ISSN: 2633-4828 Vol. 5 No.2, June, 2023

International Journal of Applied Engineering & Technology

# MONITORING AND ASSESSMENT OF AIRBORNE RESPIRABLE DUST AND DUST CONTROL ANALYSIS OF SONADIH LIMESTONE MINES OF DISTRICT- BALODABAZAR (CHHATTISGARH): A CASE STUDY

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## ABSTRACT

*Dust pollution is the most important environmental issue associated with any open cast mining activity. Drilling, blasting, loading, transporting, crushing, conveying, haul road and the exposed overburden face generate large quantity of fugitive dust. Ensuring an impact assessment of mining activity on the surrounding environment necessitates the prediction of dust concentration in and around the mine.*

*In the view of this current project work focus on the real time monitoring of the dust level at different sources of the mine using Dust Trak II, personal exposure of dust to different work personal dust sampler, characterization of dust collected from different location using FTIR and finally prediction of dust concentration at different location of the mine and nearby areas using Aermod view software.*

*The dust concentration was found to vary between 0.474mg/m$^3$ to 150.0mg/m$^3$ in $PM_{10}$ Drilling and loading operations were found to be the major sources of dust generation. Minimum silica content was found at haul road at 0.23% and maximum silica content was found at drilling point at 0.49%. the predicted value of dust concentration ($PM_{10}$) at most of the places was found to be below NAAQS-2023 limit for annual average of 60$\mu$g/m$^3$*

*Keywords: Respirable Dust, Free Silica, Time-Weighted Average (TWA), Fourier Transform Infrared Open Cast Mine, Director General Of Mines Safety.*

## INTRODUCTION

India boasts a diverse landscape, blessed with abundant mineral resources with significant potential.According to theIndian Mineral Year book Report (2013), India produces around 90 minerals. Out of these, 4 are fuel minerals, 11 are metallic minerals, 52 are non-metallic minerals, and 23 are minor minerals (used for building and other purposes). This highlights the crucial role of the mining industry in India, which is vital for the country's economic development. Limestone is a nonmetallic mineral and is a raw ingredient required for the manufacturing of cement, an important construction material. The combined estimated limestone resources of all categories and grades in India amount to 184,935 million tonnes. Among these, 14,926 million tonnes (8%) are categorized as reserves, while the remaining 170,009 million tonnes (92%) fall under the remaining resources category.Nuvoco Vistas Corp. Limited (Formerly Lafarge India Limited) is in the Cement, aggregates & Concrete businesses. Sonadih Cement Plant, a unit of Nuvoco Vistas Corp. Limited is located near Sonadih village, Balodabazar Tehsil of Balodabazar-Bhatapara District in Chhattisgarh state. The present plant capacity is 3.5 mtpa clinkers which require 5.5 million tonne per annum of limestone. The balance limestone reserve in existing mining lease is 29.39 million tones as on 31/03/2018, which will meet the plant limestone requirement for 5.34 years only. Thus a new mine with production capacity of 1 million tonnes per annum is required to be opened up.

## METHODOLOGY

**GRAVIMETRIC DUST SAMPLER**- This sampler consist of a constant flow sampling pump size selective cyclone end filter cartridge in metal nonmetal mining operations the pump should be operated at 1.7 lpm. The

10M door Oliver cyclone separates the over sized dust from the respirable fraction. The oversized dust is deposited into the greet port at the bottom of the cyclone while the respirable fraction. is deposited into37 M diameter polyvinylchloride PVC filter..[6,7]

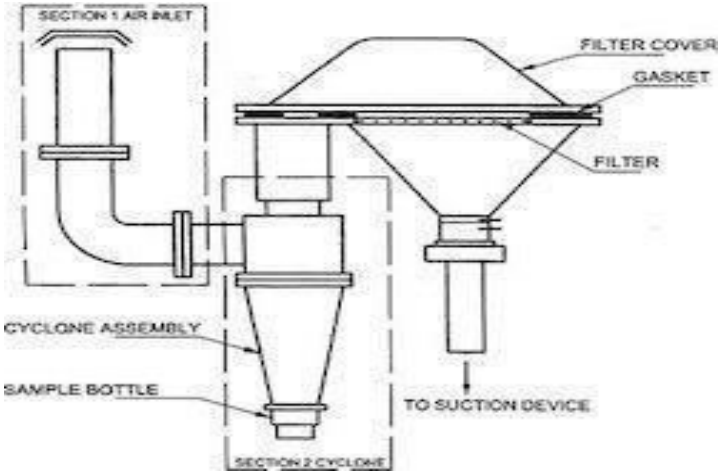



**Figure 1**: Model of gravimetric dust sampler used in mines.

Environmental pollution persists in industrial production, with industrial dust being a prevalent issue. Its release not only contaminates the air but also poses significant health risks. It's imperative to implement effective preventive measures. Employing a dust collector system can efficiently manage industrial dust and ensure emission safety. To enhance the performance of the dust collector system and optimize the purification process, upgrading the system and incorporating electric automation control technology for seamless operation are crucial steps. Such advancements play a pivotal role in environmental preservation. Dust control measures are implemented to mitigate these risks and to adhere to regulatory standards. These measures aim to reduce dust emissions, prevent respiratory diseases, and minimize environmental impacts. Effective dust control strategies are essential for maintaining a safe and productive mining environment. Some common dust control methods in coal mining include.

**NERTIAL PRECIPITATION**- Dust Sampling Instruments Using Inertial Precipitation Are Based On Three Principles: Impaction, Impingement And Centrifuging. Konimeter Is The Most Widely Used Instrument Utilizing Impaction. The Cascade Impact Or Developed By May 47and Later Modified By Sonkin43 Collect The Dust Samples In Separated Size Ranges..[5;7]

**RESPIRABLE DUST MONITOR-** This is a gravimetric sampler developed in a usa .which give an automatic digital read out of the mass concentration of the respirable dust by a betray absorption technique . The equipment includes a cyclone elutriator for segregating the larger particles and a filter for capturing the respirable fraction.The mass of dust deposited on the filter per unit area is obtained from the absorption of beta radiation from a carbon14 source as measured by a Geiger.

Mining Operations Induce Change In Geomorphology And Land-Use Pattern With Loss Of Habitat, Dust, Generation Of High Levels Of Noise, Vibrations, Erosion, Subsidence And Sedimentation. Impact On Land And Soil Like Open Cast Mining Has Been Associated With A Change In Land Use And Land Cover Of A Region. The process of clearing trees and vegetation in preparation for mineral excavation has significant impacts on the environment.

**Fig 2:** Respirable dust monitor

There Are Quite A Number Of Ways In Which Monitoring Air Borne Dust Can Be Carried Out.

Based On Principles Of Operation, They Can Be Classified As

a. Filtration

b. Sedimentation

c. Inertial precipitation

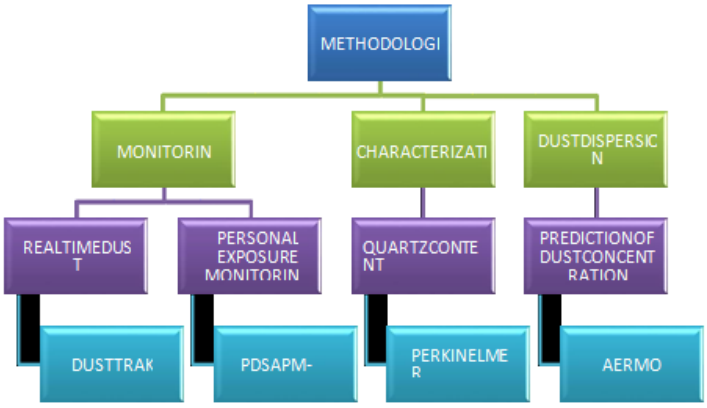
d. Thermal precipitation

e. Electrical precipitation

f. Optical methods based on light scattering

However, For This Study Dust Trak II Is Used For Real Time Dust Monitoring At Different SourcesOf Mine. It Is Based On The Principle Of Scattering Of Light

The Methodology Followed For Carrying Out There Search Investigations Have Been Presented In Figure




## COLLECTION OF DATA

Nuvoco Vistas Corp. Limited (Formerly Lafarge India Limited), Is In The Cement, Aggregates & Concrete Businesses. Sonadih Cement Plant, A Unit Of Nuvoco Vistas Corp. Limited Is Located Near Sonadih Village, Balodabazar Tehsil Of Balodabazar-Bhatapara District In Chhattisgarh State. The Present Plant Capacity Is 3.5 Mtpa Clinkers Which Require 5.5 Million Tone Per Annum Of Limestone. The Balance Limestone Reserve In

Existing Mining Lease Is 29.39 Million Tonnes As On 31/03/2018, Which Will Meet The Plant Limestone Requirement For 5.34 Years Only. Thus A New Mine With Production Capacity Of 1 Million Tones Per Annum is required To Be Opened Up. Out Of The Total Clinker Production, About 12-15% Clinker Is UtilizedAt Sonadih Cement Plant For Manufacturing Of Portland Pozzolana Cement, While 85-88% Clinker Would Continue To Be Sent To Jojobera & Mejia Grinding Unit. Nuvoco Vistas Corp. Limited (Mines And Plants) Have Received Various Awards From MOEF, Green Technical Foundation, NCBM, MOCCM, CII In Relation To Energy Saving And Mines Have Received Awards From IBM And DGMS During MEMCW And Mines Safety Week Celebration.

The Study on The Mine Is Broadly Divided Into Four Headings Like

- Real Time Dust Monitoring At Sources Using Dust Trak II
- Personal Exposure Monitoring Of Different Workers Using PDSAPM-800
- Characterization Using FTIR To Determine Silica Content
- Dispersion Modeling Using AERMO

**REAL TIME DUST MONITORING**

Different Sources Of Dust Generation In The Mine E.G. The monitoring sites selected included loading points, drilling areas, surface miner sites, blasting operations, haul roads, and transportation roads. According to the Coal Mines Regulation, 1957 (CMR): 123, the instrument was positioned within 1 meter of the dust source in the downwind direction. Initially, zero calibration was performed using a zero filter. Subsequently, various size selectors such as PM10, PM4, PM2.5, and PM1 were sequentially employed for a duration of 1 hour each to assess dust concentration at designated sites.The Data Generated Were Transferred To Desktop And Trak Pro Software Was Used To Analyze The Data. Trak Pro Provides

The Statistical Analysis of The Data Along With The Generation Of Graph. The Concentrations Of Dust At Different Locations For Different Size Are As Follow.

**DUST MONITORING AT LOADING POINT (SHOVEL-DUMPER)**

The loading point is a significant contributor to dust generation in any large open-cast mine. thousands of dumpers were loaded with coal each day to meet the annual target of 15mtat locp. the loading point (shovel-dumper) of locp. a comparative study for different sizes segregated dust fractions at loading point was carried out the variation of dust concentration with time for pm10, pm4, pm2.5and pm1 respectively. the peaks of the graph represents the time when loading action was taking place. The peaks varied based on wind direction and loading duration. The lower concentration section of the graph corresponds to periods when the shovel was not in operation.Dust Monitoring at Surface Miner.

The surface miner poses another area of concern for any large opencast mine.it is one of the eco- friendly mining methods adopted to reduce ground vibration due to blasting and to It finds widespread application in the coal industry due to the fact that coal's compressive strength typically falls within the cutting capacity of surface miners, and coal seams often exhibit relatively flat gradients Also appropriate for surface miner operations. However, the operation of surface miners generates significant amounts of fine dust during the coal cutting process. Therefore, if an adequate amount of water is not utilized to control dust, it can pose hazards to mine workers. at top, wirt gen surface miner was used for coal cutting purpose. the operation of surface miner at locp the graph of dust monitoring near surface mineral locp for the particle size of pm10, pm4, pm2.5 and pm1 were plotted. thepeaks in the graph depicted surface in operation whereas low concentration shows idle time of surface miner.

The direction of the wind also significantly influenced the dust concentration. Insufficient water was utilized for dust suppression, resulting in higher concentrations compared to other locations, as depicted in the graph.

Monitoring dust during drilling operations reveals that drilling is likely the most significant source of pollution for any mine.

Insufficient usage of water can lead to the generation of a significant amount of fine dust within the respirable range, posing potential health hazards to workers.Over burden bench so that it can be blasted further for removal of over burden material At Loskop co drilling machine with 150mm diameter drill bit were generally used.

The drilling machine is show how ever insufficient use of water for drilling resulted in highest concentration of dust at drilling point. he fluctuation of concentration over time across various particle sizes.

The peaks in the graph depicted drilling in operation whereas low concentration shows idle time of drilling machine. The highest concentration was observed at the drilling point due to inadequate dust suppression with water. Across all particle sizes, the dust concentration was notably elevated. Drilling operations also contributed to a higher presence of fine dust, as evidenced by numerous peaks in PM1 levels. Dust Concentration at Wet Haul Road of LOCP

Typically, haul roads are responsible for the highest levels of dust generation in any mining operation. But At LOCP Proper Measures Were Taken To Reduced Us Generation From The Haul Road. Water SprinklingWas Carried Out In Regular Intervals Hence Dust Problem Was Effectively Managed. But As The Mine Utilized Large Number Of Small Dumpers Instead Of Few Large Dumpers Hence The Movement Of Dumpers Was More Which Results In Generation Of More Dust And Other Pollutants. Shows The Wet Haul Road Of LOCP Please provide the sentence you'd like to be changed, and I'll be happy to assist you in rewriting it.The Peaks Of The Graph Represent High Concentration Level At The Time Of Movement Of Dumpers Near Monitoring Location. Fewer Peaks Were Obtained As Effective Dust Suppression Methods Were In Place. For Most Of The Time Concentration Remained Low.

Customers residing near the mine and those engaged in roadside selling were served. A considerable fleet of small-sized dumpers was employed for coal transportation.

**DUST MONITORING AT TRANSPORTATION ROAD AT LOCP**

At LOCP, the transportation road served as the conduit for conveying coal from stockyards to various nearby customers, as well as for roadside selling. A significant fleet of small-sized dumpers was utilized for the transportation of coal. The Road As Such Was Not Suitable For Heavy Vehicular Movements. Regular implementation of effective dust suppression measures was lacking, leading to higher concentrations of dust on transportation roads compared to wet haul roads.Shows The Transportation Road Of LOCP

**Summary of Dust Monitoring at LOCP**

| Sl no | Location | Particle Size | Avg.Conc. ($mg/m^3$) | Min.Conc. ($mg/m^3$) | Max.Conc. ($mg/m^3$) |
|---|---|---|---|---|---|
| 1 | Loading point Shovel-dumper | 1µm | 1.800 | 0.379 | 39.400 |
| | | 2.5µm | 0.958 | 0.372 | 62.600 |
| | | 4µm | 0.787 | 0.364 | 13.700 |
| | | 10µm | 0.474 | 0.326 | 4.350 |
| 2 | Surface Miner | 1µm | 13.300 | 0.311 | 150.000 |
| | | 2.5µm | 8.350 | 0.306 | 146.000 |
| | | 4µm | 4.860 | 0.284 | 103.000 |
| | | 10µm | 2.470 | 0.402 | 110.000 |
| 3 | Drilling | 1µm | 8.730 | 0.412 | 150.000 |
| | | 2.5µm | 11.100 | 0.399 | 150.000 |
| | | 4µm | 30.500 | 0.328 | 150.000 |
| | | 10µm | 26.800 | 0.293 | 150.000 |
| 4 | Wet Haul Road | 1µm | 0.631 | 0.386 | 23.100 |

| | | | | | |
|---|---|---|---|---|---|
| | | 2.5µm | 0.487 | 0.379 | 1.780 |
| | | 4µm | 0.428 | 0.376 | 3.080 |
| | | 10µm | 0.483 | 0.389 | 4.080 |
| **5** | Transportation Road | 1µm | 1.500 | 0.410 | 12.300 |
| | | 2.5µm | 0.642 | 0.417 | 2.320 |
| | | 4µm | 0.467 | 0.353 | 12.100 |
| | | 10µm | 1.420 | 0.325 | 62.000 |
| **6** | OB Bench (After firstblasting) | 10µm | 1.420 | 0.367 | 10.600 |
| **7** | OB Bench(After second blasting) | 10µm | 1.590 | 0.369 | 122.000 |
| | | 4µm | 0.604 | 0.411 | 14.200 |
| | | 10µm | 0.587 | 0.424 | 2.830 |
| **8** | OB Bench (Before blasting)(MCL) | 1µm | 1.550 | 0.358 | 20.000 |
| | | 2.5µm | 0.538 | 0.360 | 5.680 |

**Personal Dust Exposure of Different Persons**

| Person | Initial Weightof Filter Paper(mg) | Final Weight of Filter Paper(mg) | Flow rate(l/min ) | Duration(hr) | Concentration ($mg/m^3$) |
|---|---|---|---|---|---|
| Traffic controller | 59.7 | 61.7 | 1.7 | 3.33 | 5.89 |
| Dozer Operator | 59.5 | 61.8 | 1.7 | 4.33 | 5.21 |
| Explosive Carrier | 58.7 | 67.7 | 1.7 | 3 | 29.41 |
| Dumper Operator | 58.4 | 60.1 | 1.7 | 3.66 | 4.55 |

Puts emphasis on characterization of dust and its sources which involve determination of quartz content in respirable air borne dust. Dust dispersion models are commonly employed to assess dust concentrations in the vicinity, ensuring that they remain within acceptable limits as prescribed by regulations. It is most essential that the modeling technique precisely estimates the emission and dispersion of dust From mining site. In this project work dust dispersion modeling was carried out for sonadih open cast mining project.

The Predicted Concentration At Different Locations In And Around The Mine Was Obtained From AERMOD. A Comparison Was Made For The Highest 24 Hour Predicted Concentration In PM10 For The Year 2023 At 4.2 At Most Of The Locations The Predicted Concentration Level Was Higher Than NAAQS Limit Of 100µg/$M^3$

The project is important to the area/ region in interest of mineral development and improves the socioeconomic conditions of the local habitants. The operation of the proposed project will have various social and economic benefits to the local communities of the area in addition to the existing benefits due to providing better employment opportunities and improvement in social infrastructure of the area, apart from increased financial benefits accruing to state and central agencies by ways of taxes, royalties etc.

Fourier Transform Infra-Red Technique Was Used For The Determination Of Quartz Content Of Mine Dust. Dust Samples Were Collected From Different Locations Of The Mine To Measure Quartz Content Of Dust Through FTIR.

FTIR was chosen over XRD due to its superior efficiency, particularly at lower particle sizes.

The Dust Samples Were Sieved With 200 Mesh Size And Then Heated At105ºc For One And Half Hour For Removal Of Moisture. Next, a predetermined amount of dust was blended with 200 mg of KBr.The Mixture Was Finely Mixed With A Pestle And A Pellet Is Made Using Pellet Maker.

FTIR Of The Pellet Was Carried Out At From 4000cm$^{-1}$ To 400cm$^{-1}$ At A Resolution Of4cm$^{-1}$with 4 Scans Per Samples. The Absorbance Peak Sat 800 Cm$^{-1}$was Compared With Standard Quartz To Determine Quartz Content Of The Sample.

Carried Out Dispersion Modeling In An Opencast Coal Mine And Validated The Results With The Actual Field Data. The Research Was Aimed For The Validation Of FDM Model. They've evaluated the potential for dust generation activity wise and analyzed the relationship between distance and dust concentration to define the impact zone of dust dispersion.Major Polluters Were Haul Road And Transportation road.

The dust emissions from the mine correlated directly with both the length of the transportation road and the speed of vehicles traversing it.Fugitive Dust Modeling Used For Dust Dispersion Modeling Was 90% Accurate In Predicting Dust Concentration.They Have Found That Dust Particles Are Largely Deposited Within100m. The concentration decreases as the distance from the source increases, reaching background levels within 300 to 500 meters.Also 80% Of dust Generated By The Haul Trucks Is Greater Than 10µm.

**RESULT**

The Results and Conclusions That Arise from a Study on Different Aspects of Dust Control measures At the Sonadih Limestone Deposit in Balodabazar Chhattisgarh. The Following information Frmentioned Case Study.

**ENVIRONMENTAL IMPACT:** The Study May Evaluate the Effectiveness of Dust Control measures In Mitigating the Environmental Impact of the Sonadih Limestone Deposit. The Expected Results Include A Reduction In Airborne Dust Particles, Which Can Help Minimize Air Pollution And Respiratory Health Risks In The Vicinity.

.**HEALTH AND SAFETY:** The Study May Assess The Impact Of Dust Control Measures On The Health And Safety Of Workers And Nearby Communities. Effective Dust Control Measures Contribute To Improved Air Quality, Reducing The Risk Of Respiratory Diseases Among Workers And Nearby Residents.

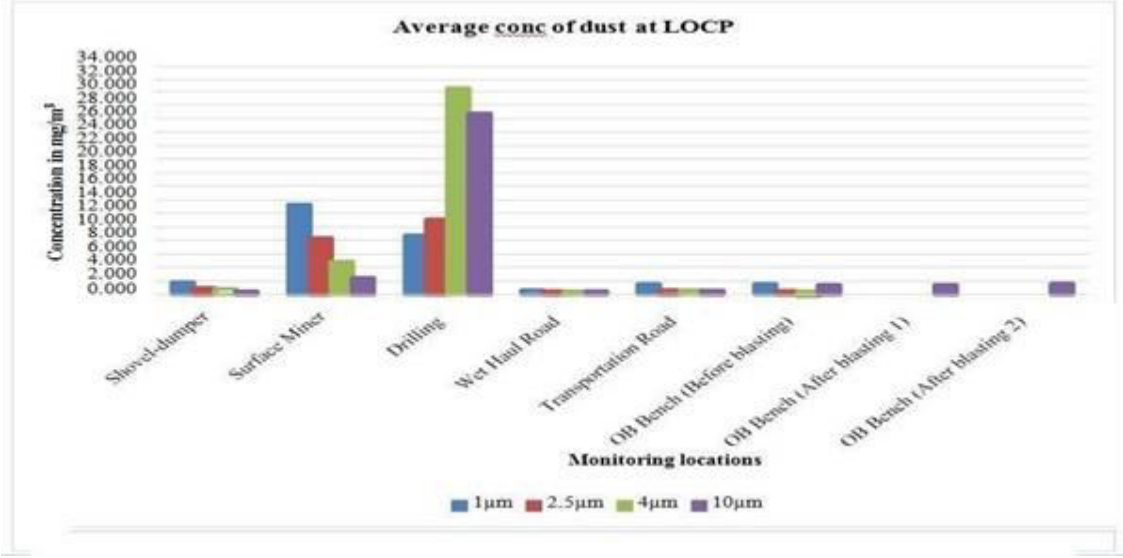



**Fig 4** Average, minimum & maximum concentration of dust

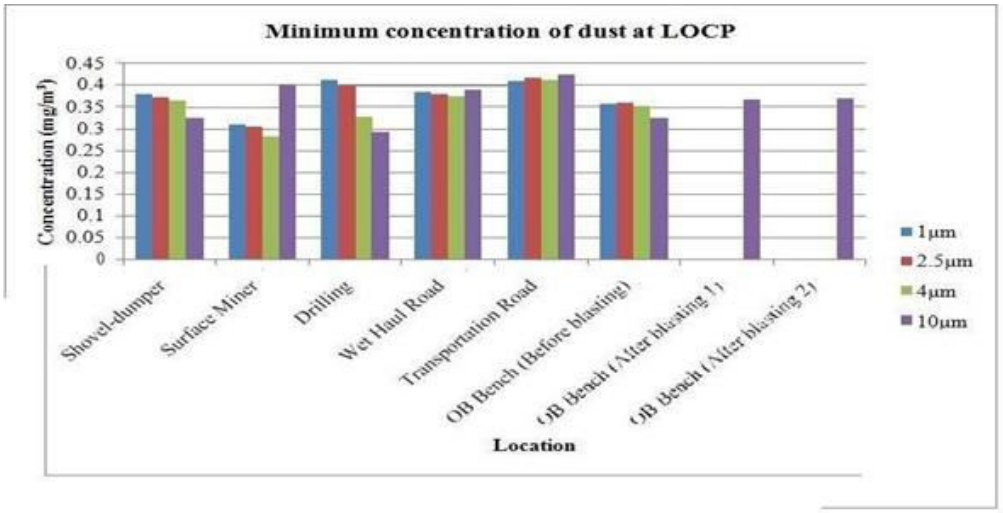



**Fig 5** Minimum concentration of dust at LOCP

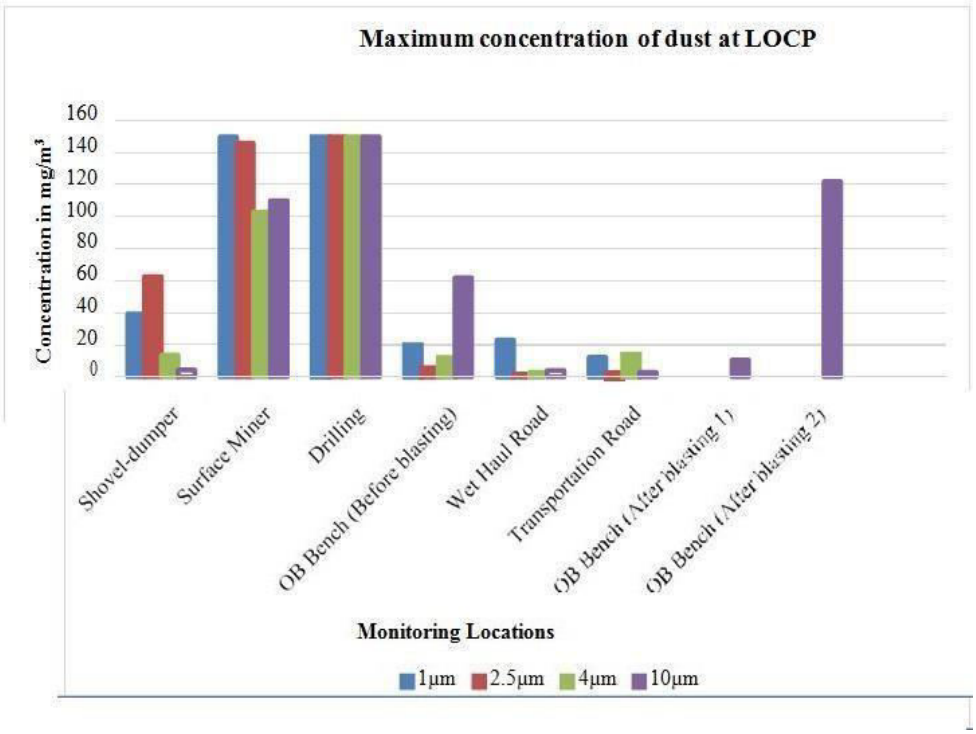



**Figure 6** Maximum concentration of dust at LOCP

**CONCENTRATION OF DUST AT DIFFERENT LOCATIONS OF LOCP**

The Monitoring At Various Sources Of LOCP, A Comparison Can Be Made For Different Dust Generating Sources. The Comparison Of Average Dust Concentration In $PM_{10}$, $PM_4$, $PM_{2.5}$ And $PM_1$ At Different Locations Was Plotted In Fig. 4.3.It Can Be Concluded That Drilling Was The Most Polluting Source In $PM_{2.5}$, $PM_4$ And $PM_{10}$ Where As Surface Miner Was The Most Polluting Source.

Minimum Concentration In $PM_{10}$, $PM_4$, $PM_{2.5}$and $PM_1$at Different Locations Was Plotted In Fig. 7.2 It Shows That Least Concentration Was Obtained At Surface Miner For $PM_1$, $PM_{2.5}$ And $PM_4$. For $PM_{10}$, Least Concentration Was Obtained At Drilling Point.

Maximum Concentration In PM10, PM4, PM2.5and PM1at Different Locations Was Plotted In Fig.18 It Can Be Concluded That At Drilling Point Maximum Concentration Was Obtained Forpm1, PM2.5, PM4, & PM10. Surface Miner Was The Second Most Polluting Source At All Size Range. Insufficient Use Of Water For Drilling And Cutting Purpose At These Locations Resulted In Generation Of High Quantity Of Fine Dusts.

Personal Dust Exposure To Different Workers Was Plotted In Exposure Level Of Explosive Carrier Was Highest Where As Exposure Level Of Dumper Operator Was Lowest. However, For Most Of The Workers The Exposure Was Beyond Statutory.

The Predicted Concentration At Different Locations In And Around The Mine Was Obtained From AERMOD. A Comparison Was Made For The Highest 24 Hour Predicted Concentration In PM10 For The Year 2023 At 4.2 At Most Of The Locations The Predicted Concentration Level Was Higher Than NAAQS Limit Of 100µg/$M^3$. Similarly Another Comparison Was Made For The Annual Average Predicted Dust Concentration In PM10 In. It Can Be Seen That Debarring A Few Locations, Dust Concentration Was Below The NAAQS Limit Of 60µg/$M^3$

## CONCLUSION

Conclusion From The Field Monitoring Of Dust Concentrations Using Dust Trak-II At LOCP, It The Maximum Dust Concentration Was Obtained At Drilling Point With Average Concentration 26.8 Mg/$M^3$ And Maximum Concentration Of 150.0mg/$M^3$ In PM10 Range. Minimum Mean Dust Concentration Was Found At Loading Point At 0.474mg/$M^3$in The PM10 Range. Drilling And Surface Miner Operations Were Found To Be The Major Sources Of Dust Generation.

Based on the personal dust exposure monitoring of workers using PDS APM-500, it can be inferred that:

The Dust Exposure Of Worker Was The Maximum For Explosive Carrier At 29.41mg/$M^3$which Is Much Above The Regulatory Limit Of 3mg/$M^3$. In General, For Most Of The Employees Under Study, Personal Respirable Dust Exposure Was Found To Be Beyond The Permissible Limit.

From Characterization Of Dust Using FTIR, It Can Be Concluded That Minimum Quartz Content Was Found At Coal Transport Road At 0.23% And Maximum Quartz Content Was Found At Wet Haul Road Of LOCP At0.49%.

From The Dust Dispersion Modeling, It Could Be Observed That:

For 24hr Period For The Year, The Highest Dust Concentration For PM10 At All Other Places Except At Sonahdih Limestone Mine And Baliput Were Found To Be Above NAAQS Limit Of 60µg/$M^3$.

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