 435 each from BBC and BCC zones. Including air watching repeat was 3*8 hours for every day at each site on every substitute days for 1 year; close by the recording of various parameters, for instance, temperature, relative dampness, air speed and its bearing. They used high volume samplers to gage SPM and SO2, and NOx vapour and were accumulated by permeating the case in a particular holding plan. The results from the above examinations exhibited that 95 percentile estimations of SPM and NOx surpassed beyond what many would consider possible in an extensive bit of the stations yet 95 percentile estimations of SO2 level didn't cross quite far. Further their infrequent

assortment was seen by them which highlighted "winter" as the most dirtied season as a result of high gathering of defilements, than summer took after by tempest. In this way, they surmised that the mining close by other advanced activities are only accountable for the high centralization of toxic substances here . [7]

Anastasiadou and Gidarakos (2006) gathering evaluated the common way of outside asbestos mine over a drawn out stretch of time by measuring and checking the gathering of asbestos strands in air. The study was done in Asbestos Mine of Northern Greece (MABE). Air looking at was performed by standard methodology for asbestos reviewing—the NIOSH Technique 740 for stage contrast microscopy (PCM) and as demonstrated by the air analyzing process depicted by the EU. Static illustrations were taken at settled territories, 1.5m above floor level. The examples were at first observed optically and were dismembered a while later with X-pillar powder diffraction (XRD). A separating electronic amplifying lens (SEM) was moreover used and the suspect fibers were dissected with an essentialness dispersive X-shaft for their creation. Overwhelming a portion of events exhibit that asbestos presentation is credited to human activities, for instance, the treatment of asbestos, the usage of asbestos and the exchange of asbestos things into landfills. [8]

Dahmann et al. (2008) inquired about the outcomes of presentation assessment with respect to nitrogen oxides and carbon monoxide in German hard coal mines. The estimation campaign was joined by an epidemiological study exploring possible prosperity sways on the flying courses of the lungs. Therefore time weighted 8-hour shift qualities were controlled by them, for ordinary social occasions of coalminers as demonstrated by the European estimation measures. Considering these estimations and on authorities' assessments of the survey presentation condition, time-subordinate joined and ordinary NO and NO_2 presentation evaluations were induced for a starting accessory of two get-togethers of coalminers. They contemplated that Diggers working in affecting groups (no affecting bosses) were evaluated by authorities to experience 2/3 of the nitrogen oxide presentation of affecting specialists. Especially, for the diesel engine drivers, presentation can be ideally higher than the prescribed regard . [9]

Sharma and Siddiqui (2010) finished a study for the evaluation and organization of the air quality around Jayant open cast coal mining masterminded at Jayant in Sidhi locale of Madhya Pradesh, India. Air checking for SO2, NOx and TSP was proficient for 24 hrs. Once at standard interims at each destinations and center were conveyed as μgm. Mean quality for poison were

figured on 24 hours analyzing premise. For the testing of particulate matter HVS (High Volume Sampler) was used. Tests were assembled for quite a while using glass fiber channel paper on stronghold day by day premise. They furthermore searched for upon the recognitions on 'spatial and transient assortments in centralization of vaporous and particulate poisons' finished by Chaulya (2004) in the midst of both the year of air checking. The study suggested that centralization of particulate toxin surpassed beyond what many would consider possible especially in the midst of summer and winter season.

They finally recommended executing a game plan of standard cleaning of transportation boulevards, watering of cleared and unpaved roads with engineered limiting authorities, foundation of sprinkler structure at high dirtying coal transport lanes inside the plant premises and effective dust covering segment at coal dealing with plant. [10]

Silva et al. (2010) watched that checking of light hydrocarbons is to an incredible degree fundamental, basically on two viewpoints; one is a direct result of overall ecological change and other one for fiscal and prosperity reasons. Due to the inconvenience to get to and nonattendance of right systems of gas inspecting in Brazilian coal mines, they proposed to apply standard gas chromatography strategies for gas testing to choose LHCs (light hydrocarbons) levels from their 2 surface mines and 3 underground mines. Tests of gas were assembled with the help of back to back sampler and were set in polypropylene tedler gas analysing packs. By then the LHCs centre was figured from gas chromatograph outfitted with flame ionization marker. The results demonstrated higher rate of LHCs in u/g mines than surface mines with CH4 levels changing from 3 ppm to 27% in coal mine atmosphere. They found that the proposed methodology was extraordinarily suitable in measuring LHCs levels and was finally contemplated that assessing of air using tedler packs and progressive sampler was better than anything steel canisters . [11]

Chen et al. (2010) dealt with the utilization of matter-segment procedure in estimation of encompassing air quality in Huizhou opencast coal fields in Fuxin colliery. Study drove by Fu et al (2000) portrayed air tainting of Fuxin to be made out of total suspended particulates (TSP), SO_2 and NOx. To check their studies, dust tests were taken from four different watching stations arranged in 4 particular ranges around Fuxin colliery. They associated 'soft thought' to the air quality evaluation in light of development of matter-part speculation, which handles the possibility of inadequate truth. What's more this idea can predict the relative effect of each dust poison on environment in light of the upper and lower most noteworthy allowable presentation

limits. They induced that re-vegetating fitting regions and also the exercises from government can successfully help in concurring 'air quality' inside the suggested furthest reaches of CAAQS, 1996. The future work of this study is to develop a fused and automated decision candidly steady system for air quality evaluation with the help of a programming vernacular . [12]

Khan and Bagaria (2011) finished the study in Dhanappa limestone mines, Nagpur with the essential focus to prescribe a watching framework to survey the sufficiency of astute measures to cover air poisons starting from mining domains. The areas which were decided for the studies were of three particular sorts of anthropogenic activities i.e. sensitive, private and business and cutting edge district in around the mining areas. Yearly Number juggling mean of minimum 104 estimations in a year taken twice consistently 24 hourly at uniform break was taken for the study. The APM-460 Respirable Dust Sampler that they used was outfitted with a tornado. The twister was expected to give separation of PM_{10} particulate matters for a more exact testing. Looking at of SO2 and NOx was done through an impinger which was revealed for 24 hours at an impingement rate of 1 LPM to get one case in a day. They inspected SO_2 and NOx on spectrophotometer using West-Geake procedure and JacobHochheiser strategy independently. The results that they got recommended that enveloping air quality in the mines zones with respect to SO_2 and NOx exhibits low tainting, while concerning RSPM and SPM it is moderate. They furthermore recommended that standard checking and dismembering of those parameters will keep them underneath supported points of confinement . [13]

Mandal et al. (2011) separated that larger piece of air poisons that are corrupting the atmosphere takes after its source from the draw and transport lanes in coal mining zones therefore overhauling unmistakable prosperity issues. As high as 93.3% of total made dust begins from force avenues of South African coal mines, as showed by the examination finished by Amponsah-Dacosta using USEPA rules [19]. As a result of the midway dissatisfaction of the open techniques, the dust doesn't get ousted from the draw road completely. In this study the subjective and moreover quantitative parts of road cleans is being overseen by them. For this, they assembled operator road dust tests from four one of a kind coalfields of India. Determination of PH of dust tests were finished by Orion molecule analyser using glass cathode; moistness content by grill dry system using Indian standards; Unpredictable matter by warming the example inside a secured pot in a quiet radiator; red hot stays content using Indian measures and settled carbon by deducting the entire of suddenness, shaky matter and soot content from 100. Their results were totally encouraging as in coal dust from force and haul

roads of mining zones can be effectively used as a family unit fuel. They surmised that some road dust (counting fine coal) could be accumulated and changed over into a solid casing with the objective that it can be used as a private fuel versus sustenance of a sound circumstance and essentialness . [14]

Khalaji et al. (2011) used the new system of blaze instigated breakdown spectroscopy (SIBS) as a direct, speedy and in situ method for steady clean checking as this procedure can perceive crucial game plan of dust in the meantime and no illustration arranging is required. They point by point an exploratory technique using a high voltage and a breakdown is made between two cathodes. Each segment in the plasma between anodes transmits its trademark powerful releases by looking at the spooky surge of plasma, the fundamental formation of dusty air is determined. With this trial the gathering showed that SIBS can be used as a technique for dust level checking moreover can be used to alert an earth shattering augmentation of dust in mines . [15]

Chapter 3

Air Sampling Techniques

3. AIR SAMPLING TECHNIQUES

3.1 Basic methods of sampling

Basic methods of sampling comprising in 6 different operations which are:

3.1.1 Filter Sampling Respirable Dust

Filter paper is used for air sampling, the paper traps the strong particulate e.g. dust, aerosols and filaments. Gravimetric investigation is normally used to quantify results (i.e. by measuring the weight picked up by the channel). Further examination can be done on the channel to distinguish the particular chemicals caught.

3.1.2 Sorbent Sampling

Sorbents are regularly contained in a little glass tube with fixed closures. Air is drawn through the sorbent, which catches particles of the gas or vapor to be examined. The caught contaminants are discharged utilizing dissolvable washing or warmth to a gas chromatograph (GC) for examination. One of the best known sorbents is charcoal.

3.1.3 Respirable Dust Sampling

The I.O.M. Sampler with a froth plug put in the tape delta is fit for inspecting respirable dust. The particular froth isolates the respirable division, which is gathered on the channel, from other particulate matter sizes.

3.1.4 Bag Sampling

Especially reasonable for "grab" or Short Term Samples (STS), the air is gone through the pump into an uncommon plastic sack. Elective strategies for filling a sack without passing air through a pump can likewise be utilized. The pack, containing a generally huge volume of examined environment is then taken to the research facility for examination.

3.1.5 Filter Sampling of Respirable (An alter method)

The Cyclone Sampler utilizes a channel contained as a part of a tape, which isolates out the respirable part of dust in the sample.

3.1.6 Bubble Sampling/Impinger

Air drawn into the impinger is constrained through a spout, which is secured with a fluid such a high immaculateness water. The toxins break down in the fluid media and is thusly examined, for the most part by colorimetric strategies of discovery.

3.2 Gravimetric Sampling

In this strategy for test air is gone through a channel, the channel or other examining authority is weighed to decide the sum the particulate matter gathered. This is a non-particular procedure. All material gathered on the channel is incorporated, albeit some of them may not be the contaminant of interest. While most contaminants are dictated by different techniques that give quantitative investigation of the compound noticeable all around test, material, for example, wood dust, coal dust, and so forth are still measured gravimetric component.

3.2.1 PM_{10} and $PM_{2.5}$ Samplers of High volume type

For PM_{10} evaluation, customary peak top of the high volume sampler is supplanted by an impactor outline size-select channel. For the impaction outline the air test entering the symmetrical hood is redirected upward into a support chamber. The support chamber is cleared at a rate of 68 cubic meter for every hour through various roundabout spouts. The entering particulate matters get quickened as they go through the spout to an impaction chamber; this procedure helps the particulate matter to increase some force and accordingly particulate matters having width bigger then bay 10μm cut outline affect the surface of the impaction chamber. Little particulate matters ascend through the impactor chamber at rates ease sufficiently back to minimize re-entrainment of the effectively affected particles and afterward go through various twisted tubes to high volume sampler's channel where they are gathered.

The second size select configuration of PM_{10} estimation is 'cyclone inlet'. Here omnidirectional violent wind is utilized for fractionation as a part of the channel permitting particulate matters to enter from all edges of methodology. In the channel, a precise speed segment is added to the example air and the particulate matters contained in it by a progression of uniformly dispersed vanes. Bigger particulate matter evacuation happens in the internal gathering tube. This tube consolidates an immaculate safeguard which is generally an oiled surface to dispense with

bobbing of particulate matters. The specimen stream then enters the middle tube where the direction of the particulate matters is changed to an upward course. An extra turn is added to change the stream to a descending course to permit the staying particulate matters to store on a channel for ensuing investigation. Likewise with the impaction channel control of air speeds in cyclonic gulf, it is basic to keep up the right particulate matter size cut point. It is basic to keep up right outline volumetric course through the inlet.

3.2.2 Personal samplers for $PM_{2.5}$ and PM_{10} particulate matter sampling

These forms of air samplers are lightweight sort for gathering air borne particulate matters in the $PM_{2.5}$ and PM_{10} size extent. These are much of the time used to give a measure of air borne particulate matters fixation for concentrating on potential wellbeing effects of dust particulate matters in the encompassing environment.

The vaporized specimen enters the sampler through multi spout single stage impactors to evacuate vast particulate matters having streamlined equal width bigger than 2.5um and 10um. Particulate matters having width littler than the impactor cut size are gathered on a 37mm distance across channel of decision. The gathered particulate matter can be examined gravimetrically to get air borne particulate matter's mass or investigated for particular synthetic mixes. Figure 3.1 shows the instrument for PM_{10} sampling.

Highlights:

- Light-weight individual samplers with single stage impactors.
- Specific impactor cut-purpose of 2.5 µm or 10 µm.
- Can be worked with an individual sampling pump

Applications:

- Personal dust testing for presentation appraisal.
- Ambient air contamination thinks about.
- Ambient air quality appraisal.
- Personal examining for modern cleanliness applications.

Fig. 3.1: Envirotech APM 460 NL

(Source: http://www.envirotechinstruments.in/ambient-air-pm10-samplers.html)

3.3 Methods of Air analysis and sampling As Recommended by CPCB

3.3.1 Guidelines for sampling and analysis of particulate matter (PM_{10}) in ambient air (gravimetric method)

PM_{10} Refers to the particulate matter which are in range of 10 micrometers or smaller in diameter.

3.3.1.1 Standard

Table 3.1 shows the standards given by CPCB for existing coal mines for the concentration of PM_{10}.

Table 3.1: Standard for existing coal mine by NAAQS for PM_{10}

Pollutant	Time weighted average	Mine Area	Residential area
PM_{10} (μgm/m^3)	annual	215	60
	24 hour	300	100

3.3.1.2 Principle of the method

Air is drawn through a size-particular bay and through a 20.3 X 25.4 cm (8'' X 10'') channel at a stream rate, which is ordinarily 1132 L/min. Particulate matters with streamlined width not exactly the cut-purpose of the bay are gathered by the channel. The mass of these particulate matters is controlled by the distinction in channel weights before and subsequent to examining. The grouping of PM10 in the distinction of the mass isolated by the aggregate volumetric stream. Assigned size reach is computed by isolating the weight addition of the channel by the volume of air examined.

3.3.1.3 Equipment

The accompanying things are important to perform the checking and examination of Particulate Matter

- PM_{10} in surrounding air:
- Analytical parity
- Sampler: High Volume Sampler with size specific channel for PM_{10} and programmed volumetric stream control.
- Calibrated stream measuring gadget to control the wind stream at 1132 l/min.
- Top stacking opening pack.

3.3.1.4 Sampling

Field Sampling - Tilt back the channel and secure it as per producer's directions. Relax the faceplate wing nuts and expel the faceplate. Expel the channel from its coat and focus it on the bolster screen with the harsh side of the channel confronting upwards. Supplant the faceplate and fix the wing nuts to secure the elastic gasket against the channel edge. Tenderly lower the bay. For naturally stream controlled units, record the assigned stream rate on the information sheet. Record the perusing of the passed time meter. The predefined length of inspecting is

normally 8 hours or 24 hours. Amid this period, a few perusing (hourly) of stream rate ought to be taken. After the required time of testing, record the stream meter perusing, take out the channel media from the sampler and put in a holder or envelope. Figure 3.2 shows the cyclone inlet.

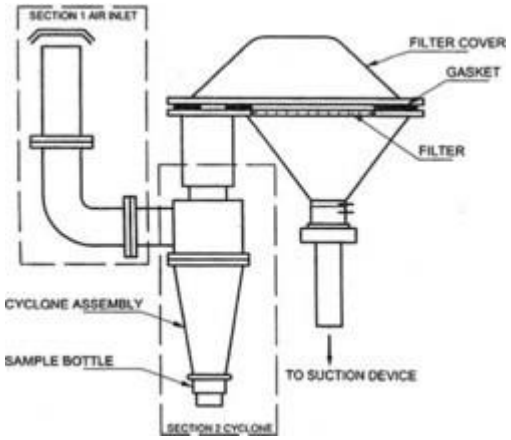

Fig 3.2: Schematic PM10 sampler (cyclone inlet)

(Source: http://3.imimg.com/data3/NR/LW/MY-10261127/respirable-dust-sampler-250x250.jpg)

3.3.1.5 Calibration

Periodical adjustment of the sampler is being finished by Orifice Transfer Standard. The PM10 sampler adjustment opening comprises of a 3.175 cm (1.25'') width gap at last top of 7.62 cm (3 '') breadth by 20.3 cm (8") long empty metal barrel. This opening is mounted firmly to the channel support set up of the gulf amid alignment. A little tap in favor of the chamber is given to quantify the weight drop over the hole. A stream rate of 1132 L/min through the opening normally brings about a weight distinction of a few inches of water. The relationship between weight contrast and stream rate is built up through an alignment bend got from estimations against an essential standard, for example, a Roots meter at standard temperature and weight. Stream resistances that mimic channel resistances are presented toward the end of the calibrator inverse the opening by an arrangement of punctured roundabout circles.

3.3.1.6 Calculation

PM_{10} ($\mu gm/m^3$) = (W_f – Wi) x 10^6 / V

Where,

PM_{10} = Concentration of PM_{10}in $\mu gm/m^3$

W_f= Initial weight of filter in gm

W_i = Initial weight of filter in gm

10^6 = Conversion of gm to µgm

V = Volume of air sampled in m^3

3.3.1.7 Quality Control

Quality control is the method which is used to fulfill the needs for quality. The quality control measures for air sampling and monitoring sessions of this protocols include procedures like maintenance of equipment, calibration of equipment, etc.

3.3.2 Guidelines for sampling and analysis of the particulate matter ($PM_{2.5}$) in mine air (ambient air) by gravimetric method

3.3.2.1 Standard

Table 3.2 shown below shows the guidelines provided by the CPCB.

Table 3.2: National ambient air quality standards (NAAQS) for PM2.5

Size of pollutant	Time weighted Average	Residential/Standard Area	Ecologically Sensitive area
$PM_{2.5}$ (µgm/m3)	Annual	40	40
	24 Hours	60	60

3.3.2.2 Principle

The electrically controlled air sampler draws surrounding air at a consistent volumetric stream rate (16.7 lpm) kept up by a mass stream/volumetric stream controller coupled to a microchip into uncommonly planned inertial particulate matter-size separator (i.e. twisters or impactor) where the suspended particulate matter in the $PM_{2.5}$ size extents is isolated for gathering on a 47 mm polytetrafluoroethylene (PTFE) channel over a predetermined examining period. Every channel is weighed prior and then afterward test accumulation to decide the net increase because of the particulate matter. The mass fixation in the encompassing air is processed as the aggregate mass of gathered particulate matters in the $PM_{2.5}$ size extents partitioned by the genuine volume of air inspected, and is communicated in µgm/m^3. The microchip peruses midpoints and stores five-minute midpoints of encompassing temperature, surrounding weight, channel temperature and volumetric stream rate. Also, the chip computes the normal

temperatures, weight, and aggregate volumetric stream for the whole specimen run time and the coefficient of variety of the stream rate.

3.3.2.3 Sitting Requirements

Samplers ought to be sited to meet the objectives of the particular observing venture. For schedule inspecting to decide consistence with the National Ambient Air Quality Standards (NAAQS), sampler sitting is depicted in CPCB rules should apply. The checking ought to be done outside the zone of impact of sources situated inside the assigned zone of representation for the observing site. Stature of the gulf must be 3–10 m over the ground level and at an appropriate separation from any immediate contamination source including activity. Substantial adjacent structures and trees reaching out over the tallness of the screen may make obstructions or statement surfaces for PM. Separation of the sampler to any wind current deterrent i.e. structures, must be more than two times the tallness of the snag over the sampler. There ought to be unlimited wind current in three of four quadrants. Certain trees may likewise be wellsprings of PM as garbage, dust, or creepy crawly parts. These can be maintained a strategic distance from by finding samplers by putting them >20 m from adjacent trees. On the off chance that assembled examining must be performed the base separation between two Samplers ought to be 2 m.

3.3.2.4 Apparatus and Materials

- Designation of sampling equipment as FRM (Federal Reference Method) or FEM (Federal Equivalent Method)
- Minimum resolution of electronic microbalance of 0.001 mg and a precision of ±0.001 mg, supplied with a balance pan. The microbalance must be positioned on a vibration-damping balance support table.
- Non-serrated forceps for handling filters. Non-metallic, non-serrated forceps for handling weights .
- 47 mm Filter: Teflon membrane, 46.2 mm effective diameter with a polypropylene support ring or filters.
- Filter support cassettes and covers.
- Filter equilibration racks.
- Impactor oil/grease.

3.3.2.5 Procedure

The procedure is same as that of PM10 sampler.

3.3.2.6 Calculation

The equation to calculate the mass of the particulate matter collected on Teflon filter is as below:

$$M_{2.5} = (M_f - M_i)\ mg \times 10^3\ \mu gm$$

Where,

$M_{2.5}$ = total mass of fine particulate collected during sampling period (μgm)

M_f = final mass of the conditioned filter after sample collection (mg)

M_i= initial mass of the conditioned filter before sample collection (mg)

10^3 = unit conversion factor for milligrams (mg) to micrograms (μgm)

Field records of $PM_{2.5}$ samplers are required to give estimations of the aggregate volume of surrounding air going through the sampler (V) in cubic meters at the genuine temperatures and weights measured amid examining.

Use the following formula if V is not available directly from the sampler:

$$V = Q_{avg} \times t \times 10^{-3}\ m^3$$

Where, ·

- V = total sample value (m3) ·
- Q_{avg} = average flow rate over the entire duration of the sampling period (L/min) ·
- t = duration of sampling period (min) ·
- 10^3 = unit conversion factor for liters (L) into cubic meters (m^3)

The equation given below can be used to determine $PM_{2.5}$ mass concentration:

$$PM_{2.5} = M_{2.5} / V$$

Where,

- $PM_{2.5}$ = mass concentration of $PM_{2.5}$ particulates (μgm/m^3)
- $M_{2.5}$ = total mass of fine particulate collected during sampling period (μgm)
- V = total volume of air sampled (m^3)

Chapter 4

Health Effects due to Airborne Dust in Coal Surface mine

4.1 PHYSIOLOGICAL EFFECTS OF MINERAL DUST

4.1.1 Human Respiratory System

Through nose and mouth air is brought into the respiratory framework. With air different pressurized canned products (dust, microscopic organisms, and dust) are additionally brought into the body. At the point when the pressurized canned products go through the nasal entries, bigger particles are cleared by hair and bodily fluid. After that wind currents through the nasopharynyx district, where it is warmed. At that point air goes through the trachea (windpipe), the bronchi (the two short branches off the trachea), and the bronchioles (branches off the bronchi) and into the alveoli (the terminal lung sacks where oxygen is transmitted into the circulatory system). Along the trachea, bronchi and bronchioles, particles of medium size are affected on the mucous layer coating the openings. Particles bigger than 10μm are gotten in ciliary lift and brought move down through the bronchial tree to the throat. This material is at that point hacked or gulped. Be that as it may, littler particles are saved on the lung surface through setting, impaction, Brownian movement. For these sorts of cleans, body's protection instrument comprises of phagocytes (meandering forager cells) called alveolar microphages. These microphages inundate the particles and confine them to lymph hubs for transfer. These forager cells are known as the trash specialist of respiratory framework as they ingest attacking particles. In the event that the particles are normal family unit tidies, then ingestion happens and the particles are walled off by microphages. Be that as it may, if the microphages ingest free silica molecule, it blasts. The lung is left with crushed microphages and free silica molecule. The molecule is then ingested by another microphage which thus is wrecked by blast and this procedure goes on. Each person has billions of microphages. The human body has advanced into a productive association intended to take out particles found in regular habitat. In any case, when an individual breathes in adequate particles underneath 10μm, the microphages are overpowered. At the point when enough microphages are decimated, the remaining natural material structures scar tissues. At first the scars are sufficiently little yet thusly nearby scars mix. As the scar tissue proceed to build, more lung tissue

is rendered pointless. Individual creates shortness of breath and his future is lessened. Fig.4.1 demonstrates human respiratory framework.

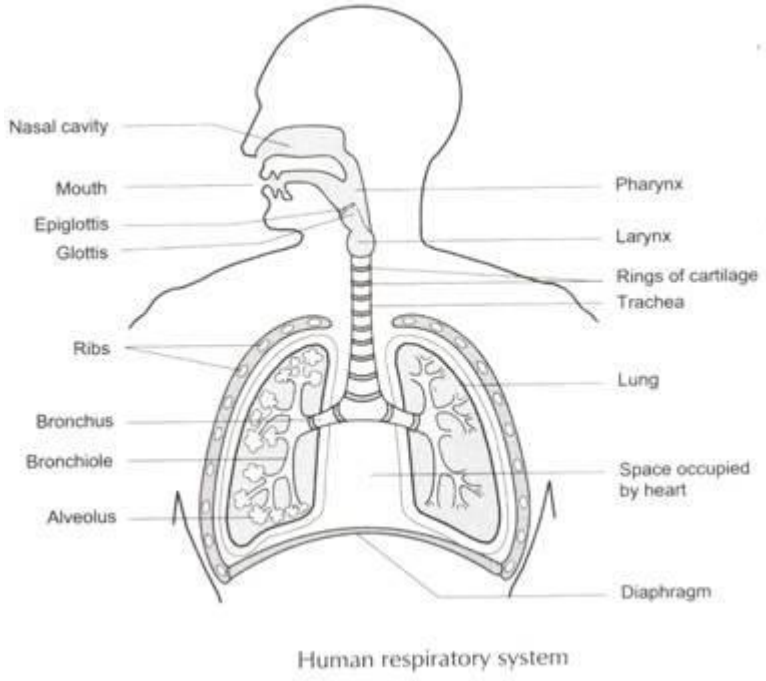

Fig 4.1: Human Respiratory System

(Source: http://www.biologydiscussion.com/wp-content/uploads/2014/01/clip_image0025.jpg)

4.1.2 Pneumoconiosis

Pneumoconiosis is characterized in the ILO working gathering in 1971 [16] as the aggregation of dust in lungs and the subsequent response of dust of lung tissues to it. It is the most widely recognized lung brokenness seen among mineworkers. Pneumoconiosis is described by the development of stringy tissues in lungs because of dust testimony. Pathologically, pneumoconiosis is partitioned into two classes:

- Collagenous
- Non-Collagenous

Non-fibrogenic dust cause the non-collagenous pneumoconiosis. Have general features

- Alveolar architecture remain intact

- Least stomal reaction comprising primarily reticular fibres
- Reversibility of dust reaction

On other hand fibrogenic dust causes the collagenous pneumoconiosis, as tissue response is altered to non-fibrogenic dust. Which is classified by:

- Permanent modified alveolar architecture
- Collagenous stromal varies from moderate to high
- Permanent scarring of lungs

Be that as it may, distinction amongst collagenous and no-collagenous pneumoconiosis is extreme and consistent presentation may bring about change from non-collagenous to collagenous. Contingent on particular easygoing material, diverse wordings are connected with various sorts of pneumoconiosis. Such as,

- Silicosis (dusts of quartz, trydymite and cristobalite)
- Silicate pneumoconiosis (dusts of silicate mineral such as kaolin, talc, tremolite, actinolite and anthophylite)
- Coal workers' pneumoconiosis (coal dust)
- Beryllium disease (dusts of beryllium compounds including ores)
- Siderosis (dusts of iron including ores) [17]

4.1.2.1 Factors responsible for Pneumoconiosis

Health effects mainly affected by

- Composition
- Concentration
- Size of particles
- Time of exposure

a. Composition: Chemical and mineralogical structure of dust is presumably the most essential component in deciding the level of destructiveness of dust. Some mineral cleans are innocuous whereas a few other mineral cleans are hurtful e.g. free silica is more unsafe than joined silica,

asbestos is cancer-causing in nature. The surface vitality of the particles and solvency is likewise imperative in the event of lethal cleans. Free silica substance is acknowledged all around as the most clean achieving lung not that of the air borne dust or the mineral or rock creating the dust that is imperative. Free silica substance of dust can be resolved through X-beam diffraction investigation, differential warm examination (DTA) and infra-red spectrograph.

b. Concentration: Mass concentration in the respirable size reach has been set up as the criteria for the determination of pneumoconiosis event. For silica dust, surface territory convergence of the respirable division is expected to decide destructiveness, as the harmfulness of silica dust is all the more nearly connected with the surface range of particles, since surface zone decides the solvency of the molecule. Tyndalloscope is the main instrument through which molecule surface territory focus can be measured.

c. Time of Exposure: The vast majority of the diseases connected with mineral dust introduction take quite a while of word related presentation to create to basic level. Asbestosis takes almost 10 years to create though silicosis may create inside a couple of years of presentation. The time of presentation required to create silicosis increments with diminishing in fixation. A few ailments like coal laborer's pneumoconiosis stop advancing when introduction to the dust is wiped out. Though silicosis is dynamic in nature, once created it advances regardless of the fact that presentation to tidy is ended.

There is a sure degree to which human respiratory framework can arrange breathed in dust. Bigger size particles kept in the upper respiratory tract is expelled through ciliary activity. Where as in the event of fine particles, microphages overwhelm them and evacuate them to lymph hubs, though fibrosis may create. At the point when the lymph hubs accomplish immersion fibrosis creates. Henceforth, clearly rate of event of pneumoconiosis can be straightforwardly co-identified with introduction time.

d. Size of the Particles: It is the most vital component in deciding the destructiveness of dust as it controls the area of the respiratory tract where the dust particles will dwell. Particles size alludes to the equal breadth, which is characterized as the distance across of the circular

particles of unit thickness having the same falling speed as the molecule being referred to. Particles lesser than 5µm measurement are well on the way to enter to lungs and got to be saved in alveoli. Most extreme harm is brought on by particles of 1µm size. It diminishes for both higher and lower sizes. It happens on the grounds that particles bigger than 5µm are kept in the upper respiratory tract, though particles of 1µm or lesser size achieve the alveoli.

Chapter 5

Assessment and characterization of airborne dust

Assessment and Characterization of airborne dust- A case study

5.1 Study Area: Lajkura Opencast Project:

5.1.1 Geographical location:

Lajkura opencast project is located in IB Valley coalfields over Orient Colliery leasehold. This project is situated in the District of Jharsuguda and well connected to NH-200. NH-6 and NH-10, and is beside Mumbai-Hawrah main line. Brajrajnagar is the nearest railway station.

Figure 5.1 Satellite view of LOCP

Lajkura Opencast Project (1MTY) was sanctioned by the Government of India in August 1983 and the production started from 1984-1985. At present Lajkura Opencast Project is running on an extension of 1.01 MTy. Which got approval in the year 2002. Previously the mine life was decided up to 2015 but further extension of the mine had been approved for 29 years, whose land acquisition work is in process. There is a proposal for 4.5 MTy for further expansion for which action has been taken.

- Land acquisition for mining 392.98 Ha is being processed.

- For 159.18 Ha forest Land, stege-1 is already approved and stage-II approval is under process.
- 116.056 Ha of non-forest (Govt.) Land has already been acquired and ready for mining.
- Outsourcing proposal for 4.5 MTY has been processed.
- Environmental clearance for 4.5 MTY has been obtained from Ministry of Environment and forest.

5.1.2 Geology:

IB Valley Coalfields form a part of Chhatishgarh Gondwana outlier within the main sone Mahanadi Valley Gondwana Basin. The topography of the block is generally flat barring from hillocks in the extreme dip of the property. Its highest altitude above mean sea level is about 278 mtrs and the lowest is 232 mtrs in the area.

Lajkura Coal horizon occur in Lajkura II block of IB Valley coalfields. The seam occur in Barakar Karaharbari formation of lower Gondwana. The Overburden of Lajkura OCP is medium hard course grained sand stone with shale bands and clay beds at places. This area is generally free from any major fault. The details parameter of the mine is given in Table 5.1.

Table 5.1 Details Parameters of the mine:

Name of the mine	**Lajkura Seam**
Thickness of the seam	18 to 23 Mtr
Location	South-Eastern part of the coalfield
Latitude	21 48’ 39” to 21 49’ 55” N
Longitude	83 53’ 15” to 83 54’ 50” E
Toposheet No.	64 0/13(RF 1:50,000)
District	Jharsuguda (Odisha)
Full dip	1in 23, N-70˚W
Present gradient of the seam	1in 16
Maximum quarry depth	159 m
Average stripping ratio	1:3.4
Grade of coal	Gev-G-13”
Target capacity	3..0 Mte

Date of opening of mine	7/8/1984
Main coustomers	Steel plants, power house in MSEB, TNEB, APGen. Corp etc.
Crossing point of Lajkura seam	135˚C
Ignition point of Lajkura seam	155˚C
Quarry Area	2554400m^2 255.44 Ha
Target of OB	6.00 M m^3
Coal target	3.00 M te.
Incubation Period	90 days

5.1.3 Mining System:

Removal of OB is done by Shovel- dumper combination. In the combination, rope shovel, hydraulic excavator, both front end and back hoe in connection with 50te/ 60 te dumpers are used. Extraction by the help of surface miner is shown in figure 5.2.

Drilling is done with the help of drills having 260mm dia. are used and blasting is done by SMS/SME.

At present the dragline is not in operation.

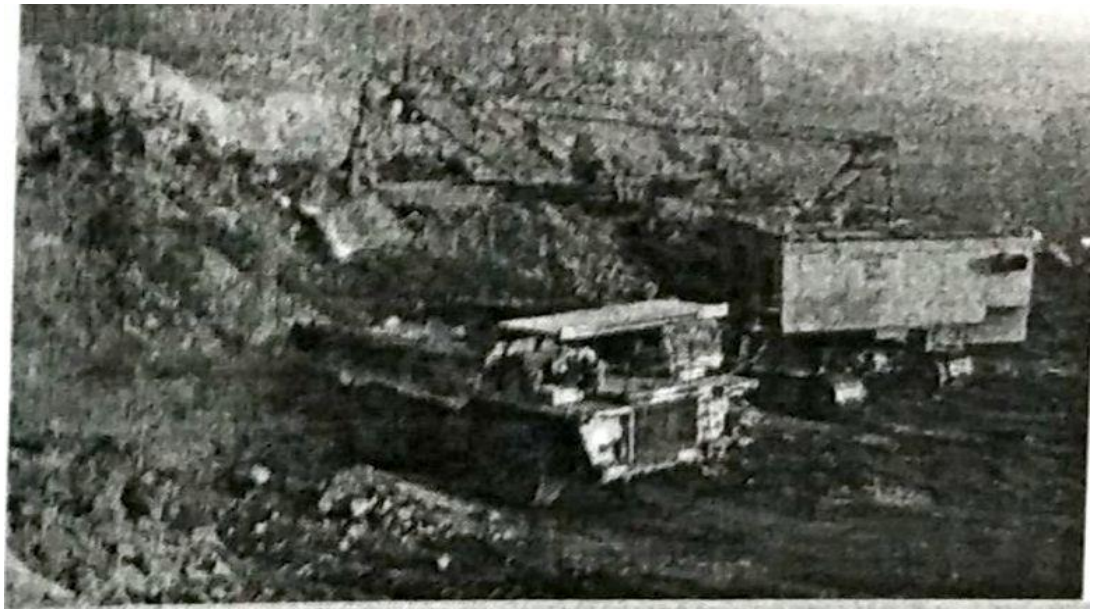

Figure 5.2 Extraction of coal by Surface miner

5.2 There are 3 studies those were done in the mine such as:

1. Dust monitoring by using Envirotech APM 460 NL and Envirotech APM 550
2. Personal dust Exposure Monitoring by using PDS
3. Characterization of the dust sample using FTIR to determine the dust components

5.2.1 Dust Monitoring by using Envirotech APM 460 NL:

Two different locations i.e. Mine's Managers office and time keeper's office were chosen for dust monitoring. The instrument was installed in those locations following these procedures. The installed Envirotech APM 460 NL is shown in Figure 5.3 and Figure 5.4.

- The sampler was installed at a particular height where the sample was to be taken.
- Initial weight of the filter paper was measured and noted.
- The filter paper was then gently placed inside the filter adapter assembly and the nuts were tightened.
- Then manometer was filled with distilled water (up to zero mark).
- Power supply was then given to the sampler.
- After giving the current time, the duration of sampling was fed into the timer.
- Then after starting the sampler, after about 5 minutes (when the water level is stabilized) initial flow rate was recorded.
- After the run time the sampler automatically switched off and the final flow rate was recorded.
- The filter paper was carefully removed and the final weight was taken in the lab.

After following these above procedure, the concentration of those particular area were calculated using the below formula.

$$\text{Total dust concentration} = \frac{\text{final weight} - \text{initial weight}}{\text{average flow rate x total sampling time}} \text{ X } 10^6$$

By using the above formula, we got the below concentrations from the two locations. The measured concentrations are shown in the Table 5.2.

Table 5.2 Concentration of dust measured by Envirotech APM 460 NL

Location	Initial time	Final time	Initial wt. of filter paper (gm)	Final wt. of filter paper (gm)	Initial flow rate (lpm)	Final flow rate (lpm)	Average flow rate (lpm)	Total dust conc. ($\mu g/m^3$)
Mine's Manager's office	3:10 pm	4:00 am	2.7005	3.4117	1.10	0.78	0.94	984
Time keeper's office	10:00 am	10:00 pm	2.6970	3.4355	1.10	0.81	0.955	1074

Figure 5.3 Dust samplers installed at Mines Manager's office

Figure 5.4 Dust sampler installed at time keeper's office

5.2.2 Dust monitoring by using Envirotech APM 550:

A location was chosen for the dust (PM 2.5) monitoring i.e. mine's Manager Office. The instrument was installed on the dust monitoring station of the mine. The below procedure was followed to install and run the instrument.

- The instrument is installed at a particular height for better results.
- The initial filter paper weight was recorded.
- Initial Direct Gas Meter (DGM) reading is noted down.
- After the desired run time the instrument is switched off.
- Final Direct Gas Meter (DGM) reading was noted down.
- Final weight of the filter paper was taken in the lab and recorded.

After the above procedure the concentration was found out by using the below formula

Total dust concentration =

$$\frac{final\ weight\ of\ the\ filter\ paper - initial\ weight\ of\ the\ filter\ paper}{final\ DGM\ reading - initial\ DGM\ reading}\ X\ 10^6$$

The calculated Total dust concentration is shown in the Table 5.3

Table 5.3 Concentration of dust measured by Envirotech APM 550

Location	Initial time	Final time	Initial wt. of filter paper (gm)	Final wt. of filter paper (gm)	Initial DGM reading (m^3)	Final DGM reading (m^3)	Total air volume (m^3)	Total dust conc. ($\mu g/m^3$)
Mine's Manager's office	3:00 pm	10:00 am	0.1581	0.1616	58.449	76.318	17.869	196

5.3 Personal dust exposure sampling:

By using Personal Dust Sampler (Model Arelco Ineris CIP 10) the personal dust exposure is measured at various mine site of different workers engaged with mining operation. A constant flow rate was maintained i.e. 10l/min for the duration of the dust exposure. As per CMR 123 if the weighted average concentration of airborne dust at a place during 8 hour shift is less than 3 then that place is in a harmless state for persons to work. The measured dust concentration is shown in the Table 5.4.

Table 5.4: Personal dust exposure measured at different mining operation sites

Location	Initial weight of the cup (gm)	Final weight of the cup (gm)	Flow rate (l/min)	Duration (min)	Concentration (mg/m^3)
Dumper operator	3.3926	3.3968	10	450	0.933
Dozer operator	3.3940	33985	10	420	1.07
Surface miner operator	3.3931	3.3982	10	420	1.214
Pay loader operator	3.3935	3.3975	10	420	0.952
Supervisor (coal face)	3.3970	3.4013	10	450	0.955
Filter C.H.P.	3.3938	3.3987	10	450	1.088
Tipper driver (Coal face)	3.3941	3.3988	10	420	1.119
Shovel helper	3.3089	3.3132	10	405	1.06
IDM 30 drill operator	3.3814	3.3857	10	360	1.194

5.4 Dust characterization:

As we know that there are various types of compound present in the mine dust which may be harmful for the miner's health, so in the characterization we have found out the various compounds like silica, sulfoxide, sulphates, carboxylates etc. through FTIR.

Fourier Transfrom Infra-Red Technique was used to find out the compounds present in the dust sample collected from the filter papers. Dust samples were extracted from the filter papers of PM 10 and PM 2.5 sampler to find out the compounds present in the dust sample by the help of FTIR. FTIR is more effective than XRD because it has more enhanced efficiency at lower particle size. A little amount of dust samples were collected from the surface of the filter paper. Then the dust sample is mixed with the KBr (200 mg). The two products were thoroughly mixed. Then pallets were constructed with the help of pallet maker. FTIR of those pallets were carried out from 4000 cm^{-1} to 400 cm^{-1}at a resolution of 4 $cm^{-1}$with 4 scans per sample. The data collected from the FTIR machine were put into the Origin software to get the wavenumber of the peaks. From the literature studies the compound present in the sample were found out according to the wavenumber of those peaks. And the health effects of those compounds were studied. The graph those are obtained from Origin are shown in Figure 5.5, Figure 5.6 and Figure 5.7.

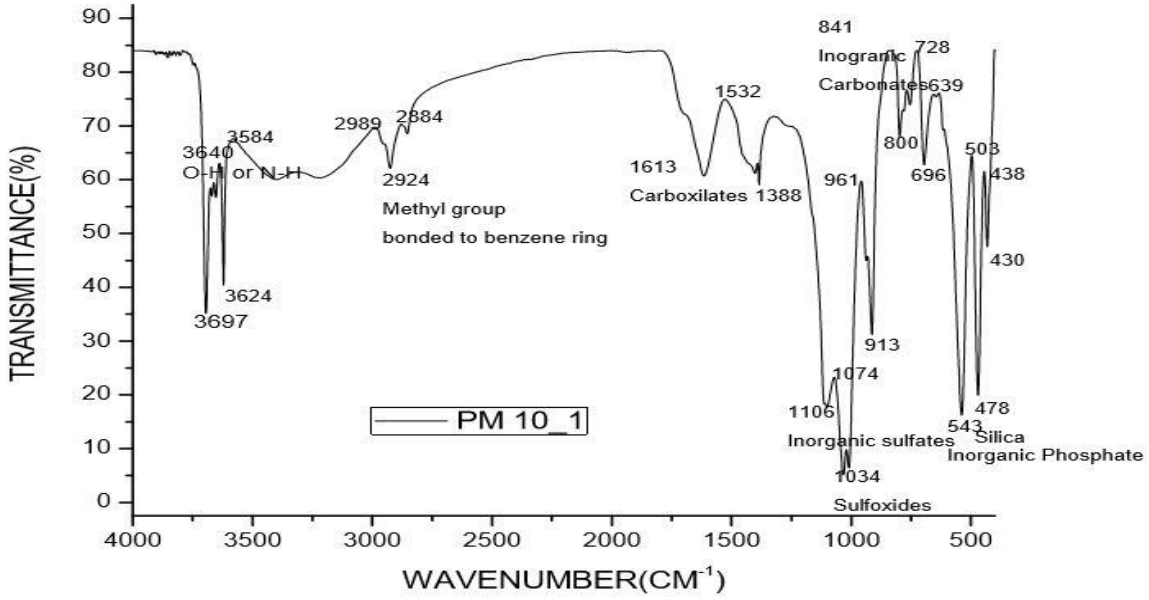

Figure 5.5 Characteristics graph for dust collected from PM 10(1) sampler

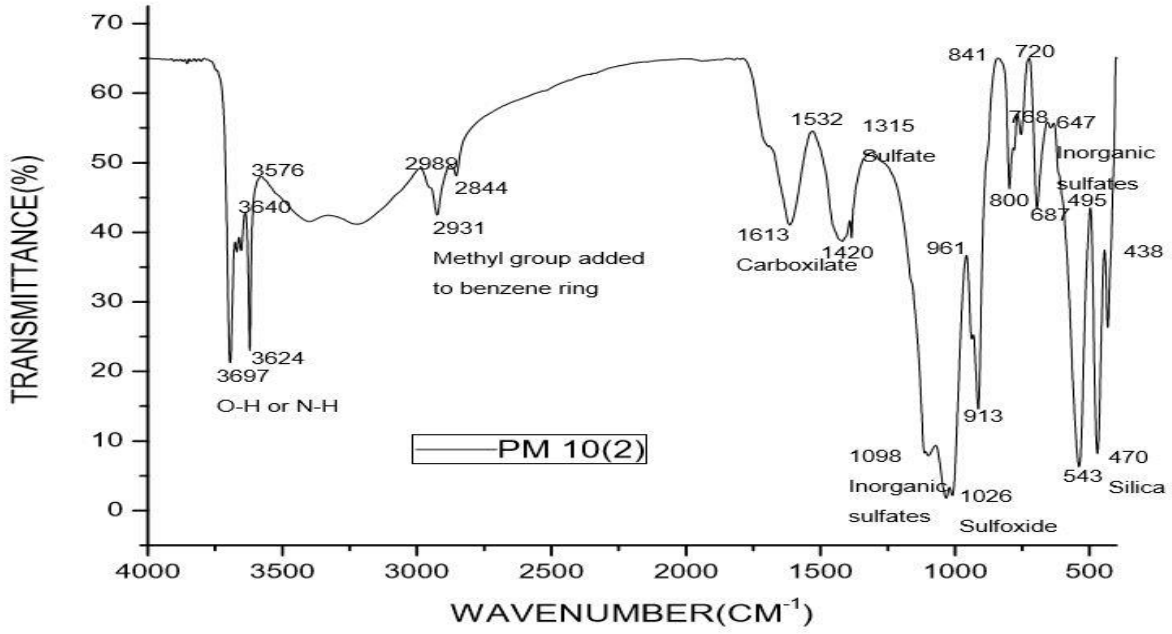

Figure 5.6 Characteristics graph for dust collected from PM 10(2) sampler

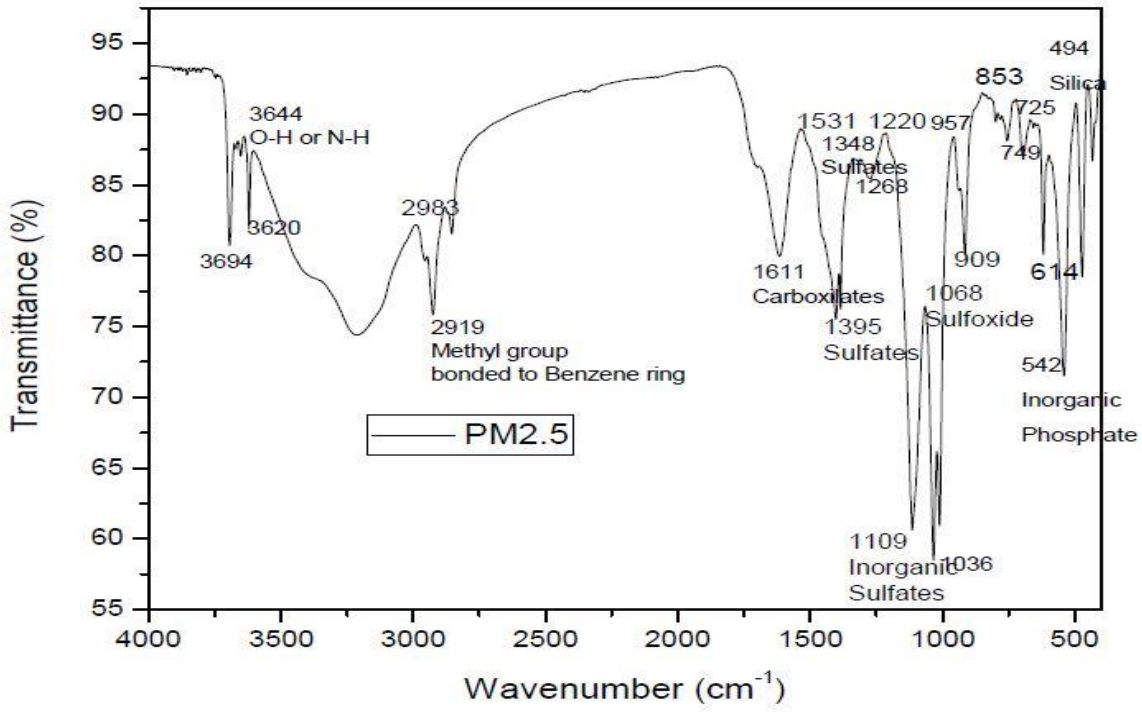

Figure 5.7 Characteristics graph for dust collected from PM 2.5 sampler

Chapter 6

Result and Discussion

RESULTS AND DISCUSSIONS

Lajkura opencast Project:

6.1 Results from Dust monitoring

From the dust monitoring process at two different locations at LOCP, a comparison has been made for both sources. The total dust concentration at both the sources is shown in the figure 6.1 from where it is seen that the concentration is high at Times Keeper's office as compared to Mine's Manager's office.

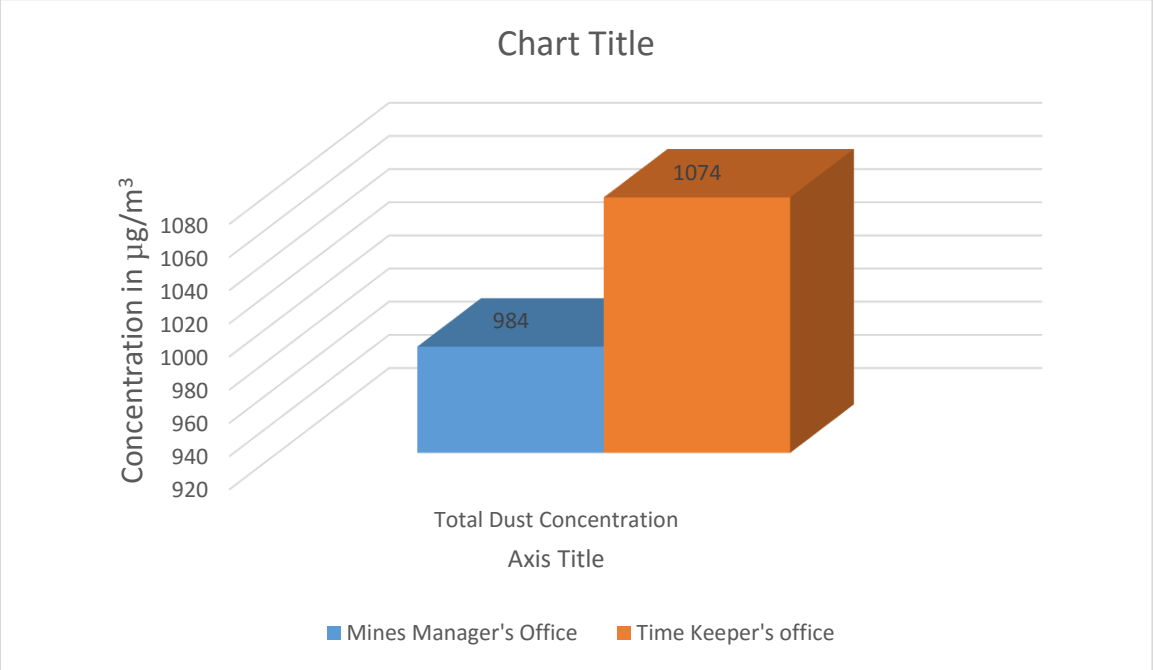

Figure 6.1 Comparison of dust concentration at both locations of LOCP

6.2 Results from Personal Dust Sampler (Model Arelco Ineris CIP 10) [18]

Personal dust exposure to different workmen was plotted in figure 6.2. Exposure level is high for surface miner operator and is minimum for dumper operator. But both are under limit, and every workmen is exposed to very les amount of airborne dust i.e. < 1.5mg/m^3.

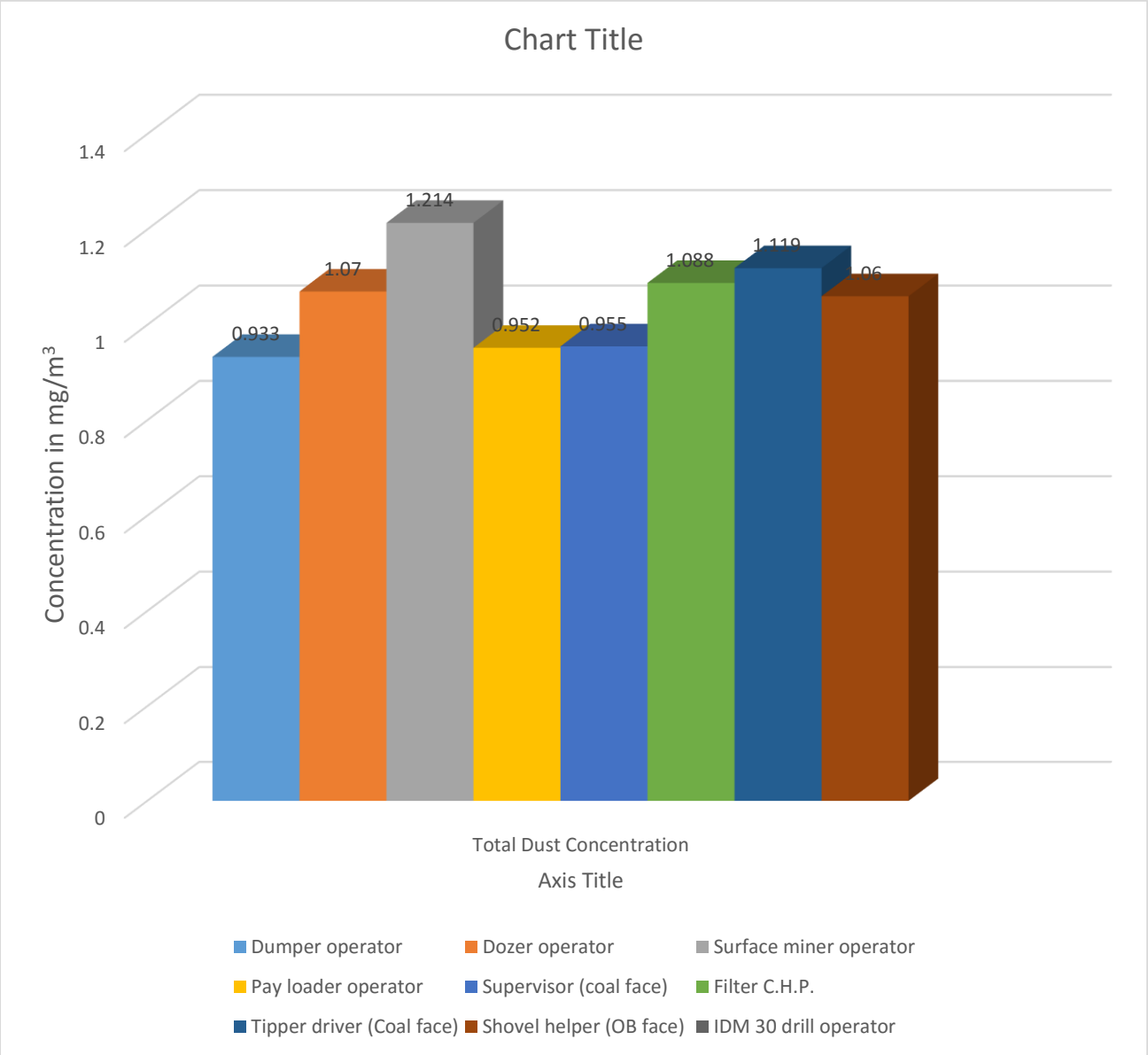

Figure 6.2 Comparison of personal dust exposure at different mining operation sites

6.3 Results from Characterization of Dust

From FTIR of the dust sample collected from the filter paper we found out various types of compounds from which some of the compounds are very toxic in nature and can affect human health in various ways eg. Silica, Sulfoxide, Sulfates, Carboxylates etc.

The wavenumber (cm^{-1}) and the corresponding compound and bond exist between the compound is written in table 6.1.

Table 6.1 Standards for FTIR Analysis

Compound/ Functional group	Bond exist in the Functional group	Wavenumber (cm^{-1})
Silica	Si-O-Si stretch Si-O-Si bend	1200-1000 ~450
Sulfoxide	S-O	1070-1030
Sulfate	SO_2 Stretch	1430-1330
Carboxylate	CO_2 stretch	1650-1540

CHAPTER 7

Conclusion

CONCLUSION

- From the dust monitoring at two different locations by using Envirotech APM 460 NL we can conclude that:

  The dust concentration at Mine's Manager Office is 984μg/m^3 and at time keeper's office is 1074 μg/m^3 which is very high as compared to the standard.

  And by seeing the results of Envirotech APM 550 we can conclude that:

  The total dust concentration is 196 μg/m^3 which is also far more than the standard value. So as to control such dust dispersion proper precautions should be taken so that it can't affect the health of the people.
- From the data collected by using Personal Dust sampler (PDS), it can be concluded that:

  The concentrations that we obtained from different mining location are under limit i.e. between 0.9mg/m^3-1.3 mg/m^3. And surface miner operator is exposed to maximum amount of dust as compared to other ones i.e. 1.214 mg/m^3, but it is not so harmful. Proper precautions were being taken in the mining sites to control the airborne dust.
- From the Characterization of the dust sample using FTIR, it can be concluded that:

  There are various types of compound exist in the dust from which some of the compounds are very harmful to the health of human being eg. Silica, Sulfates, Sulfoxides, Carboxylates etc. So the dust concentration should come below its standard limit so that the toxic compound can't affect the health so much.
- For future studies quantitative estimation can also carried out of compounds found in current study and apart from FTIR which is a part of whole characterization one can go for characterization by using X-ray diffractometer.

Chapter 8

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