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DUST MONITORING, CHARACTERIZATION AND PREDICTION IN AN OPENCAST COAL MINE

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ABSTRACT:

Dust contamination is the most serious environmental hazard associated with open-pit mining. Haul roads, pulverizing, conveying, loading, blasting, drilling, and the overburden face all contribute significantly to fumigant dust production. Silica exposure among employees can lead to silicosis and lung cancer. Dust concentration forecasting is essential to assess a mine's environmental impact.

KEYWORDS: *Fugitive Dust, Dust Track II, PDS, AERMOD, Quartz, FTIR.*

1. INTRODUCTION

Silt can induce pneumonia and chronic bronchitis in mine workers. The ability to merge. PM2, PM10, and TSP. Size is a feature of five particles. Dust is commonly measured in particles per cubic meter. All mining operations generate dust. Dust is produced throughout the entire operation. Open-pit miners emit more dust than subterranean miners. During the mining process, dust is generated through blasting, loading, transportation, crushing, conveying, haul roads, and overburden extraction. To evaluate mining air quality, dust emission rates and sources from mine site activities must be identified. Because silicone is toxic, working with it can accelerate the development of silicosis and lung cancer. Measure ambient silica to measure miners' health. Diffusion models struggle to analyze dust emission and dispersion patterns due to the wide range of fugitive sources that can produce dust during mining, the local climate and topography, and the empirical emission characteristics. Monitoring ambient air quality validates dust concentrations, whereas dispersion modeling predicts isopleths. Long-term monitoring is required to determine mining dust concentrations. Dust dispersal is influenced by emissions, wind speed, precipitation, and sprinkling. Even in low-dust mines, background dust can interfere with the detector.

2. REVIEW OF LITERATURE

The greatest environmental threat that open-pit miners face is dust exposure. Several investigations have pinpointed the source of mining dust. Top priorities include effective particle management within the mine and determining the most and least ecologically damaging sources. Miners frequently develop pneumoconiosis as a result of dust exposure. Several studies show that dust mite exposure is legally permitted. Workers' exposure to silica must be monitored due to its carcinogenic qualities. Environmental Impact Assessments (EIAs) are required to forecast the levels of particulate matter linked with mining activities. Weather conditions have a considerable influence on particle dispersion.

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Consequently, several mathematical models are produced. Scientists test these models under various weather conditions to discover which one is best suited for a certain region. The following research initiatives are being considered.

Erol et al. (2013)] In coal mines, the amount of quartz in respirable dust and the risk of pneumoconiosis among coalface workers were assessed. The dust sampler MRE-113A gathered dust samples, and the concentration of silica was evaluated using FTIR. The majority of coal faces had mean respirable particle concentrations that exceeded the permitted limit. An ANOVA was used to determine the effect of seam and workplace variables on dust. Fissures and collieries had varying levels of respirable dust and quartz.

Ghosh and Majee (2007) They analyzed opencast mine dust from the Jharia coalfield. Natural particles had a median diameter of 20µm, increasing their respirability. The ambient air had less TSP, RPM, and benzene soluble matter than the air in the work zone. The concentration of SPM was highest at the dragline and lowest along the transportation road. The TSP was highest near the feeder. Summer was the season with the highest levels of respirable particle matter. The day's TSP concentration was higher than the previous two because the majority of work was accomplished between 0800 and 1700. In the majority of regions, TSP concentrations surpass PCB guidelines during the winter, summer, and monsoon seasons. The weight % of respirable fraction was higher for haul road TSP compared to feeder breaker TSP.

Chaulya (2004) Lakhanpur in Ibvalley was assessed as having fair quality. TSP, PM10, SO2, and NOx concentrations were measured at thirteen locations over a one-year period. The average 24-hour and annual amounts of TSP and PM10 surpassed the NAAQS limits, whereas SO2 and NOx stayed within them.31.94% TSP was found in PM10.Greenbelts were advocated.

Kumarietal.(2011) The concentration of respirable particulate quartz in the air was measured using an FTIR spectrometer. Personal dust samplers and GLA-500 PVC membrane filters were used to collect respirable dust from the air at several mines. The quartz concentration of practically every working in the Jharia coalfield was less than 1%. The usual workplace MEL is 3 mg/m3. Several metal mine workings, however, had quartz concentrations more than 5%.In some areas, pollution is controlled using wet drilling and ventilation, while in others, worker rotation is required.

Mukherjeeetal.(2005) Between 1988 and 1991, a risk assessment for coal worker pneumoconiosis was undertaken in nine eastern Indian coal mines, with respirable dust, free silicon concentration, and worker exposure used as indicators. MRE113 and AFC123 samples were examined for particle monitoring using FTIR. Turnip particle levels at B&P and Longwall were elevated. Particulates were mostly produced during loading, blasting, and drilling operations. Longwall workings had a greater impact on shearer operators, DOSCO loaders, and power support face workers than they did on drillers and loaders. Drillers and compressor operators in opencast mining were especially vulnerable to risk. Silica concentration is often less than 5%, and quarryloaders and opencast mine drillers are especially vulnerable to it.

Mishra and Jha (2010) Mishra and Jha (2010) used field data to validate their findings on dispersion modeling in an opencast coal mine. This inquiry confirmed the FDM model's validity. A dust concentration impact zone was constructed by assessing dust production related with activities and comparing distance to dust concentration. Coal transportation and haul roadways were the most polluting. The link between transit route length, vehicle speed, and mine dust emissions. For dust dispersion modeling, 90% of the projected dust concentrations using fugitive dust modeling were correct. They determined that the majority of dust is deposited within 100 metres of the source, with levels dropping to background levels 300-500 metres away. More than 80% of haul vehicle dust is greater than 10 µm.

Trivedi et al. (2008) Analyzed point, line, and area sources of dust in an open pit coal mine and calculated dust emissions. The air quality was represented by the Fugitive Dust Model. Beyond 500 meters, mining dust does not improve air quality. To determine emissions, a modified Pasquill and Gifford formula was used. The projected amount of suspended particulate matter was 68-92% of what was measured. TSPM concentrations declined dramatically as distance from the source increased. Mine dust has no visible environmental consequences beyond a 500-meter radius. Dust sources included truck highways, overburden, and coal loading and unloading.

Chaulya et al. (2002) SPM emission rates were researched to determine open-pit mining emission rates. Validation using PAL2 and FDM. Two models independently forecasted concentrations at three receptor locations for each mine. The performance of FDM in Indian mines was excellent. The most dust was emitted by coal handling facilities, haul routes, and transportation corridors. At specific sites, the PAL2 and FDM models agreed on observed and anticipated SPM values by 60-71% and 68-80%, respectively.

3. BACKGROUND WORK

Dust is composed of invisible airborne particles. The air includes a few micrograms to hundreds of micrograms per cubic meter of dust particles ranging in size from a few nanometers to one hundred micrometers. Dust can come from a variety of sources, including the environment, mining, or volcanic eruptions. Wind-induced turbulence disturbances drive dust particles into the air. Mechanical disturbances and the emission of gaseous pollutants containing a high concentration of particle matter are additional possible causes. Dust particles measure less than one micrometer to one millimeter. The size spectrum ranges from 1 to 20 µm, with few particles below 1 µm and fast settling of particles over 20 µm. Particle properties are strongly influenced by their dimensions. Sort dust by particle size.

Particlesgreaterthan10µm:

The law of gravity governs how particles settle. They accelerate to a complete halt in the quiet air.

Particlesbetween0.1µmto10µm:

Particles in motion obey Stoke's law and descend at a constant velocity. The velocity of particles is influenced by their acceleration, as well as the size, mass, and viscosity of the medium.

Particlesbetween0.01µmto 0.1µm:

Instead of sedimentation, these particles remain colloidal

ATMOSPHERIC DUST

Salinization and sandblasting mechanisms, which take particulates from surfaces by wind action, contribute to the formation of atmospheric dust. The troposphere enables the movement of atmospheric particles. Arid and dry regions generate the majority of airborne particle matter because they are particularly sensitive to erosion caused by strong winds.

FUGITIVE DUST

The phrase "fuggitivedust" refers to a substance suspended or scattered in the air, typically including minute particles or particulate matter.

As a result of dust formation, aerosol particles became airborne and traveled in the opposite direction of the wind's velocity. Fugitive dust is a word used to describe dust that comes from multiple sources or whose origin is difficult to determine. Fumigant dust is produced during mining operations by the movement of heavy machinery along unpaved transit routes, as well as blasting and loading activities. Because mining dusts are mostly created by non-point sources, they are commonly classed as fugitive dusts.

MINE DUST

Mineral deposit extraction and refining necessitate drilling, blasting, crushing, and grinding. Surface abrasion and mechanical crushing produce small particles, which remain in the environment. Dumpers and other heavy equipment generate dust along the transportation path. Mine dust is generally fugitive, implying that surface disturbances are its primary source. Surface mining generates more dust than underground mining due to large-scale automation, heavy machinery, and airflow-prone locations. To extract ore from open-pit mines, large amounts of overburden must be mined. Dumpers, shovels, draglines, and other equipment that emits tiny particles into the air are required for waste removal. Explosives can produce a substantial amount of airborne particles. Dust is also produced during the management and transportation of residual minerals once mining is completed. Many overburdened landfills are dust sensitive if no dust-reduction measures are implemented.

4. CLASSIFICATION OF DUST

Mine dust's chemical makeup is determined by the mineral content of the ore. Classification of dust by hazard:

Fibrogenic Dust

- Silica(quartz, crystobalite, tridymite, chert)
- Silicates(asbestos, talc, mica, silimanite)
- Metalfumes
- Berylliumores
- Ironores
- Carborundum
- Coal(bituminous,anthracite)

Carcinogenic Dusts

- Asbestos
- Radondaughters
- Arsenic
- Dieselparticulatematter (asuspendedcarcinogen)
- Silica(asuspended carcinogen)

Toxicaerosols (poisonous to body organs and tissues etc.)

- Dusts of ores of beryllium, lead, uranium, radium, thorium, chromium, vanadium, manganese, arsenic, mercury, cadmium, antimony, selenium, nickel, tungsten, silver.
- Mists and fumes of organic and other body-sensitising chemicals

Radioactive dusts

- Oresofuranium,radium, thorium(injuriousbecauseofalphaandbetaradiation)
- Dustswithradondaughtersattached(sourceof alpha radiation)

Explosive dusts (combustibles when air borne)

- Metallic dusts (magnesium, aluminium, zinc, tin, iron)
- Coal(bituminous, lignite)
- Sulphideores
- Organicdusts

Nuisance dusts (little adverse effects on humans)

- Gypsum
- Kaolin
- Limestone

PHYSIOLOGICALEFFECTSOFMINERALDUST

HumanRespiratorySystem

Iris enters the respiratory system through the mouth and nose. Pollen, dirt, and infections enter the body via air. Hair and mucus prevent larger aerosol particles from entering the nose. Warm breath enters the asopharynx. After that, air passes via the bronchioles, alveoli, trachea, and bronchi. Alveoli provide oxygen to the cardiovascular system. Medium-sized particles harm bronchi, trachea, and bronchiole mucous. Ciliary escalators recirculate particles larger than 10µm into the neck via the bronchial tree. Aspirated or coughed up. Alternatively, impaction, Brownian motion, and settling deposit smaller particles in the alveoli. Pneutrophils, or itinerant scavenger cells, attack dirt. To remove particles, microphages carry them to lymph nodes. Respiratory scavenger cells catch intruding particles. Microphages that block household dust imply ingestion. Microphages devour freed silica, which bursts. The lungs contain silica and damaged macrophages. After consuming the particle, another microphage erupts and destroys it.

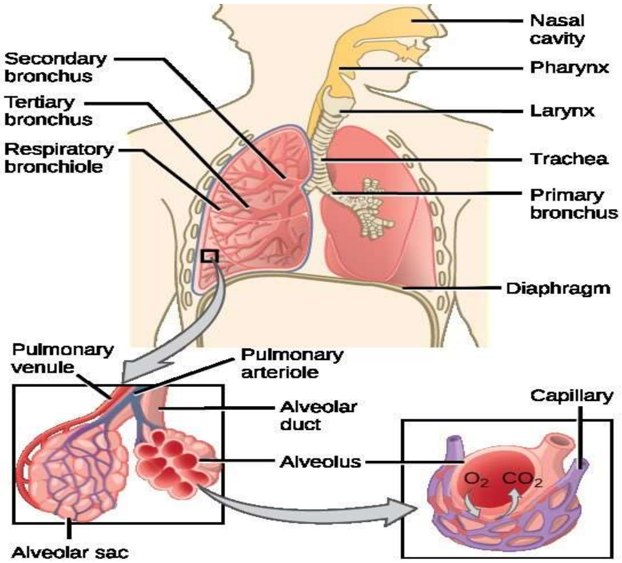

Figure1 Human respiratory system

Pneumoconiosis

In 1971, an ILO working group defined pneumoconiosis as the accumulation of lung dust and the reactivity of lung tissue to dust. The most common type of pulmonary dysfunction among miners is this. Dust accumulation causes fibrous lung structures as a result of pneumoconiosis. Pathology distinguishes two kinds of pneumoconiosis.

- Collagenous
- Non-collagenous

Non-fibrogenic dusts are the cause of non-collagen pneumoconiosis. Typical symptoms include.

- Alveolararchitectureremainin tact
- Least stromal reaction comprising primarily reticular fibres
- Reversibilityof dust reaction

Fibrous dusts modify tissue reactivity to non-fibrous dusts, causing collagenous pneumoconiosis. Composed of:

- Permanent modification or destruction of alveolar architecture
- Collagenousstromalreactionfrommoderatetohighest point
- Permanentscarringoflungs

In contrast to non-collagenous pneumoconiosis, collagenous pneumoconiosis can develop as a result of long-term exposure.

Pneumoconiosis is referred to in numerous ways in informal literature. For example:

- Silicosis(dusts of quartz, try dymite and cristobalite)
- Silicatepneumoconiosis(dustsofsilicatemineralsuchaskaolin,talc,tremolite, actinolite and anthophylite)
- Coalworkers’pneumoconiosis(coal dust)
- Berylliumdisease(dustsofberylliumcompoundsincludingores)

- Siderosis(dustsofironincludingores)

FactorsResponsibleforPneumoconiosis

The bulk of dust health effects on

- Composition
- Concentration
- Sizeofparticles
- Timeofexposure

Composition

Dust's dangerous nature is mostly influenced by its chemical and mineralogical composition. Some mineral dusts are safe, but others are harmful. Mixed silica is less harmful than free silica, although asbestos is carcinogenic by definition. Furthermore, particle surface energy and solubility affect dangerous dusts. Free silica dust has the highest lung impact when compared to mineral, boulder, and airborne dust. The free silica content of any dust can be determined using an infrared spectrograph, DTA, or X-ray diffraction.

Concentration

There are three viable approaches for assessing particle concentration:

- The particle number per milliliter of air, measured in milligrams or micrograms.
- "PPCC" is an abbreviation for "number of particles per unit volume."
- The density of particles' surface areas.

The prevalence of pneumoconiosis is determined by an examination of mass concentration within the respirable size range. The surface area of silica dust particles determines their solubility, which, in turn, influences their toxicity. To estimate the harmful effects of silica dust, the concentration of the respirable portion must be calculated in relation to surface area. The Tyndall scope is the single instrument used to quantify particle surface area concentration.

Time of Exposure

The majority of ailments caused by occupational exposure to mineral dust typically progress to a critical stage over time. While silicosis can develop after a few years of exposure, asbestosis typically progresses over ten years. As the concentration lowers, the amount of exposure required to cause silicosis increases. Certain disorders, such as pneumoconiosis in coal miners, stop progressing after particle exposure is reduced. On the contrary, silicosis is a degenerative disorder that worsens even when dust exposure is stopped.

The respiratory system has a limited capacity to remove ingested particulates. Ciliary activity facilitates the removal of bigger particles that have collected in the upper respiratory tract. Foreign particles have the potential to cause fibrosis, but macrophages envelop and remove them from the lymph nodes. Fibrosis is distinguished by lymph node saturation. As a result, it is clear that there is a direct relationship between exposure length and the occurrence of pneumoconiosis.

Size of the Particles

Dust toxicity is mostly determined by its ability to govern the placement of dust particles in the respiratory tract. The phrase "particle size" refers to the equivalent diameter of spherical particles under inquiry with the same density and descending velocity as the subject particle. Particles less than 5µm in diameter are more likely to penetrate the pulmonary system and collect in alveoli. Particles one micrometer in diameter cause the most damage. It applies to all sizes. Particles larger than 5 µm enter the upper respiratory tract, whereas those smaller than 1 µm can penetrate the alveoli.

Real Time Dust Monitoring

Mine dust was measured at loading points, drilling locations, surface miners, blasting, haul roads, and transportation routes. The Asper The gadget was placed one meter from the dust source and facing the breeze, in accordance with CMR:123 of the 1957 Coal Mines Regulation. Zero calibration started with a zero filter. After that, sensors that detect PM10, PM4, PM2.5, and PM1 were used consecutively to quantify particle levels at specific locations for one hour. The generated data was processed using Trak Pro on a PC. Trak Pro makes it easier to graph and analyze acquired data. The data below depicts dust concentrations by particle size at various locations.

5. RESULTS

Dust monitoring at Loading point (Shovel-Dumper)

One could claim that a large open-pit mine's loading point contributes significantly to dust formation. A large number of dump trucks were constantly loaded with coal on a daily basis to enable LOCP fulfill its annual objective of 15 million tons. Figure 2 depicts the loading position in the LOCP for the shovel-dumper. An examination was done at the transfer point to compare various dust fraction sizes. Mine dust was measured at loading points, drilling locations, surface miners, blasting, haul roads, and transportation routes. The Asper The gadget was placed one meter from the dust source and facing the breeze, in accordance with CMR:123 of the 1957 Coal Mines Regulation. Zero calibration started with a zero filter. After that, sensors that detect PM10, PM4, PM2.5, and PM1 were used consecutively to quantify particle levels at specific locations for one hour. The generated data was processed using Trak Pro on a PC. Trak Pro makes it easier to graph and analyze acquired data. The data below depicts dust concentrations by particle size at various locations. Figures 3–6 depict the temporal evolution of particle concentrations for PM10, PM4, PM2.5, and PM1.

Figure2 Loading point at LOCP for shovel and dumper

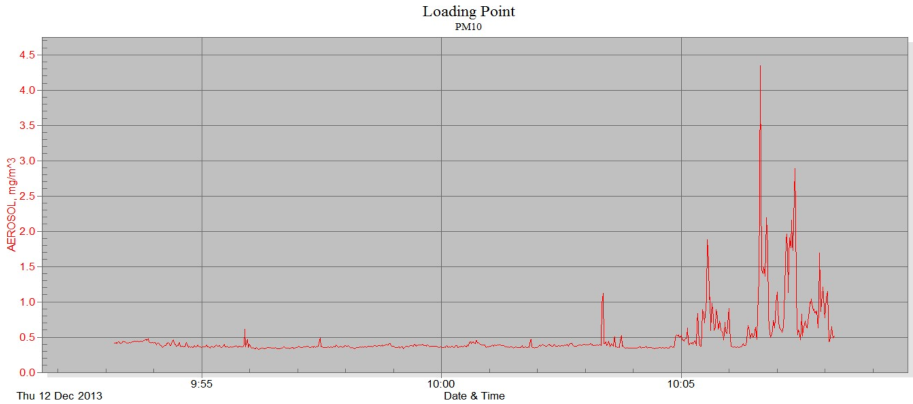

Figure3 Concentration vs Time graph for dust at loading point in PM10

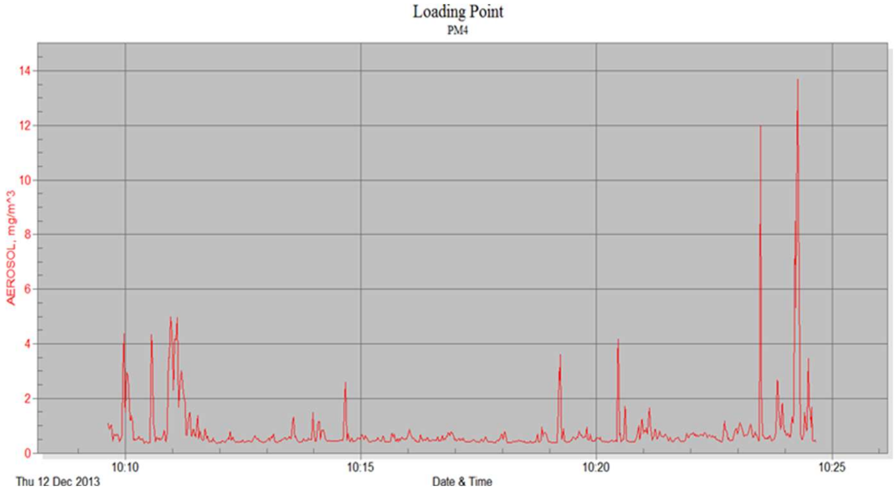

Figure 4 Concentration vs Time graph for dust at loading point in PM4

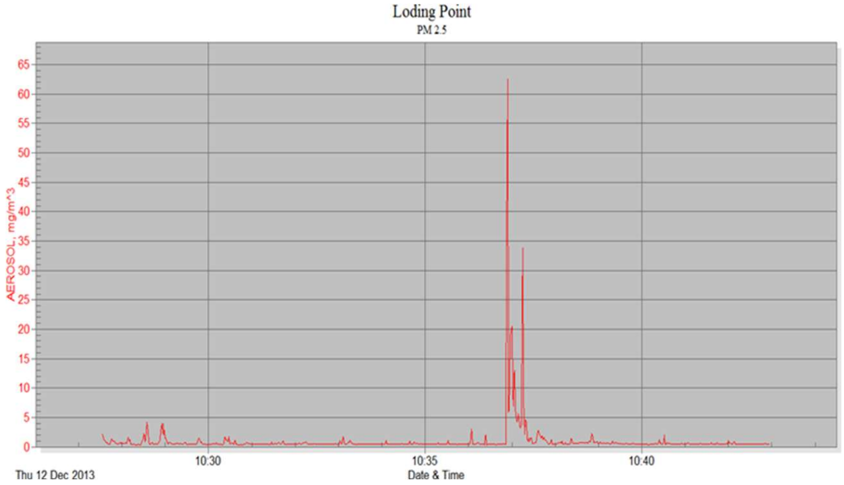

Figure5 Concentration vs Time graph for dust at loading point in PM 2.5

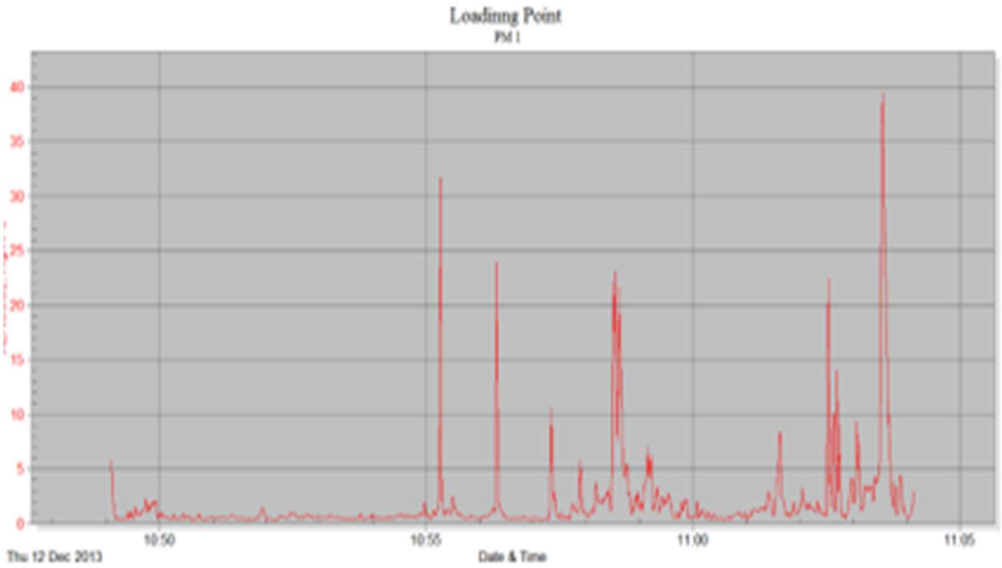

Figure 6 Concentration vs Time graph for dust at loading point in PM1

The graph's extremities represent individual instances of loading. The prevailing wind direction and length of loading caused variances in summit forms. The lower concentration region of the graph represents the interval during which the shovel is inactive.

DustmonitoringatDrilling Operation

The primary and most harmful cause of environmental contamination in any mine is drilling. Inadequate water supply may result in the formation of a large number of fine dust particles, which are potentially detrimental to laborers' health if inhaled. Traditionally, drilling activities at LOCP were carried out on an overburden bench, which helped to speed up the blasting process and remove a higher amount of overburden material. Atlas Copco drilling machinery typically used 150mm drill blades. Figure 7 shows the drilling apparatus. The fundamental cause of the significant dust accumulation at the drilling site was the inefficient use of water during the drilling operations. Figures 8, 9, 10, and 11 show how the concentration of variable particle sizes changes over time

Figure7 Drilling operation at LOCP

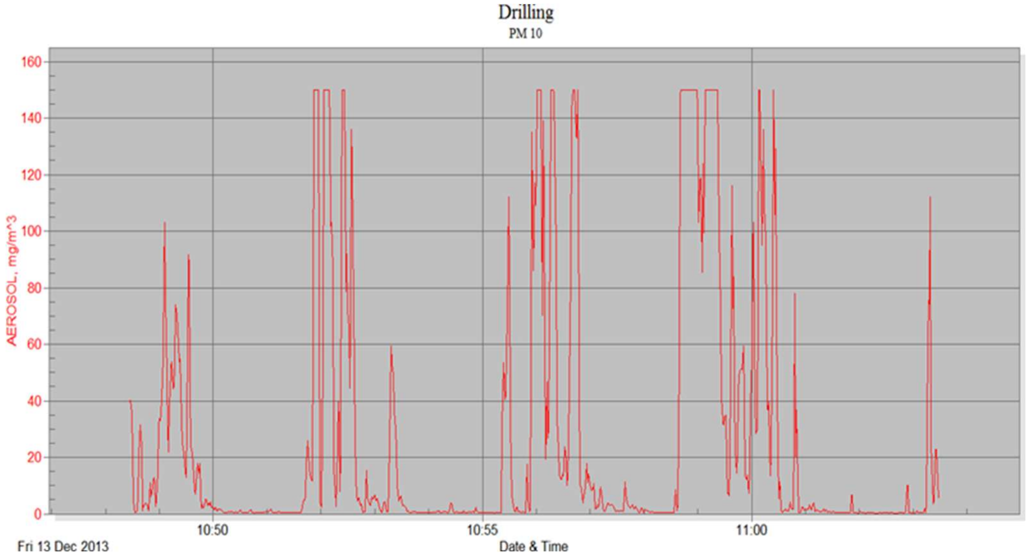

Figure8 Concentration vs Time graph for dust at drilling point in PM10

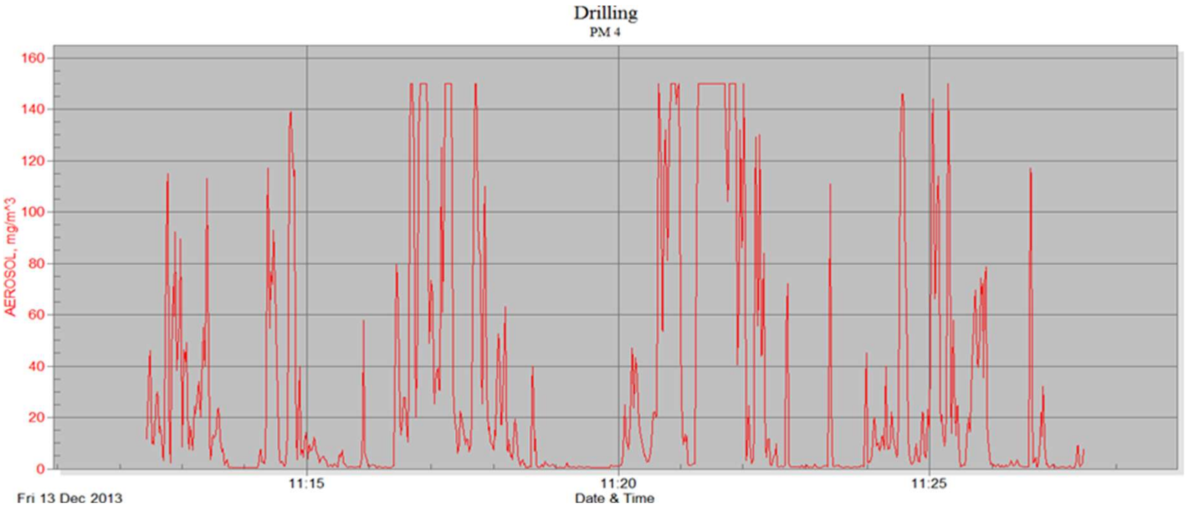

Figure9 Concentration vs Time graph for dust at drilling point in PM 4

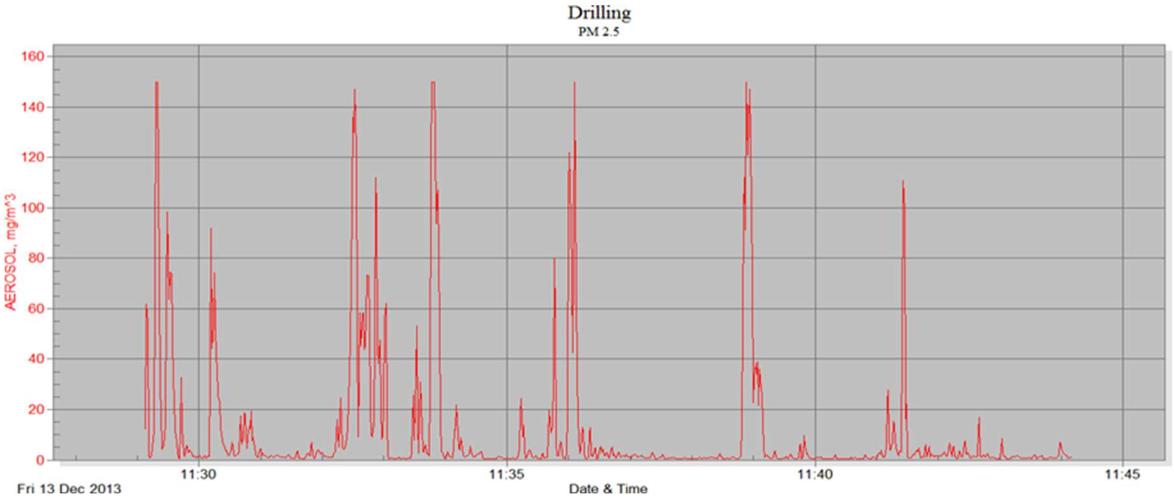

Figure10 Concentration vs Time graph for dust at drilling point in PM 2.5

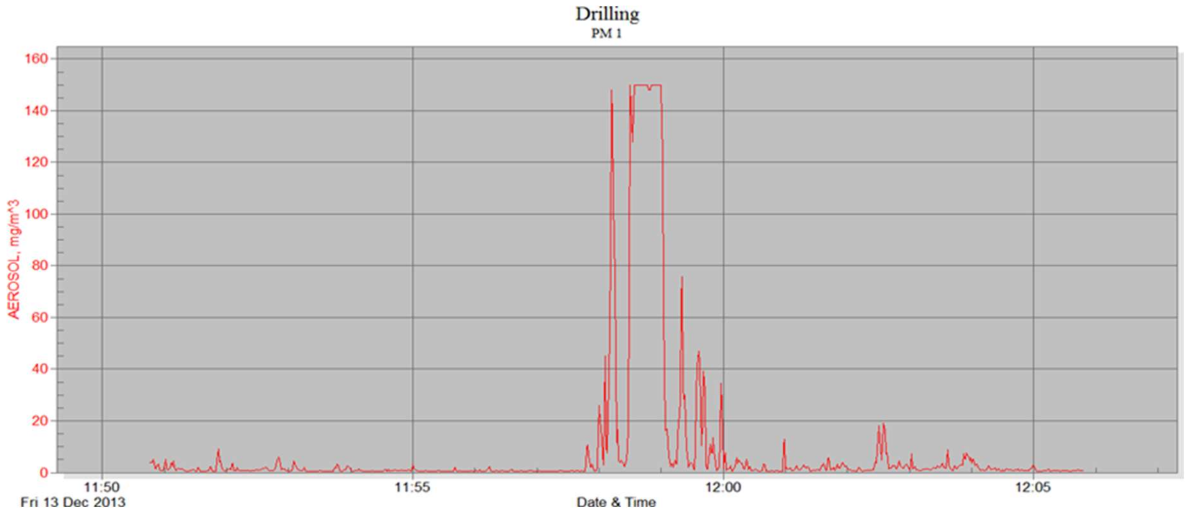

Figure4.11Concentration vs Time graph for dust at drilling point in PM1

6. CONCLUSION

The field monitoring of dust concentrations using Dust Trak-II at LOCP yielded the following conclusions: The drilling location had the greatest particle concentrations, with a maximum of 150.0 mg/m3 and an average of 26.8 mg/m3 in the PM10 range. The minimum average particle concentration in the PM10 range at the loading site was found to be 0.474 mg/m3. It was established that surface mining and drilling are the primary sources of dust production.
The use of PDS APM-500 for measuring employees' personal dust exposure can result in the following deductions: The laborer's maximum dust exposure was 29.41 mg/m3, which for explosive carriers is significantly greater than the permitted threshold of 3 mg/m3. The majority of individuals assessed had been exposed to respirable dust at levels over the permitted limit.

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