AMBIENT AIR QUALITY ASSESSMENT IN OPENCAST METAL MINES

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

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

BY

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Dr. H. B. SAHU

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National Institute of Technology
Rourkela

C E R T I F I C A T E

This is to certify that the thesis entitled **"AMBIENT AIR QUALITY ASSESSMENTIN OPENCAST METAL MINES"** submitted by **Sri Rajat Sahu and Sri Partha Sarathi Panda** in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

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

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ABSTRACT

The term 'mining' is more or less synonymous to environmental pollution. The growing emphasis on open cast mining operation in recent years to achieve ever increasing production targets has further aggravated the problem of air pollution. Great amount of respirable dust concentration are added into the environment by the mining activities due to mechanization, escalating production, large scale blasting etc. Major sources of air pollution in open cast mines are drilling, blasting, overburden loading and unloading, material handling and workshops.

The National Ambient Air Quality Standards (NAAQS) are the basis for India's Central Pollution Control Board (CPCB) to regulate air pollutants including particulate matter and five other criteria pollutants. $PM_{2.5}$ and PM_{10} particles are currently accepted indicators for respirable pollutants. Several methods normally exist to measure the amount the dust.

Method of sampling

Air Sampling: Air sampling is capturing the contaminants from a known volume of air, measuring the amount of contaminants captured, and expressing it as a concentration.

There are many different methods for taking air samples. But the most widely used and preferred method gravimetric sampling. Here a pump is connected to a filter medium; the pump should be capable of drawing air through the filter at a constant rate for a time in excess of 8 hours even in adverse conditions such as extreme cold or heat. For this particular work, 'ENVIROTECH APM 460NL' size selective air sampler was used. The sampling system comprises of an omni directional air inlet, size selective impactor, filter medium, oil-less rotary suction pump, dry gas meter for overall sampling procedure. The sampling was performed as per CPCB guidelines.

Results and discussion

In the month of December-2012, air sampling was carried out in Raikela Tantra iron ore mines in four locations namely, core zone-Mine office area and buffer zones- village Dengula, Tensa town and village Bahamba. The air quality index (USEPA, 2011) was calculated for the above mentioned locations and other parameters like PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO were compared to NAAQS.

Table 1: AQI of Sampled air quality data and conc. of other gaseous pollutants at Raikela Tantra iron ore mines

Location	Mines office area	Village Dengula	Tesnsa Town	Village Bahamba	NAAQS	Unit
PM $_{2.5}$	29	30	41	27	60	µgm/m^3
PM $_{10}$	82	88	97	75	100	µgm/m^3
SO_2	4	4	4	4	80	µgm/m^3
NO_x	9	16	9	9	80	µgm/m^3
CO	0.1	0.1	0.1	0.1	4	mg/m^3
AQI	77.56	79.53	100.98	73.63		
Remarks	Moderate	Moderate	Unhealthy for sensitive group	Moderate		

From the above sampled data, it is observed that the level of pollution comes to be in Moderate level. The concentration of gaseous pollutants was much lower than the NAAQS limits. In overall sense, it can be said that in opencast mines particulate matter pollution is more prominent. The PM_{10} concentrations at these sites were observed close to NAAQS limits.

Conclusion

The study reveals that the air quality index varies from simple to moderate category. However, the AQI for Tensa town is coming under 'unhealthy to sensitive people' group. Thus various dust suppression measures need to be taken to control particulate matter dispersion within environment. It is noticed that majority of the concern is the particulate matter pollution caused by transportation, crushing and grinding operations. It is suggested that in addition to teh fixed and mobile sprinklers, the mine management should adopt some additional dust suppression measures viz., proper housekeeping, black topping of permanent roads, utilization of wetting, binding and agglomerating agents, foam suppression. Development of a green belt around the periphery of the mines with plants having thick foliage should also be stressed upon.

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Chapter 1

INTRODUCTION

1. INTRODUCTION

Mining is a vital industry for industrial and economic growth of any country. The development of infrastructure and core sector is directly linked with increased production of minerals, like coal for power sector, iron ore for steel sector, limestone for cement for housing and infrastructure development. With increased industrialization, urbanization and other developmental activities; there is a greater need for increased production of minerals. The emphasis therefore is now on surface mining which is adopted for quick and economic extraction with higher percentage of recovery compared to underground mining; in fact bulk of the minerals obtained in India now comes from opencast mines. Some of the important minerals like limestone, dolomite, iron ore, bauxite, granite, silica and magnetite etc. are obtained exclusively by opencast mining. Opencast mining is more damaging to the environment than underground mining as are less to remove substantial amount of land to reach the mineral It starts within a natural ecosystem and it not only disturbs the existing ecosystems, but also generates an artificial one, which has its own factors including pollutants and contaminants. The important environmental problems that arise out of the opencast mining operation are air, water and soil pollution. In this project various aspects of air pollution and their effect on the local habitat of a iron ore mine are discussed (Chaulya, 1999).

Air pollution in the open cast mining areas are caused by drilling, blasting, overburden loading and unloading, material loading and unloading, road transport and losses from exposed overburden dumps, material handling plants, exposed pit faces and workshops. In development stage of an opencast mine, massive overburden (OB) has to be taken out to reach the mineral deposit. This necessitates the use of excavators, loaders, dumpers, and conveyor belts, which results into massive discharge of fine particulates from OB material. Likewise, normal production and operation will need excavation, size reduction, waste removal, transportation, loading, and stockpiling. All these operations generates particulate matter and is reported that plying of heavy earth moving machinery on haul roads of mechanized opencast mines could contribute as much as 80% of the dust emitted.

Characterization of potential health risks resulting from exposures to ambient air toxics requires assessing the impact of ambient sources on personal exposures. This is a challenging task because the variables needed to assess individual and population exposures are not always available (Ghose and Majee, 2001).

The National Ambient Air quality Standards (NAAQS) are the basis for the Central Pollution Control Board to regulate air pollutants, including particulate matter (PM) and five other criteria pollutants. Particles with an aerodynamic equivalent diameter (AED) less than or equal to a nominal 10 micrometre (also known as PM_{10}) and 2.5 micrometre ($PM_{2.5}$) are the currently accepted indicators for PM pollutants.

1.1OBJECTIVES

Keeping the aforementioned problems in mind the current work has been carried with teh following objectives:

- Assessment of the ambient air quality in the open cast iron and manganese ore mines in the Keonjhar district of Odisha.
- Collection of data from EIA reports and SPCB, Rourkela for the above areas.
- Analysis of data for variation of air quality.
- Classification of air quality according to standard Air Quality Index.

Chapter 2

LITERATURE REVIEW

2. LITERATURE REVIEW

The following is a brief review of scholarly work of different researchers in the field of Ambient Air Quality Assessment:

Stein and Corn (1975) observed that to provide a clear picture on the physical nature of the size fractions, additional characterizing parameters based on density, particulate matter size by optical microscopy, random and projected area & specific surface area need to be provided. They collected air samples from underground coal mines from Pittsburg seam, lower Freeport and lower Kittaning seams and with the use of horizontal elutriator and collected over 8 in*10 in membrane filter (Millipore SCW P00010). Each sample was separated into four different size fractions by Bahco centrifugal classifier. Then various experiments were conducted by them to calculate the above parameters for each size fractions. Then the difference in parameters for the size fractions were analysed and discussed. Thus, it is made possible to co-relate the advent and seriousness of respirable lung diseases with the physical and chemical properties of different size fractions of the ARD (Airborne respirable dust), more closely.

Kumari et al. (1995) the study puts a great emphasis on determination of quartz present in the airborne respirable dust (ARD) known to cause silicosis & cancer. FT-IR spectrometer was being used in direct on filter method for quartz determination in ARD with quartz doublet peak at 800 & 700 cm-1. For taking air samples from different locations of mine personal dust samplers were used and collected over GLA -5000 PVC membrane filters.

Certain dust generating sources were selected where dust samplers may be placed and it was even attached with different workers engaged in the shifts. The analysis in different coal and metal mines showed that quartz content in respirable dust is <1% which is less than the prescribed MEL (Maximum exposure limit) $3mg/m^3$ except for 2-3 locations in Longwall and bunker top. It was observed that drilling, haulage, crusher house are main high risk zone of silicosis and was eventually concluded that wet drilling as well as improved ventilation is effective to control airborne dust as well as emission of quartz. Frequent rotation of workers is a must in locations like crusher sites where, even after adoption of dust suppression measures, dust is not reduced to safe limits.

Chaulya (1999) for a period of 1 year, carried out a study for assessment of air quality in Lakhanpur area. He found out that the annual average of concentrations of TSP & PM_{10} were higher than the prescribed limits given by NAAQS. He took the help of linear regression analysis to predict the concentrations of one type of particulate matter by knowing the level of the other, for O/C coal mines with same as conditions. Monitoring stations were placed to evaluate air quality and plan any control measures. Sampling and analysis were done twice monthly for residential areas (buffer zone) and six times monthly for industrial areas (core zone/mining area) during the year from September 1998 to August 1999.

He suggested that effective control measures at the CHP, excavation area & o/b dumps should be optimised to mitigate the TSP emission at source. Concentrations of carbon monoxide (CO) and lead (Pb) were below detectable limits or negligible as per the bi-monthly monitoring report for the area during the study time.

Krupa and Legge (1999) studied the use of passive samplers for gaseous air pollutants. They evaluated the specificity and linearity of the response of passive samplers; results obtained by such an approach were initially compared and cross-correlated with co-located active samplers or continuous monitors for accuracy. It was found that the seasonal influences in any comparisons of data from passive sampling versus active monitoring, particularly in the cold climates and associated atmospheric processes of the northern latitudes. They found that the differences between the two systems can be highly significant during the winter months. Some pollutants such as NH_3 need to be converted to a second compound (NO_2) before quantification. This can lead to technical complications on site with instrument performance. Finally they concluded that although passive samplers are very desirable from economic and logistic perspectives, they should be co-located with passive samplers, with continuous monitors at sampling locations.

Ghose and Majee (2001) observed that In India, coal is mainly mined out from opencast mines, contributing more than 70% of total coal production and it also has a high share in air pollution. To keep a track upon the local atmosphere impact, a survey was conducted by them taking emissions data which were utilised to find out the dust generation due to various mining activities. They noticed that the air pollutants coming from mines and their seasonal fluctuations in its quantity had high pollution potential and greater negative impact on human health. They have given a lot of control measures to deal with this situation and even chalked out ‘afforestation and tolerating capability of trees’ against the dust particulate matter. They emphasised the need of utilisation of different chemicals to minimize the air pollutants coming from haul road and stated that a pollution free environment can be achieved by implementing suitable abatement measures.

Chakraborty et al. (2001) developed empirical formulae with the objective to calculate emission rate of various opencast mining activities. They selected 7 coal mines and 3 iron ore mines with the consideration of geographical location, working method, accessibility and resource availability. 12 Empirical formula for Suspended particulate matter were developed for many opencast mining activities like drilling, coal loading ,coal handling plant , haul road , workshop , etc. but the formula was for the overall mine for NO_x and SO_2 estimation. To verify the universal applicability of the empirical formulas, they selected Rajpura opencast coal mine. A good accuracy was indicated between the calculated value and field measured value which varied from 77.2% to 80.4%. They concluded that Suspended particulate matter is the main constituent of emissions while emissions due to NO_x & SO_2 are negligible. They revealed that the results of this study is of great importance for mine environmental engineers and scientists working in the field of air quality monitoring to monitor air quality and its impact from pollutants generating projects.

Reddy and Ruj (2002) carried out the ambient air quality assessment in the Raniganj – Asansol area based on sulphur dioxide, oxides of nitrogen and suspended particulate matter (SPM) at four stations namely – Raniganj girls college (RGC), Searsol raj high school (SRS) Raniganj, B.B college (BBC) Asansol and B.C college (BCC) Asansol; where a total of 429 samples each were taken from RGC & SRS and 435 each from BBC & BCC locations. Ambient air monitoring frequency was 3*8 hours per day at each site on every alternate days for 1 year; along with the recording of other parameters such as temperature, relative humidity, air speed and its direction. They used high volume samplers to measure SPM & SO_2, and NOx fumes and were collected by bubbling the sample in a particular absorbing solution. The results from the above investigations showed that 95 percentile values of SPM & NOx exceeded the reference limit in most of the stations but 95 percentile values of SO_2 level didn’t cross the prescribed limit.

Further their seasonal variation was observed by them which highlighted ‘winter’ as the most polluted season due to high concentration of pollutants, than summer followed by monsoon. Thus, they concluded that the mining along with other industrial activities are solely responsible for the high concentration of pollutants in this area.

Anastasiadou and Gidarakos (2006) and their team evaluated the environmental quality of open air asbestos mine over a long period of time by measuring and monitoring the concentration of asbestos fibres in air. The study was carried out in Asbestos Mine of Northern Greece (MABE). Air sampling was performed according to the standard method for asbestos sampling—the NIOSH Method 740 for phase contrast microscopy (PCM)—and according to the air sampling process described by the EU. Static samples were taken at fixed locations, 1.5m above floor level. The samples were first observed optically and were analyzed afterwards with X-ray powder diffraction (XRD).

A scanning electronic microscope (SEM) was also used and the suspect fibres were examined with an energy dispersive X-ray for their composition. Majority of incidents show that asbestos exposure is attributed to human activities, such as excavations, the treatment of asbestos, the use of asbestos and the disposal of asbestos products into landfills.

Dahmann et al. (2008) investigated the results of exposure assessment with respect to nitrogen oxides and carbon monoxide in German hard coal mines. The measurement campaign was accompanied by an epidemiological study investigating possible health effects on the airways of the lungs. For this purpose time weighted 8-hour shift values were determined by them, for typical groups of coalminers according to the European measurement standards. Based on these measurements and on experts' assessments of the retrospective exposure situation, time-dependent cumulative and average NO and NO_2 exposure estimates were derived for an inception cohort of two groups of coalminers. They concluded that Miners working in blasting crews (no blasting specialists) were estimated by experts to experience 2/3 of the nitrogen oxide exposure of blasting specialists. Especially, for the diesel engine drivers, exposure can be rather higher than the prescribed value.

Sharma and Siddiqui (2010) carried out a study for the assessment and management of the air quality around Jayant open cast coal mining situated at Jayant in Sidhi district of Madhya Pradesh, India. Air monitoring for SO_2, NO_x and TSP was done for 24 hrs. once every 15 days at each sites and concentration were expressed as μgm. Mean value for pollutant were calculated on 24 hours sampling basis. For the sampling of particulate matter HVS (High Volume Sampler) was used. Samples were collected for two years using glass fibre filter paper on fort nightly basis. They also sought upon the observations on 'spatial and temporal variations in concentration of gaseous and particulate pollutants' had done by Chaulya (2004) during both the year of air monitoring. The study suggested that concentration of particulate pollutant exceeded the prescribed limit especially during summer and winter season.

They finally recommended implementing a plan of regular cleaning of transportation roads, watering of paved and unpaved roads with chemical binding agents, installation of sprinkler system at high polluting coal transport roads within the plant premises and effective dust suppression mechanism at coal handling plant.

Silva et al. (2010) observed that monitoring of light hydrocarbons is extremely critical , basically on two aspects; one is due to global climate change and other one for economic & safety reasons. Due to the difficulty to access and lack of correct procedures of gas sampling in Brazilian coal mines, they aimed to apply standard gas chromatography procedures of gas sampling to determine LHCs (light hydrocarbons) levels from their 2 surface mines and 3 underground mines. Samples of gas were collected with the help of sequential sampler and were placed in polypropylene tedler gas sampling bags. Then the LHCs concentration was calculated from gas chromatograph equipped with flame ionization detector. The results indicated higher percentage of LHCs in u/g mines than surface mines with CH_4 levels varying from 3 ppm to 27% in coal mine atmosphere. They found that the proposed methodology was very effective in measuring LHCs levels and was finally concluded that sampling of air using tedler bags and sequential sampler was better than steel canisters.

Chen et al. (2010) dealt with the application of matter-element method in estimation of ambient air quality in Huizhou opencast coal fields in Fuxin colliery. Study conducted by Fu et al (2000) described air pollution of Fuxin to be composed of total suspended particulates (TSP), SO_2 and NO_x. To verify their studies, dust samples were taken from four different monitoring stations located in 4 different districts around Fuxin colliery. They applied 'fuzzy concept' to the air quality assessment based on extension of matter-element theory, which handles the concept of partial truth. Moreover this idea can predict the relative influence of each dust pollutant on environment based on the upper and lower maximum allowable exposure limits. They concluded that re-vegetating appropriate sites as well as the initiatives from government can successfully help in complying 'air quality' within the prescribed limits of CAAQS, 1996. The future work of this study is to develop an integrated & automated decision support system for air quality assessment with the help of a programming language.

Khan and Bagaria (2011) carried out the study inDhanappa limestone mines, Nagpur with the main objective to suggest a monitoring programme to evaluate the effectiveness of meditative measures to suppress air pollutants coming from mining areas. The sites which were selected for the studies were of three different types of anthropogenic activities i.e. sensitive, residential and commercial and industrial area in around the mining sites**.** Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval was taken for the study. The APM-460 Respirable Dust Sampler that they used was provided with a cyclone. The cyclone was designed to provide separation of PM_{10} particulate matters for a more accurate sampling. Sampling of SO_2 and NOx was done through an impinger which was exposed for 24 hours at an impingement rate of 1 LPM to get one sample in a day. They analysed SO_2 and NO_x on spectrophotometer employing West-Geake method and Jacob-Hochheiser method respectively. The results that they obtained suggested that ambient air quality in the mines zones with respect to SO_2 and NO_x shows low pollution, while with respect to RSPM and SPM it is moderate. They also suggested that regular monitoring and analysing of those parameters will definitely restrict them below prescribed limits.

Mandal et al. (2011) analysed that majority of air pollutants that are contaminating the atmosphere traces its source from the haul and transport roads in coal mining areas thus enhancing different health problems. As high as 93.3% of total generated dust comes from haul roads of South African coal mines, according to the analysis carried out by Amponsah-Dacosta using USEPA guidelines. Due to the partial failure of the available techniques, the dust doesn't get removed from the haul road completely. In this study the qualitative as well as quantitative aspects of road dusts is being dealt by them. For this, they collected representative road dust samples from four different coalfields of India.

Determination of PH of dust samples were carried out by Orion ion analyser using glass electrode; moisture content by oven dry method using Indian standards; Volatile matter by heating the sample inside a covered crucible in a muffle furnace; ash content using Indian standards and fixed carbon by deducting the sum total of moisture, volatile matter and ash content from 100. Their results were quite encouraging in the sense that coal dust from haul and transport road of mining areas can be effectively used as a domestic fuel. They concluded that some road dust (comprising powdery coal) could be collected and converted into a solid form so that it can be used as a domestic fuel vis-à-vis sustenance of a healthy environment and energy.

Khalaji et al. (2011) used the new technique of spark induced breakdown spectroscopy (SIBS) as a simple, rapid and in situ method for continuous dust monitoring as this method can detect elemental composition of dust simultaneously and no sample preparation is required. They formulated an experimental technique using a high voltage and a breakdown is created between two electrodes. Each element in the plasma between electrodes emits its characteristic spectral emissions by analysing the spectral emission of plasma, the elemental composition of dusty air is determined. With this experiment the team showed that SIBS can be used as a method for dust level monitoring and also can be used to alarm a remarkable increase of dust in mines.

Chapter 3

HEALTH IMPACTS OF AIR POLLUTION IN OPEN CAST METAL MINES

3. EFFECTS OF AIR POLLUTANTS ON DIFFERENT ORGANS AND SYSTEMS

$PM_{2.5}$ and PM_{10} concentration are the currently accepted criteria of National Ambient Air Quality Standard (NAAQS) for accessing air quality.

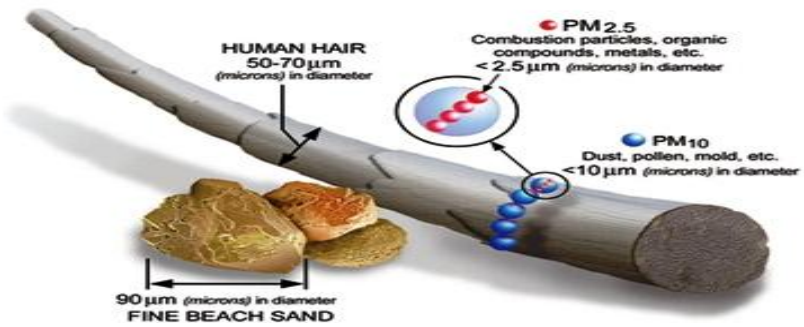
Following are the two reasons discussed:

(i) *Long retention periodof fine particulate matter (diameter<10µ) in ambient air-*

Small particles have a relatively high surface area per unit mass. A centimetre cube of quartz particle if broken into particles of $1\mu m^3$, there will be10^{12}particles with surface area of $6m^2$ in comparison to only $6cm^2$ area of original quartz cube. Their terminal velocity being very negligible of the order of cm/hour or even mm/hour remains in air borne state for a long time.

(ii) *Relative negligible absorption of fine particulate matter(diameter<10µ)in upper respiratory track-*

All dust below 10µm are considered as dangerous because of the fact that they don't get trapped in the upper respiratory track, such as trachea, bronchi and thus reach the alveoli producing toxic effect like dyspnoea, thickening of alveolar walls, etc.



[Image courtesy – U.S. EPA]

Fig 3.1 Size comparison of $PM_{2.5}$ and PM_{10}

3.1 EFFECT OF PARTICULATE MATTER ON VARIOUS SYSTEMS OF HUMAN BODY

3.1.1 Respiratory system

Numerous studies describe that all types of air pollution, at high concentration, can affect the airways. Nevertheless, same as effects are also observed with long-term exposure to lower pollutant concentrations. Symptoms such as nose and throat irritation, followed by bronchoconstriction and dyspnoea, especially in asthmatic individuals, are usually experienced after exposure to increased levels of sulphur dioxide, nitrogen oxides, and certain heavy metals such as arsenic, nickel or vanadium. In addition particulate matter that penetrates the alveolar epithelium and ozone start lung inflammation. In patients with lung lesions or lung diseases, pollutant-initiated inflammation will worsen their condition. Moreover air pollutants such as nitrogen oxides increase the susceptibility to respiratory infections. Finally chronic exposure to ozone and certain heavy metals reduces lung function, while the later are also responsible for asthma, emphysema, and even lung cancer. Emphysema-like lesions have also been observed in mice exposed to nitrogen dioxide.

3.1.2 Cardiovascular system

Carbon monoxide binds to haemoglobin modifying its conformation and reduces its capacity to transfer oxygen. This reduced oxygen availability can affect the function of different organs (and especially high oxygen consuming organs such as the brain and the heart), resulting in impaired concentration, slow reflexes, and confusion. Apart from lung inflammation, systemic inflammatory changes are induced by particulate matter, affecting equally blood coagulation. Air pollution that induces lung irritation and changes in blood clotting can obstruct (cardiac) blood vessels, leading to angina or even to myocardial infraction. Symptoms such as tachycardia, increased blood pressure and anaemia due to an inhibitory effect on haematopoiesis have been observed as a consequence of heavy metal pollution (specifically mercury, nickel and arsenic). Finally, epidemiologic studies have linked dioxin exposure to increased mortality caused by ischemic heart disease. While in mice, it was seen that heavy metals can also increase triglyceride.

3.1.3 Nervous system

The nervous system is mainly affected by heavy metals (lead, mercury and arsenic) and dioxins. Neurotoxicity leading to neuropathies, with symptoms such as memory disturbances, Sleep disorders, anger, fatigue, hand tremors, blurred vision, and slurred speech, have been observed after arsenic, lead and mercury exposure. Especially, lead exposure causes injury to the dopamine system, glutamate system, and N-methyl-D-Aspartate (NMDA) receptor complex, which play an critical role in memory functions. Mercury is also responsible for certain cases of neurological cancer. Dioxins decrease nerve conduction velocity and impaired mental development of children.

3.1.4 Urinary system

Heavy metals can induce kidney damage such as an initial tubular dysfunction evidenced by an increased excretion of low molecular weight proteins, which progresses to decreased glomerular filtration rate (GFR). In addition they increase the risk of stone formation or nephrocalcinosis and renal cancer.

3.1.5 Digestive system

Dioxins induce liver cell damage, as indicated by an increase in levels of certain enzymes in the blood, as well as gastrointestinal and liver cancer.

3.1.6 Reproductive system

It is rather critical to mention that air pollutants can also affect the developing foetus. Maternal exposure to heavy metals and especially to lead increases the risks of spontaneous abortion and reduced foetal growth (preterm delivery, low birth weight). There are also evidences suggesting that parental lead exposure is also responsible for congenital malformations, and lesions of the developing nervous system, causing critical impairment in new-born's motor and cognitive abilities. Same dioxins were found to be transferred from the mother to the foetus via the placenta.

3.2 EFFECT OF MINE GASSES ON HUMAN HEALTH

3.2.1 Nitrous Fumes

Nitrous fumes emanates mainly from exhaust of diesel automobiles and blasting of negative oxygen balance explosives. Nitrous Fumes are rarely found in mine air, and it consists mainly of nitric oxide and nitrogen dioxide. Nitrous fumes are very poisonous, the maximum tolerable concentration for long exposure being 0.00025%, as accepted by ACGIH. Concentrations of 0.025 to 0.75 % are rapidly fatal. Man affected by nitrous fumes show immediate symptoms of nausea cough, choking, perspiration and headache, but later develops serious bronchial trouble such as bronchitis and bronchopneumonia, which may prove fatal within 48 hours. It has been claimed by Canadian investigators that small quantities of Nitrous fumes stimulate the development and growth of silicosis in dusty atmosphere. In Indian mines a tolerable concentration of Nitrous fumes is taken as 0.0005 %.

3.2.2 Sulphur di-oxide

Sulphur dioxide is also produced from diesel exhaust and blast fumes. Sulphur dioxide is an irritant gas that is removed by the nasal passages. Moderate activity levels that trigger mouth breathing, such as a brisk walk, are needed for sulphur dioxide to cause health effects in most people. People with asthma who are physically active outdoors are most likely to experience the health effects of sulphur dioxide. The main effect, even with very brief exposure (minutes), is a narrowing of the airways (called bronchoconstriction). This may be accompanied by wheezing, chest tightness, and shortness of breath, which may require use of medication that opens the airways.

Symptoms increase as sulphur dioxide levels or breathing rate increases. When exposure to sulphur dioxide ceases, lung function typically returns to normal within an hour, even without medication. At very high levels, sulphur dioxide may cause wheezing, chest tightness, and shortness of breath even in healthy people who do not have asthma.

Long-term exposure to sulphur dioxide may cause respiratory symptoms and illness, and aggravate asthma. People with asthma are the most susceptible to sulphur dioxide. However, people with other chronic lung diseases or cardiovascular disease, as well as children and older adults, may also be susceptible to these effects.

3.2.3 Hydrogen sulphide

Also known as stink damp, it smells like rotten egg and has a sweetish taste. It is poisonous in nature, even more than CO, and the allowable maximum concentration for prolonged exposure is 0.001% as recommended by ACGIH, the symptoms being irritation and inflammation of the eyes and irritation of respiratory tracts. An exposure for an hour to a concentration of 0.02 to 0.03 % causes marked symptoms, while an exposure to a concentration of .05 to .07 % leads to serious poisoning in 30 minutes to 1 hour. A concentration of 0.1 to 0.3 % causes rapid paralysis of the respiratory centre leads to asphyxia and death.

3.2.4 Carbon monoxide

CO is produced from blast fumes, diesel exhaust and surface mine fires. Also known as white damp, it is colourless, odourless gas slightly lighter than air. CO is deadly poisonous gas, because the haemoglobin in the blood has 250 to 300 times greater affinity to CO than for O_2. Thus if CO is breath in large quantities for sufficiently long time, due to lack of oxygen, the brain tissues get damaged. After long exposure the blood cells also get damaged, as a result the patient suffers from headache, nausea, overstraining of the heart, mental disorder, loss of memory, paralysis, temporary blindness, etc. leading to unconsciousness. A concentration above 0.01 % for a long time causes a chronic poisoning with a slight headache resulting exertion, while 0.3 to 0.4% may be fatal in a few minutes.

Chapter 4

AIR SAMPLING TECHNIQUES

Basic sampling methods

Air sampling and analysis methods as recommended by CPCB

4. AIR SAMPLING TECHNIQUES

4.1 Basic Sampling methods

Basically there are six air sampling methods which are:

4.1.1 Filter Sampling Inhalable (Total) Dust

Air is drawn through a filter paper, the paper traps the solid particulate e.g. dust, aerosols & fibres. Gravimetric analysis is usually used to measure results (i.e. by measuring the weight gained by the filter). Further analysis can be carried out on the filter to identify the specific chemicals captured.

4.1.2 Sorbent Sampling

Sorbents are normally contained in a small glass tube with sealed ends. Air is drawn through the sorbent, which captures molecules of the gas or vapour to be sampled. The trapped contaminants are released using solvent washing or heat to a gas chromatograph (GC) for analysis. One of the best known sorbents is charcoal.

4.1.3 Sampling Respirable Dust

The I.O.M. Sampler with a foam plug placed in the cassette inlet is capable of sampling respirable dust. The specific foam separates the respirable fraction, which is collected on the filter, from other particulate matter sizes.

4.1.4 Bag Sampling

Particularly suitable for "grab" or Short Term Samples (STS), the air is passed through the pump into a special plastic bag. Alternative methods of filling a bag without passing air through a pump can also be used. The bag, containing a relatively large volume of sampled atmosphere is then taken to the laboratory for analysis.

4.1.5 Filter Sampling Respirable (Alternative Method)

The Cyclone Sampler uses a filter contained in a cassette, which separates out the respirable fraction of dust in the sample.

4.1.6 Impinger/Bubble Sampling

Air drawn into the impinger is forced through a nozzle, which is covered with a liquid such as high purity water. The pollutants dissolve in the liquid media and is subsequently analysed, usually by colorimetric techniques of detection.

4.2GRAVIMETRIC SAMPLING

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

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

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

The second size select design of PM_{10} measurement is 'cyclone inlet'. Here omnidirectional cyclone is used for fractionation in the inlet allowing particulate matters to enter from all angles of approach. In the inlet, an angular velocity component is added to the sample air and the particulate matters contained in it by a series of evenly spaced vanes. Larger particulate matter removal occurs in the inner collection tube. This tube incorporates a perfect absorber which is usually an oiled surface to eliminate bouncing of particulate matters. The sample flow then enters the intermediate tube where the trajectory of the particulate matters is altered to an upward direction. An additional turn is added to change the flow to a downward direction to allow the remaining particulate matters to deposit on a filter for subsequent analysis. As with the impaction inlet control of air velocities in cyclonic inlet, it is critical to maintain the correct particulate matter size cut point. It is critical to maintain correct design volumetric flow through the inlet.

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

These versions of air samplers are lightweight type for collecting air borne particulate matters in the $PM_{2.5}$ and PM_{10} size range. These are frequently used to provide a measure of air borne particulate matters concentration for studying potential health impacts of dust particulate matters in the ambient environment.

The aerosol sample enters the sampler through multi nozzle single stage impactors to remove large particulate matters having aerodynamic equivalent diameter larger than 2.5um and 10um. Particulate matters having diameter smaller than the impactor cut size are collected on a 37mm diameter filter of choice. The collected particulate matter can be analysed gravimetrically to get air borne particulate matter's mass or analysed for specific chemical compounds.

Features:

- Light-weight personal samplers with single stage impactors.
- Selective impactor cut-point of 2.5 µm or 10 µm.
- Can be operated with a personal sampling pump

Applications:

- Personal dust sampling for exposure assessment.
- Ambient air pollution studies.
- Ambient air quality assessment.
- Personal sampling for industrial hygiene applications.

Fig 4.1: Photographic view of PM_{10} sampler

4.3 AIR SAMPLING AND ANALYSIS METHODS AS RECOMMENDED BY CPCB

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

PM_{10}refers to fine particulate matters that are 10micrometres (µm) or smaller in diameter.

4.3.1.1 Standard

Table 4.1: National ambient air quality standard for Particulate Matter PM_{10}

Pollutant	Time weighted Average	Industrial/Residential Area	EcologicallySensitive Area
PM_{10} (µgm/m^3)	Annual	60	60
	24 Hours	100	100

4.3.1.2 Principle of the method

Air is drawn through a size-selective inlet and through a 20.3 X 25.4 cm (8 X 10 in) filter at a flow rate, which is typically 1132 L/min. Particulate matters with aerodynamic diameter less than the cut-point of the inlet are collected by the filter. The mass of these particulate matters is determined by the difference in filter weights prior to and after sampling. The concentration of PM_{10} in the difference of the mass divided by the total volumetric flow.
Designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

4.3.1.3 Instrument/Equipment

The following items are necessary to perform the monitoring and analysis of Particulate Matter PM_{10} in ambient air:

- Analytical balance
- Sampler : High Volume Sampler with size selective inlet for PM_{10} and automatic volumetric flow control
- Calibrated flow-measuring device to control the airflow at 1132 l/min.
- Top loading orifice kit.

4.3.1.4Sampling

Field Sampling - Tilt back the inlet and secure it according to manufacturer's instructions. Loosen the faceplate wing nuts and remove the faceplate. Remove the filter from its jacket and centre it on the support screen with the rough side of the filter facing upwards. Replace the faceplate and tighten the wing nuts to secure the rubber gasket against the filter edge. Gently lower the inlet. For automatically flow-controlled units, record the designated flow rate on the data sheet. Record the reading of the elapsed time meter. The specified length of sampling is commonly 8 hours or 24 hours. During this period, several reading (hourly) of flow rate should be taken. After the required time of sampling, record the flow meter reading, take out the filter media from the sampler and put in a container or envelope.

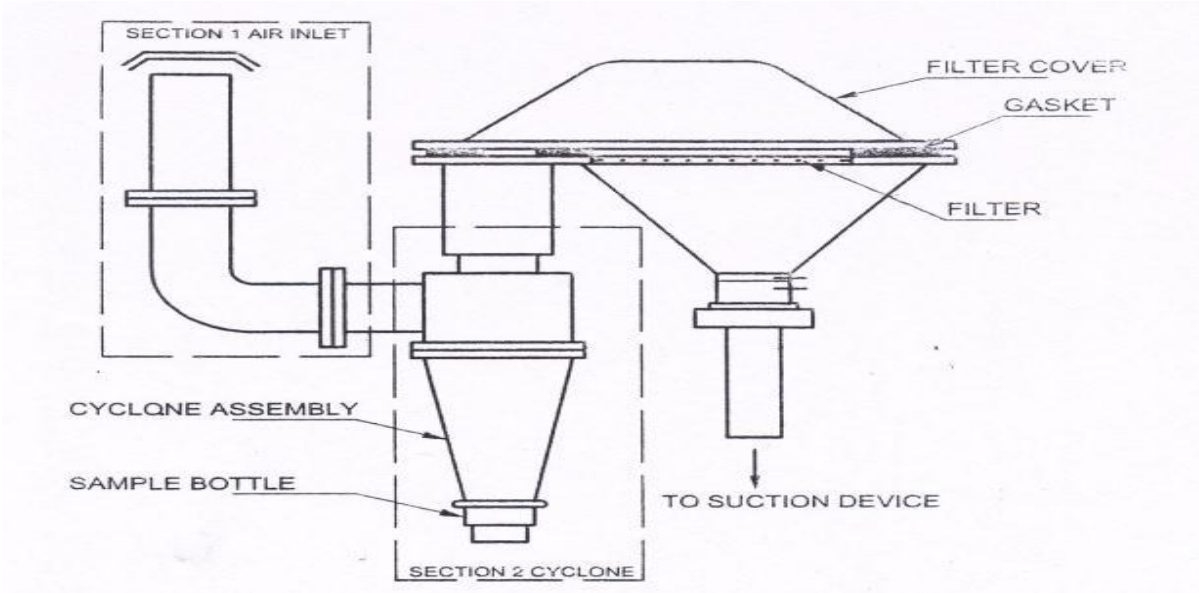


Fig 4.2: Schematic PM_{10} Sampler (Cyclonic Inlet)

4.3.1.5 Calibration

Periodical calibration of the sampler is being done by Orifice Transfer Standard. The PM_{10} sampler calibration orifice consists of a 3.175 cm (1.25 inch) diameter hole in the end cap of 7.62 cm (3 inch) diameter by 20.3 cm (8 inch) long hollow metal cylinder. This orifice is mounted tightly to the filter support in place of the inlet during calibration. A small tap on the side of the cylinder is provided to measure the pressure drop across the orifice. A flow rate of 1132 L/min through the orifice typically results in a pressure difference of several inches of water. The relationship between pressure difference and flow rate is established via a calibration curve derived from measurements against a primary standard such as a Roots meter at standard temperature and pressure. Flow resistances that simulate filter resistances are introduced at the end of the calibrator opposite the orifice by a set of perforated circular disks.

4.3.1.6 Calculation

PM_{10} (µgm/m^3) = ($W_f - W_i$) x 10^6 / V

Where,

- PM_{10} = Concentration of PM_{10}in µgm/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

4.3.1.7 Quality Control

Quality Control (QC) is the techniques that are used to fulfil requirements for quality. The QC procedures for the air sampling and monitoring sections of this protocol include preventative maintenance of equipment, calibration of equipment, analysis of field blanks and lab blanks.

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

$PM_{2.5}$ refers to fine particulate matters that are 2.5 micrometres (µm) or smaller in diameter.

4.3.2.1Standard

Table 4.2: National ambient air quality standards for Particulate Matter $PM_{2.5}$

Pollutant	Time weighted Average	Industrial/Residential Area	Ecologically Sensitive Area
$PM_{2.5}$ (µgm/m^3)	Annual	40	40
	24 Hours	60	60

4.3.2.2Principle

The electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed inertial particulate matter-size separator (i.e. cyclones or impactor) where the suspended particulate matter in the $PM_{2.5}$ size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particulate matters in the $PM_{2.5}$ size ranges divided by the actual volume of air sampled, and is expressed in µgm/m^3. The microprocessor reads averages and stores five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate. In addition, the microprocessor calculates the average temperatures, pressure, and total volumetric flow for the entire sample run time and the coefficient of variation of the flow rate.

4.3.2.3 Sitting Requirements

Samplers should be sited to meet the goals of the specific monitoring project. For routine sampling to determine compliance with the National Ambient Air Quality Standards (NAAQS), sampler sitting is described in CPCB guidelines shall apply. The monitoring should be done outside the zone of influence of sources located within the designated zone of representation for the monitoring site. Height of the inlet must be 3–10 m above the ground level and at a suitable distance from any direct pollution source including traffic.

Large nearby buildings and trees extending above the height of the monitor may create barriers or deposition surfaces for PM. Distance of the sampler to any air flow obstacle i.e. buildings, must be more than two times the height of the obstacle above the sampler. There should be unrestricted airflow in three of four quadrants. Certain trees may also be sources of PM in the form of detritus, pollen, or insect parts. These can be avoided by locating samplers by placing them >20 m from nearby trees. If collocated sampling has to be performed the minimum distance between two Samplers should be 2 m.

4.3.2.4 Apparatus and Materials

- Sampling equipment designated as FRM (Federal Reference Method) or FEM (Federal Equivalent Method)
- Electronic microbalance with a minimum resolution 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.

4.3.2.5 Procedure

The procedure of the $PM_{2.5}$sampling is same as that of PM10 sampling.

4.3.2.6Calculation and Reporting of Mass Concentrations

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

$M_{2.5} = (M_f – M_i)$ mg x 10^3 μgm

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 provide measurements of the total volume of ambient air passing through the sampler (V) in cubic meters at the actual temperatures and pressures measured during sampling.

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

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

Where,

· V = total sample value (m^3)

· 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 litres (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 samplingperiod (μgm)
- V = total volume of air sampled (m^3)

Chapter 5

AIR QUALITY MODELLING

5. AIR QUALITY MODELLING

It is the mathematical simulation of how air pollutants diffuse in the ambient atmospheric conditions. Air quality modelling is performed with computer programs that repeat and solve the mathematical equations and algorithms which simulate the pollutant dispersion. The dispersion models are used to estimate or to predict the down air concentration of air pollutants or toxins produced from sources such as industrial plants, mines, vehicular traffic or inadvertent chemical releases.

The dispersion models vary from each other depending on the mathematical algorithm used to develop the model, but all require the input of data that may include:

- Meteorological conditions such as air speed and direction, the quantity of atmospheric turbulence (as characterized by what is called the "stability class"), the ambient air temperature, the height to the bottom of any inversion aloft that may be present, cloud cover and solar radiation.
- Source term (the concentration or quantity of toxins in emission or accidental release source terms) and temperature of the material.
- Emissions or release parameters that influence such as source location and height, type of source (i.e., fire, pool or vent stack) and exit velocity, exit temperature and mass flow rate or release rate.
- Terrain heights at the source location and at the receptor location(s), such as nearby homes, schools, businesses and hospitals.
- The location, height and width of any obstructions (such as buildings or other structures) in the path of the released gaseous plume, surface roughness or the use of a more general parameter “rural” or “city” terrain.

5.1 GAUSSIAN PLUME MODEL

The Gaussian plume model of dust dispersion is a mathematical model that is used in case point source emitters, such as dust generating sources. Intermittently, this model will be applied to non-point source emitters, such as dust exhaustion from automobiles in mines.

One of the main assumptions of this model is that over short periods of time (e.g. few hours) steady state conditions exist with regard to air pollutant emissions and meteorological changes. Air pollution is characterized as an idealized plume coming from the peak of a stack of some height and diameter. One of the major calculations in this model is the effective stack height. As the gases are heated in the stack, the hot plume (dust) will be thrust upward some distance above the top of the stack: the effective stack height. For the model, we need to be able to determine this vertical displacement, which depends on the stack dusty air exit velocity and temperature, and the temperature of the neighbouring air.

Once the plume has reached its effective stack height, dispersion of dust will begin in three dimensions. Dispersion in the downwind direction is a function of the mean wind speed blowing across the plume in this direction. Dispersion in the cross-wind direction and in the vertical direction will be according to the Gaussian plume equations of lateral dispersion. Lateral dispersion relies on a value known as the atmospheric condition. It is the measure of the relative stability of the neighbouring air. The model assumes that dispersion in these two dimensions will take the outline of a normal Gaussian curve, with the greatest concentration in the middle of the plume.

$$c = \frac{q}{2\pi u \sigma_z \sigma_y} \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-h)^2}{2\sigma_z^2}\right) - \exp\left(-\frac{(z+h)^2}{2\sigma_z^2}\right)\right]$$

- c, concentration
- q, emission rate
- σ values represent diffusion along the appropriate axes
- y, horizontal distance off plume axis
- z, height
- h, emission height

In order for a plume to be modelled using the Gaussian distribution the subsequent assumption must be made:

- The plume spread has a normal distribution
- The emission rate (q) is constant and continuous
- Wind speed and direction is uniform
- Total reflection of the plume takes place at the surface
- The terrain is relatively flat, i.e., no crosswind barriers

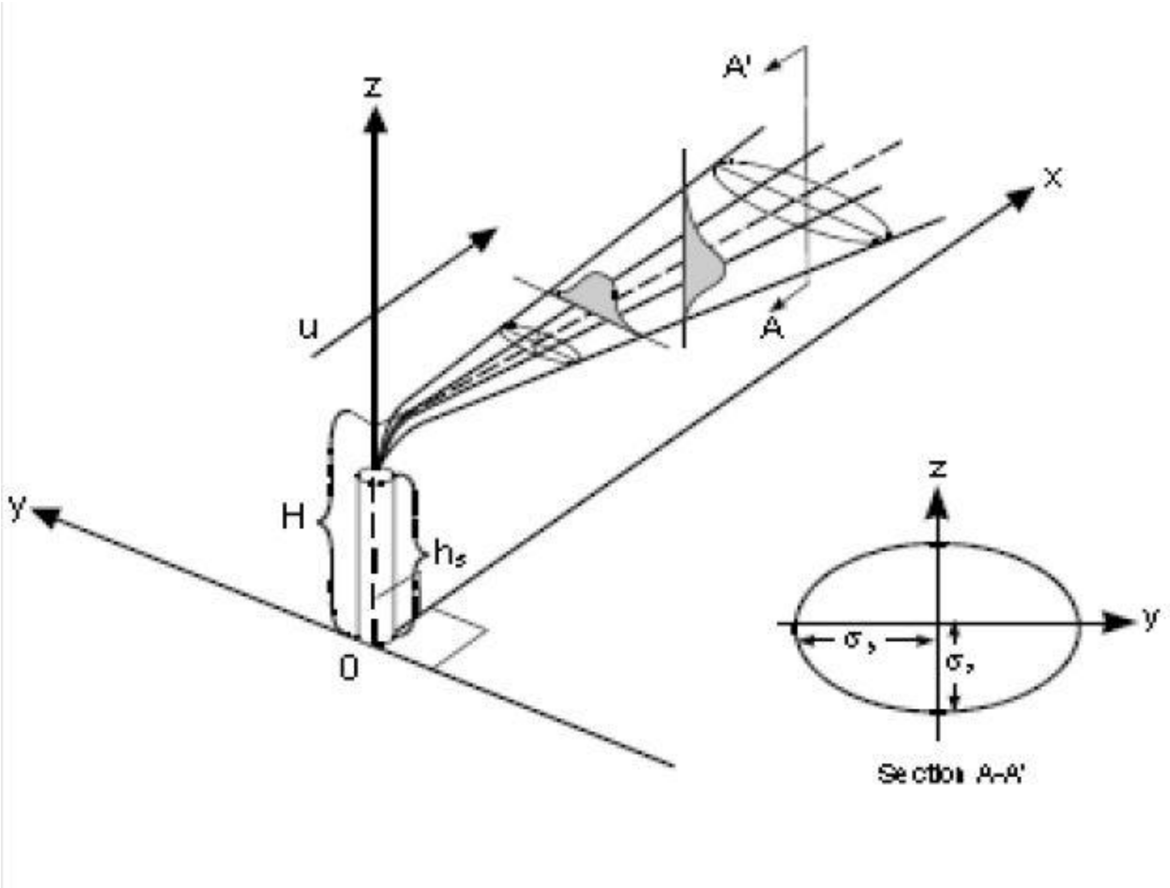


Fig 5.1: Co-ordinates of a Gaussian plume

Plume Behaviour: The mixing of ambient air into the plume is called entrainment. As the plume entrains air into it, the plume diameter grows as it travels downwind. A combination of the gases' momentum and buoyancy causes the gases to rise. This is referred to as plume rise and allows air pollutants emitted in this gas stream to be lofted higher in the atmosphere.

The final height of the plume, referred to as the effective stack height (H), is the sum of the physical stack height (H) and the plume rise (Δh). Plume rise is actually calculated as the distance to the imaginary centreline of the plume rather than to the upper or lower edge of the plume.

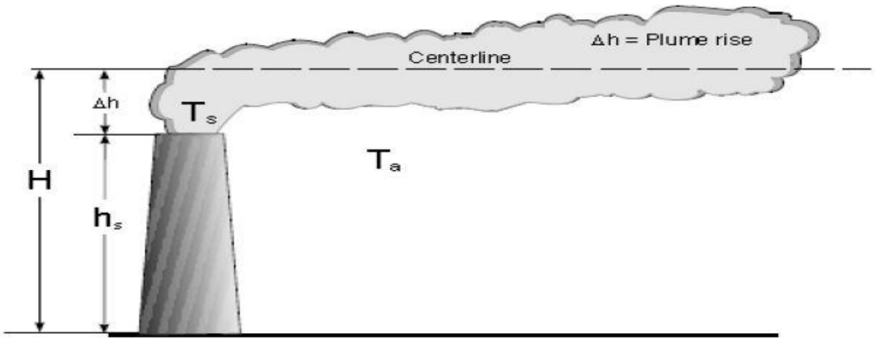


Fig 5.2: Gaussian plume from a stack

The Briggs' plume rise formula (1969) is as follows:

$$\Delta h = \frac{\quad - \quad - \quad}{\qquad}$$

Where:

Δh = plume rise (above stack)

F = Buoyancy Flux

ū = average wind speed

x = downwind distance from the stack

g = acceleration due to gravity (9.8 m/ 2)

V = volumetric flow rate of stack gas

= temperature of stack gas

= temperature of ambient air

[Ref: Briggs, G.A., "Plume Rise", USAEC Critical Review Series, 1969]

Plume Stability:

Shapes of plumes depend upon atmospheric stability conditions which depend on Environmental Lapse rate (ELR) and Dry Adiabatic Lapse Rate (DALR). If,

- ELR > DLR, atmosphere is stable
- ELR >> DLR ,very stable atmosphere
- ELR = DALR , atmosphere is neutral
- ELR < DLR , atmosphere is unstable

5.2 METEOROLOGICAL PARAMETERS THAT EFFECTS THE AIR QUALITY MODELLING

Given below is a list of some meteorological parameters:

5.2.1 Cloud cover: Cloud cover (also known as cloudiness, cloud amount) refers to the portion of the sky sheltered by the clouds when observed from a precise location. It is articulated in units of either in oktas (or eighths of the sky) or in tenths. It is because they are calculated with an okta grid. A value of 0 refers to clear sky, while 8 oktas or 10 on the decimal scale exemplify total overcast. Each okta characterizes one eighth of the sky covered by cloud as detected.

5.1.2 Global Horizontal radiation: Total solar radiation; the sum of direct, diffuse, and ground-reflected radiation; nevertheless, because ground reflected radiation is usually inconsequential compared to direct and diffuse, for all applied purposes global horizontal radiation is said to be the sum of direct and diffuse radiation only. Global horizontal radiation is the sum of both the direct and diffuse components as measured incident on a flat horizontal plane. It is thus the sum of the direct horizontal and diffuse horizontal values.

5.1.3 Hourly Precipitation: Precipitation is calculated as the deepness to which a flat horizontal surface would have been enclosed per unit time if no water were lost by runoff, evaporation, or percolation. Depth is stated in inches or millimetres. Gauging precipitation covers rain, hail, snow, rime, hoar frost and fog, and is conventionally measured using numerous types of rain gauges such as the non-recording cylindrical vessel type or the recording weighing type, float type and tipping-bucket kind.

5.1.4 Ceiling Height: Ceiling height is well-defined as the height-above-ground level of the lowest broken or overcast layer. If the sky is totally covered, the height of the vertical visibility (VV) is taken as the ceiling height. The height for the lowest broken or overcast layer is used as the ceiling height.

5.1.5 Relative humidity: Relative humidity is a term used to describe the amount of water vapour that exists in a gaseous mixture of air and water vapour.

5.1.6 Dry Bulb Temperature: The dry-bulb temperature is the temperature of air shown by a thermometer freely unprotected to the air but safeguarded from radiation and moisture.

5.1.7 Wind Speed: It is the speed of wind, the movement of air or other gases in an atmosphere.

5.1.8 Wind Direction: Wind direction is the direction from which a wind initiates. It is typically described in cardinal directions or in azimuth degrees.

5.3 Preferred and recommended models

- AERMOD - An atmospheric dispersion model based on atmospheric boundary layer turbulence structure and scaling concepts, including treatment of multiple ground-level and elevated point, area and volume sources. It handles flat or complex, rural or urban terrain and includes algorithms for building effects and plume penetration of inversions aloft.

  It uses Gaussian dispersion for stable atmospheric conditions (i.e., low turbulence) and non-Gaussian dispersion for unbalanced conditions (high turbulence). Algorithms for plume depletion by wet and dry deposition are also included in the model. This air model was in development for approximately 14 years before being officially accepted by the U.S. - EPA.

- CALPUFF - A non-steady-state puff dispersion model that simulates the effects of time and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.

- BLP - A Gaussian plume dispersion model designed to handle unique modelling problems associated with industrial sources where plume rise and downwash effects from stationary line sources are critical.
- CALINE3 - A steady-state Gaussian dispersion model designed to define pollution concentrations at receptor locations down air of highways located in relatively uncomplicated terrain.

Chapter 6

AIR QUALITY ANALYSIS

Procedure and observations

Air quality index

AQI of some iron and manganese mines in Keonjhar district In Odisha

6. AIR QUALITY ANALYSIS

WHY KEONJHAR & SUNDARGARH DISTRICT IS SELECTED FOR AMBIENT AIR ASSESSMENT?

The mineral resources of Orissa are distributed very unevenly. Most of the iron and manganese ore is found in Sundargarh and Keonjhar district. So, all the large open cast metal mines are located in this region. Due to the presence of large number of mines, there is a cumulative impact of particulate matter pollution on the environment. Therefore a detailed study on ambient air quality needs to be done on that area. Our studies spanned on mines namely, Joda east iron ore mine, Khondbond iron and manganese mines, Jilling Langalota iron and manganese mines, Raikela Tantra iron ore mines, Oraghat iron ore mines,etc. The study included direct sampling in the field, data collection from EIA/EMP reports and SPCB, Regional office, Rourkela.

6.1 PROCEDURE

The method that was used was according to the CPCB guidelines. The sampling instrument was set on a stable and levelled ground, without any type of disturbances. In the core zone, the sampler was located at an approximate distance of 40m from nearby constructions. The sampler was placed 20 m away from the trees in buffer zone. Three populous locations were selected lying within 10 km radius from the mine periphery, viz. Village Dengula, Tensa Town and Village Bahamba.

The filter paper was properly conditioned before placing it on the filter cassette of the sampler. Initial dry gas meter reading was noted. The suction pump was activated along with the timer. A total duration of 8 hours was set for sampling. After the stipulated time, the sampling instrument was stopped and the filter paper was retrieved. It was conditioned and sealed for further investigation in laboratory.

6.2 OBSERVATIONS

Air quality data from mining areas of Keonjhar district were collected from some EIA/EMP reports. Data were also collected from SPCB, Rourkela regional office. To verify the status of air quality in field, measurement of air quality were done at Raikela-Tantra iron ore mines in the month of December. Particulate matter samplers were used for the above purpose. The gases collected at the mine sited were subsequently sent to the lab SPCB, Rourkela.

The analysis of sampled air quality data of Raikela Tantra iron mines in the Keonjhar district has been presented in table given below:

Table 6.1: Sampled Air Quality data of 'Raikela Tantra iron mines'.

LOCATION	PARAMETER	Results	Prescribed standard	UNIT
Mines office area	$PM_{2.5}$	29	60	µgm/m^3
	PM_{10}	82	100	µgm/m^3
	SO_2	4	80	µgm/m^3
	NO_x	9	80	µgm/m^3
	CO	0.1	4	mg/m^3
Village Dengula	$PM_{2.5}$	30	60	µgm/m^3
	PM_{10}	88	100	µgm/m^3
	SO_2	4	80	µgm/m^3
	NO_x	16	80	µgm/m^3
	CO	0.1	4	mg/m^3
Tesnsa Town	$PM_{2.5}$	41	60	µgm/m^3
	PM_{10}	97	100	µgm/m^3
	SO_2	4	80	µgm/m^3
	NO_x	9	80	µgm/m^3
	CO	0.1	4	mg/m^3
Village Bahamba	$PM_{2.5}$	27	60	µgm/m^3
	PM_{10}	75	100	µgm/m^3
	SO_2	4	80	µgm/m^3
	NO_x	9	80	µgm/m^3
	CO	0.1	4	mg/m^3

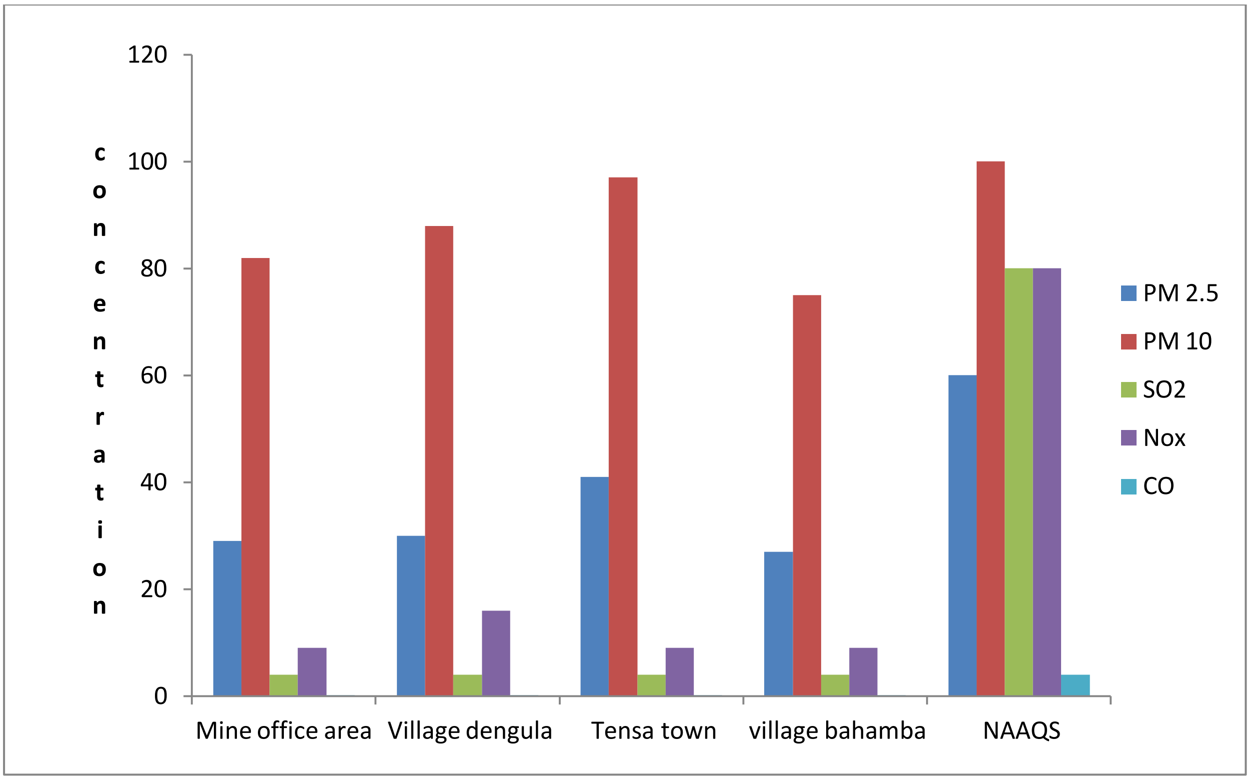


Fig. 6.1: PM Conc. in Raikela Tantra Iron ore Mine (Mining site)

Note: Concentration of PM_{10}, $PM_{2.5}$, SO_2, and NO_xin figure isμgm/m^3 and that of CO is mg/m^3

The analysis of sampled air quality data of different iron and manganese mines in the Keonjhar district taken from EIA/EMP reports are presented in tables given below:

Table 6.2: Air quality of Khondbond iron and manganese mines (mining site)

Sampling date	$PM_{2.5}$	PM_{10}	unit
Oct -2011	28.7	49.2	μgm/m^3
Nov-2011	30.6	51.2	μgm/m^3
Dec-2011	31	51.3	μgm/m^3
Jan-2012	30.9	51.3	μgm/m^3
Feb-2012	34	53.9	μgm/m^3
Mar-2012	35.3	55.9	μgm/m^3
NAAQS	60	100	μgm/m^3

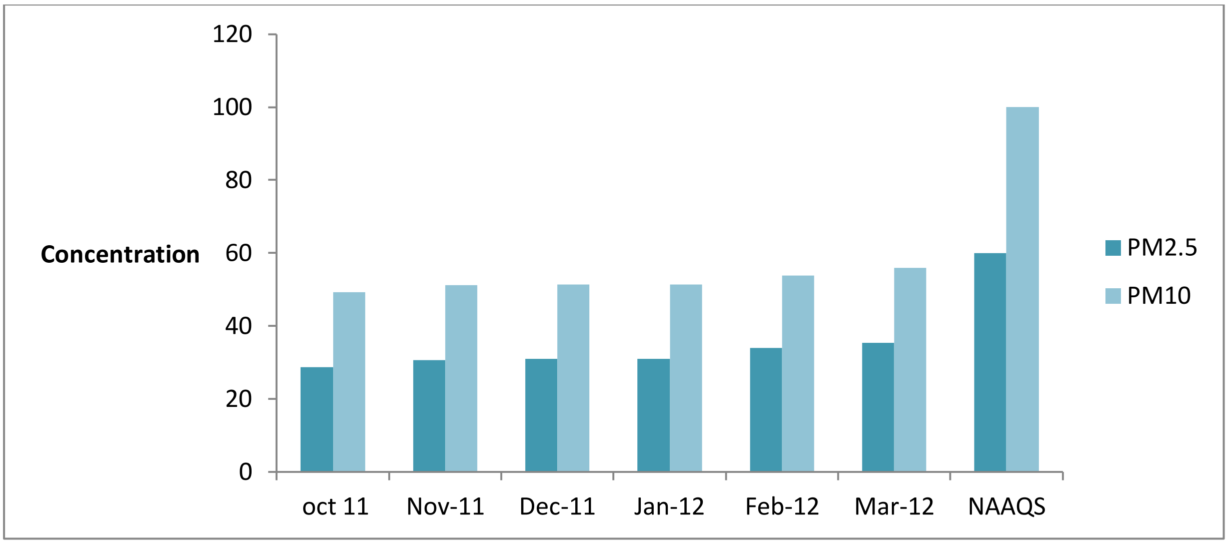


Fig. 6.2: PM Conc. in Khondbond Iron & Manganese Mine (Mining site)

Table 6.3: Air quality of Khondbond iron and manganese mines (Near plant area)

Sampling date	$PM_{2.5}$	PM_{10}	Unit
Oct-11	32.9	54.7	µmg/m^3
Nov-11	34.6	55.1	µmg/m^3
Dec-11	34	54.9	µmg/m^3
Jan-12	33.5	54	µmg/m^3
Feb-12	36.2	56.9	µmg/m^3
Mar-12	38.5	59	µmg/m^3
NAAQS	60	100	µmg/m^3

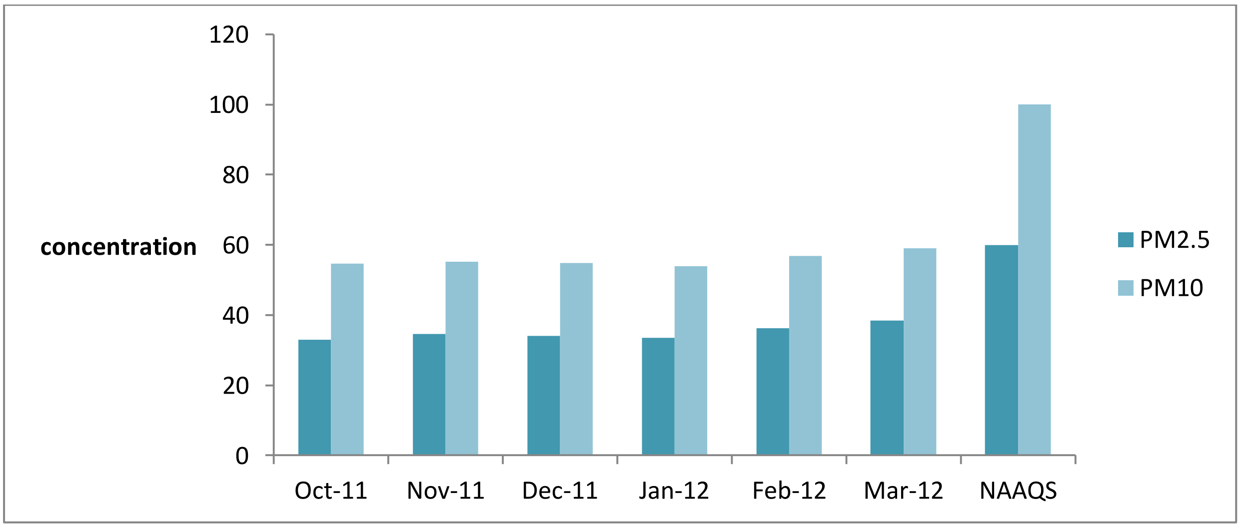


Fig. 6.3: PM Conc. in Khondbond Iron & Manganese Mine (Near plant area)

Table 6.4: Air quality of Joda east Iron ore mine (Mining area)

Sampling date	$PM_{2.5}$	PM_{10}	Unit
Apr-11	22.6	43.3	µmg/m^3
May-11	21.3	41.6	µmg/m^3
Jun-11	21.5	42	µmg/m^3
Jul-11	22	42.8	µmg/m^3
Aug-11	15	35.8	µmg/m^3
NAAQS	60	100	µmg/m^3

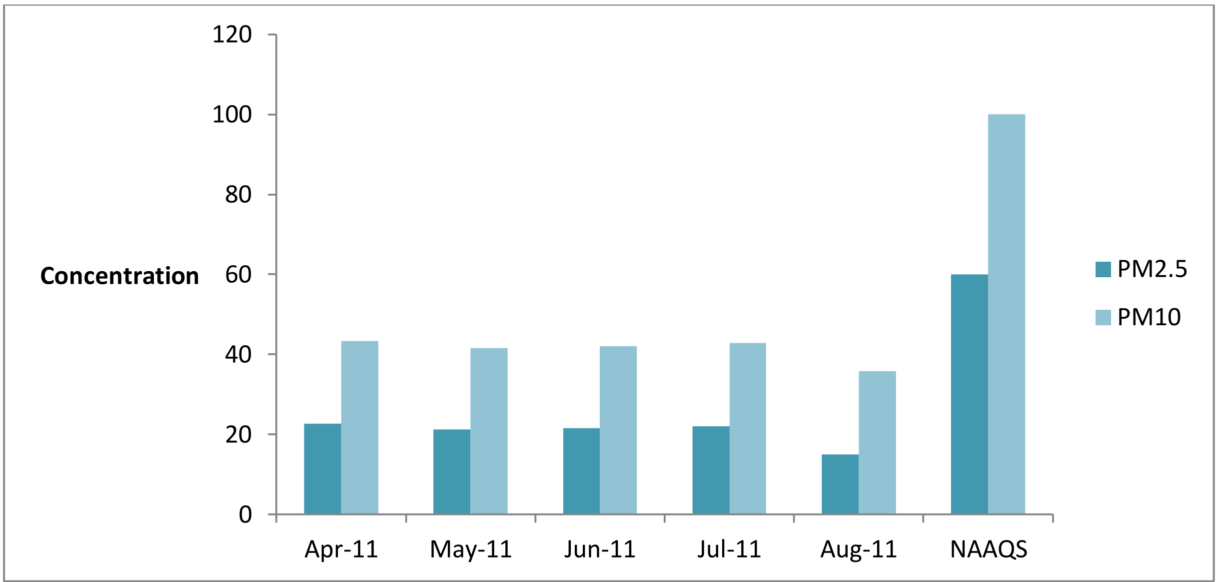


Fig. 6.4: PM Conc. in Joda east Iron ore mine (Mining area)

Table 6.5: Air quality of Joda east Iron ore mine (Residential area)

Sampling date	$PM_{2.5}$	PM_{10}	Unit
Apr-11	12.4	32.3	µmg/m^3
May-11	13.3	33.5	µmg/m^3
Jun-11	13.3	33.6	µmg/m^3
Jul-11	13.6	32.9	µmg/m^3
Aug-11	8.8	29.4	µmg/m^3
NAAQS	60	100	µmg/m^3

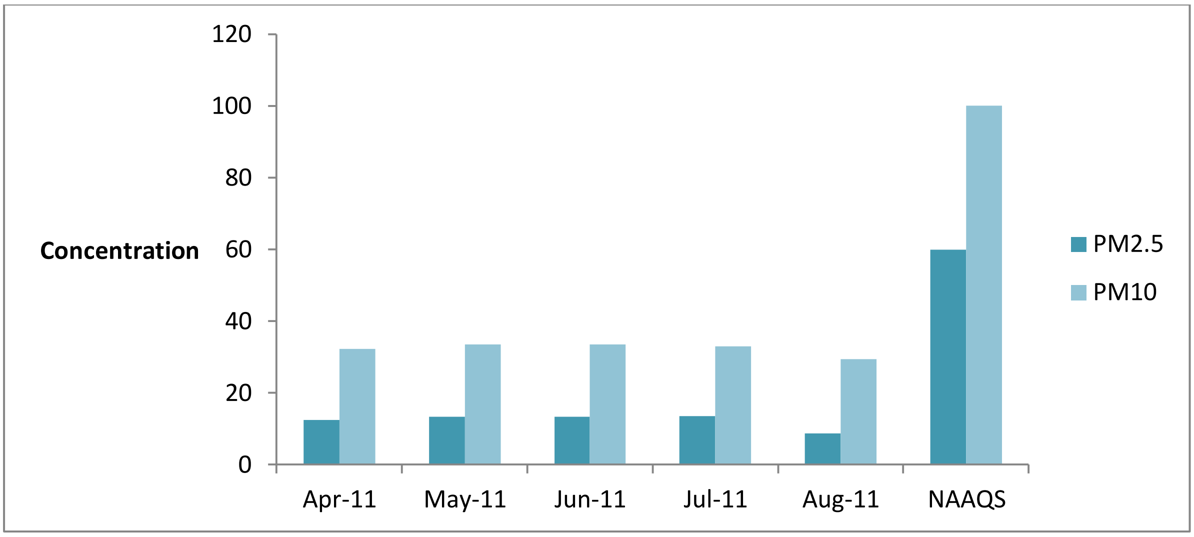


Fig. 6.5: PM Conc. in Joda east Iron ore mine (Residential area)

Table 6.6: Air quality of Jilling Langalota iron & manganese mine

Sampling date	$PM_{2.5}$	PM_{10}	Unit
05-03-2012	20	48	µmg/m^3
06-03-2012	22	56	µmg/m^3
12-03-2012	23	44	µmg/m^3
13-03-2012	18	53	µmg/m^3
19-03-2012	17	50	µmg/m^3
26-03-2012	14	62	µmg/m^3
NAAQS	60	100	µmg/m^3

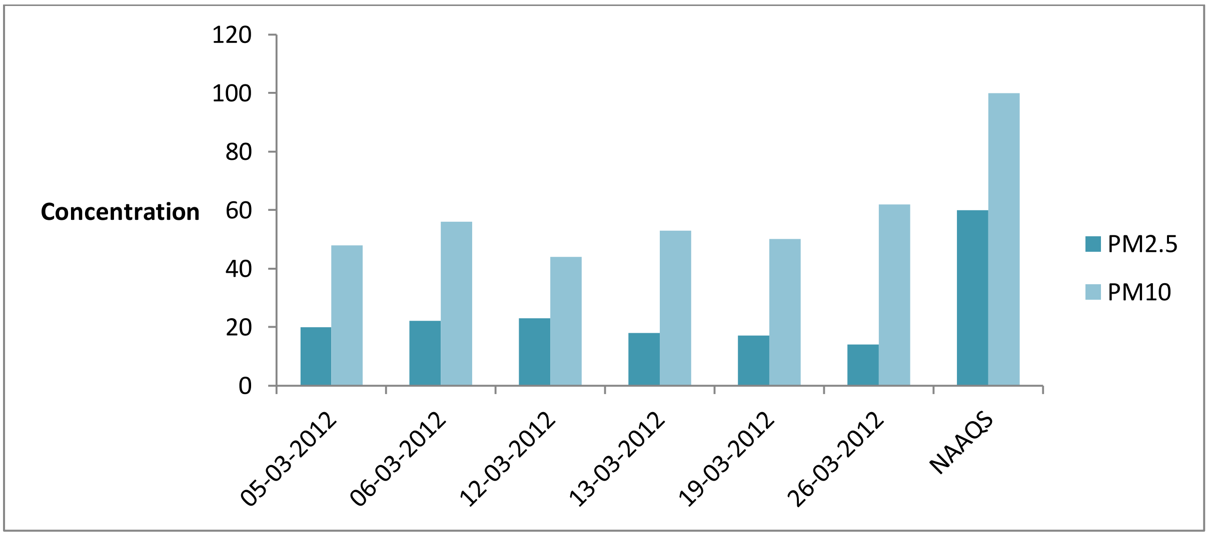


Fig. 6.6: PM Conc. in Jilling Langalota iron & manganese mine

Table 6.7: Air quality of Bhulbeda iron ore mine

Station	$PM_{2.5}$	PM_{10}	Unit
Inside ML Area	42.4	56.65	µmg/m^3
Within DLC Forest	40.05	52.1	µmg/m3
Bhulbeda village	44.1	57.05	µmg/m^3
Hariharpur village	43	57.55	µmg/m^3
Jaribahal village	47.3	62.4	µmg/m^3
Sargitalia village	45.65	58.3	µmg/m^3
Kankada village	42.15	56	µmg/m^3
Daduan village	46.35	61	µmg/m^3
NAAQS	60	100	µmg/m^3

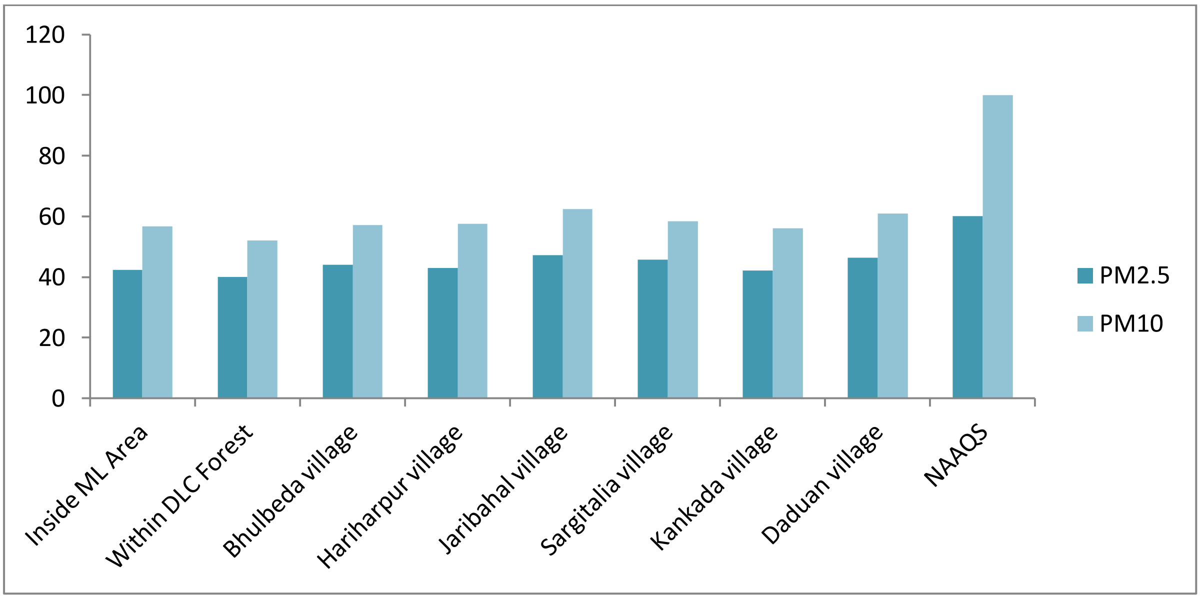


Fig. 6.7: PM Conc. in Bhulbeda iron mines

Table 6.8: Observed Air Quality data of 'Oraghat Iron ore mines' during 2009-2012

CORE ZONE						
Year	**Station Name**	**$PM_{2.5}$ (µgm/m^3)**	**PM_{10} (µgm/m^3)**	**SO_2 (<value) (µgm/m^3)**	**NO_x(µgm/m^3)**	**CO (mg/m^3)**
2009	Mines office	45	56.5	3.78	34	<0.1
2010		42.5	59	4.5	24	<0.1
2011		22	67.5	5	22	<0.1
2012		32.5	22	7	17	<0.1

			BUFFER ZONE			
2009	Oraghat village	38.5	20	1.78	25	<0.1
2010		32	29	4	15	<0.1
2011		34	64	5	17	<0.1
2012		38	24	7	13	<0.1
2009	Malda village	41	52.5	1.78	15.5	<0.1
2010		42.5	54	4.5	19.5	<0.1
2011		24	71.5	4.5	27.5	<0.1
2012		38.5	20	6	22.5	<0.1
2009	Sanindpur village	38.5	80.5	3.28	22	<0.1
2010		41	52.5	3.28	15	<0.1
2011		19.5	60	5.5	25.5	<0.1
2012		38.5	25	4	18	<0.1
2009	Pureibahal	51.5	81.5	4	17	<0.1
2010		49.5	-	4	18.5	<0.1
2011		13.5	38.5	5	11.5	<0.1
2012		43	18	4	32.5	<0.1
NAAQS		60	100	80	80	4

Table 6.9: Recent Air Quality Data of different open cast metal mines obtained from SPCB, Regional office, Rourkela.

Mine	Location	Parameter	Unit	Result	NAAQS
Barsua iron mines	Near Crusher Area(25m from source)	$PM_{2.5}$	$\mu gm/m^3$	49	60
	Near Barsua valley(25m from source)	$PM_{2.5}$	$\mu gm/m^3$	44	60
	Near Crusher Area(25m from source)	PM_{10}	$\mu gm/m^3$	86	100
	Near Barsua valley(25m from source)	PM_{10}	$\mu gm/m^3$	89	100
Nadidihi Iron and	Near Active Mining Area	PM_{10}	$\mu gm/m^3$	82	100

Manganese mines	Near Weigh Bridge	PM_{10}	µgm/m^3	89	100
Oraghat Iron mines	Near Active mining Area	PM_{10}	µgm/m^3	96	100
	Near Mining office Area	PM_{10}	µgm/m^3	80	100
KantherKoira Manganese mines	Near Active mining Area	PM_{10}	µgm/m^3	54	100
	Near Main Gate	PM_{10}	µgm/m^3	48	100
Narayanaposhi Iron and Manganese mines	Near 650 TPH iron ore crusher Area	PM_{10}	µgm/m^3	92	100
	Near Active mining Area	PM_{10}	µgm/m^3	70	100
TRB iron ore mine	Near iron Crushing Area	PM_{10}	µgm/m^3	92	100
	Near Active mining Area	PM_{10}	µgm/m^3	80	100
Bandhal Manganese Mines	Near Weigh Bidge	PM_{10}	µgm/m^3	74	100
	Near Quarry Area	PM_{10}	µgm/m^3	86	100

6.3 Air quality index

Air quality index (AQI) is a number used by government agencies to communicate to the public how polluted the air is currently or how polluted it is forecast to become. As the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. Different countries have their own air quality indices which are not all consistent. Different countries also use different names for their indices such as Air Quality Health Index, Air Pollution Index and Pollutant Standards Index.

The United States Environmental Protection Agency (EPA) has developed an index which they use to report daily air quality. This AQI is divided into six categories indicating increasing levels of health concern. An AQI value over 300 represents hazardous air quality whereas if it is below 50 the air quality is good.

The air quality index is a piecewise linear function of the pollutant concentration. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit.

To convert from concentration to AQI this equation is used.

I=(

where:

I= the (Air Quality) index,

C= the pollutant concentration,

C_{low}= the concentration breakpoint that is $\leq C$,

C_{high}= the concentration breakpoint that is $\geq C$,

I_{low}= the index breakpoint corresponding to C_{low},

I_{high}= the index breakpoint corresponding to C_{high}.

EPA's table of breakpoints for $PM_{2.5}$ is:

C_{low}	C_{high}	I_{low}	I_{high}	Category
0	15.4	0	50	Good
15.5	40.4	51	100	Moderate
40.5	65.4	101	150	Unhealthy for Sensitive Groups
65.5	150.4	151	200	Unhealthy
150.5	250.4	201	300	Very Unhealthy
250.5	350.4	301	400	Hazardous
350.5	500.4	401	500	Hazardous

6.4 Air quality index of some iron and manganese mines

Table 6.10:Joda East iron ore mine, M/s Tata Steel Ltd.

(Half yearly compliance report for the period: April to September’ 11)

(Near Mining Area)

SAMPLING DATE	PM 2.5	AQI	REMARKS
Apr-11	22.6	64.97	Moderate
May-11	21.3	62.41	Moderate
Jun-11	21.5	64.8	Moderate
Jul-11	22	63.79	Moderate
Aug-11	15	48.7	good
Sep-11	13.5	43.83	good

(Near Residential Area)

SAMPLING DATE	PM 2.5	AQI	REMARKS
Apr-11	13.3	43.18	good
May-11	12.6	40.91	good
Jun-11	8.8	28.57	good
Jul-11	7.6	24.67	good
Aug-11	12.4	40.26	good
Sep-11	13.3	43.18	good

Table 6.11 Khondbond iron and manganese mines, M/s Tata Steel Ltd.

(Half yearly compliance report for the period: October 11 to march 12)

SAMPLING DATE	PM 2.5	AQI	REMARKS
Oct-11	32.9	85.24	Moderate
Nov-11	34.6	88.58	Moderate
Dec-11	34	87.4	Moderate
Jan-12	33.5	86.42	Moderate
Feb-12	36.2	91.73	Moderate
Mar-12	38.5	96.26	Moderate

Table 6.12: Bhulbeda iron ore mines, M/s Mineral Trading Syndicate

(Executive summary report on EIA/EMP of year 2011)

STATION CODE	SAMPLING DATE	PM2.5	AQI	REMARKS
Inside ML Area	1/9/11 TO 30/11/11	42.4	104.73	unhealthy for sensitive groups
Within DLC Forest	1/9/11 TO 30/11/11	40.05	99.31	Moderate
Bhulbeda village	1/9/11 TO 30/11/11	44.1	108.08	unhealthy for sensitive groups
Hariharpur village	1/9/11 TO 30/11/11	43	105.91	unhealthy for sensitive groups
Jaribahal village	1/9/11 TO 30/11/11	47.3	114.38	unhealthy for sensitive groups

Table 6.13: Jilling Langalota iron and manganese mines, M/s Essel Mining & Industries Ltd.

(Executive summary report of draft EIA of year 2012)

MONTH	SAMPLING DATE	PM2.5	AQI	REMARKS
January	02-01-2012	39	97.24	Moderate
	03-01-2012	25	69.69	Moderate
	09-01-2012	21	61.82	Moderate
	10-01-2012	23	65.76	Moderate
	16-01-2012	24	67.72	Moderate
	17-01-2012	25	69.69	Moderate
	23-01-2012	29	77.56	Moderate
	24-01-2012	31	81.5	Moderate
February	06-02-2012	22	63.79	Moderate
	07-02-2012	23	65.76	Moderate
	13-02-2001	25	69.69	Moderate
	14-02-2012	26	71.66	Moderate
	20-02-2012	21	61.82	Moderate
	27-02-2012	19	57.88	Moderate

	05-03-2012	20	59.55	Moderate
	06-03-2012	22	63.79	Moderate
	12-03-2012	23	65.76	Moderate
March	13-03-2012	15	55.91	Moderate
	19-03-2012	17	53.95	Moderate
	26-03-2012	14	48.04	Moderate

Chapter 7

DISCUSSION AND CONCLUSION

Measures of Dust Control

7. DISCUSSION AND CONCLUSION

7.1 DISCUSSION

Mining of ore impacts the air quality to a significant extent. Air Quality study was carried out in some of the metal mining areas of Keonjhar and Sundargarh district. These two districts have a number of Iron, Manganese, Limestone, Dolomite and Chromite mines. There has been a large number of complaints from the residents of nearby villages regarding the high level of particulate matter pollution. This has also been highlighted in different newspaper reports.

Therefore a study of the air quality at some of the locations at these two districts was carried out. Since the area is too vast, air quality data was collected from the EIA reports and SPCB Rourkela Regional Office. In addition to this, air sampling was carried out in December 2012 with the help of EnviroTech $PM_{2.5}$ and PM_{10} (model no. APM 460 NL) samplers. In addition, the air quality index (AQI) of all the locations have been calculated to make a comparison of air quality in different locations and accordingly recommend suitable remedial measures. The summary of the findings are presented here.

It was observed that the concentration of gases, viz. CO, SO_2 and NOx were negligible in all cases. Therefore, emphasis has been given on particulate matter concentration in this study.

Raikela Tantra iron ore mines were the site where we went to take air quality observations of our own. In the four locations where we took sampling data, village Bahamba was found to be least polluted with $PM_{2.5}$ and PM_{10} values lowest among all the locations. This may be due to distance of the sampling location from the actual mine site and the presence of a surrounding green belt. It is observed from table 6.1 and fig 6.1 that Tensa town was the most polluted of the four locations as the particulate matter values are close to the NAAQS standards. The AQI of Tensa town was unhealthy to sensitive groups due to its high particulate matter content whereas for other three locations the AQI was Moderate suggesting that the air quality is just acceptable.

In the Khondbond iron and manganese mines, from table 6.2 and fig 6.2, it can be observed that from October to march -2011, the particulate matter concentration is slightly increasing with lowest value in October and highest value in March for both PM_{10} and $PM_{2.5}$. These phenomena can be attributed to seasonal variation of PM concentration. The overall air quality index was moderate which is depicted in table 6.11.

In both mining and residential areas of Joda east iron ore mine, the $PM_{2.5}$ and PM_{10} concentration has a decreasing trend throughout the sampling period from April-11 to August-11 depicted in Table 6.4, 6.5 and fig 6.4 and 6.5. The concentration of dust particles were much below the NAAQS standard indicating AQI (table 6.10) of the mine is good for both the sampling areas. In rainy months, the PM concentration was found to be least.

In Jilling Langalota iron and manganese mines, sampling was done throughout the month of March by SPCB. It was found that the concentration of $PM_{2.5}$ decreased during the sampling period but PM_{10} concentration showed no specific trend of change as depicted in figure 6.6. AQI of the mine area was found to be moderate as shown in table 6.13

For the air quality assessment in Bhulbeda iron ore mines, air sampling was done in eight nearby locations and the result is shown in table 6.7 and figure 6.7. The PM2.5 and PM10 concentration are constant but are relatively higher than any other mines. Village Daduan has the highest value of both $PM_{2.5}$ and PM_{10} concentration. Hence the AQI in table 6.12 depicts that the air quality is unhealthy to sensitive groups.

The yearly air quality data (2009-2012) of 'Oraghat iron ore mines' is shown in Table 1. Here we observe that $PM_{2.5}$ concentration is remaining constant for the whole period. PM_{10} concentration is at its peak in the year 2009-2011 but it reduced drastically to around half the previous values. CO concentration is remaining below 0.1 mg/m^3 in the whole time frame. The NO_x and SO_2 concentration is well within the NAAQS prescribed limits and there is no pattern of change.

The recent air quality data collected from a group of iron and manganese mines taken from SPCB, Regional office, Rourkela is given in the table 6.9. It can be observed that in all mines, PM concentration is alarmingly high near crusher areas ranging from 80-92µgm which is just below NAAQS standard. Therefore it can be suggested that appropriate dust suppression measures need to be implemented near the crusher areas such as application of foaming and wetting agents and formation of green belt.

The observed decrease in the concentration of particulate matter and other toxic gasses is due to the successful application of modern dust control methods which include dry and wet methods, and adoption of newer technology for reducing gas emission. The most common one that is used in those mines is the fixed and mobile water sprinkler system. Regular dust cleaning practises are being adopted for better air quality management.

7.1.1 Measures of Dust Control

From the above discussion it is clear that air pollution due to different gases is not a serious concern in the study area. However, particulate matter is a matter of concern, even though they are within prescribed limits at the moment. Since, there are a number of mines in cluster, the cumulative impact could be serious and is yet to be studied. It is noticed that majority of the concern is the particulate matter pollution caused by transportation, crushing and grinding operations. Some of the latest technologies which could be utilised to mitigate such challenges in mines are:

Housekeeping: Bad road conditions and overloading of vehicles lead to spillage, and the material spilled is subject to re-entrainment which leads to production of dust. Overloading of trucks/dumpers should be strictly prohibited to prevent spillage and regular clearing of roads should be carried out. If possible the trucks/dumpers should be covered to avoid spillage. The spilled material should be removed periodically. Further dust suppression can be carried out by spraying water using fixed or mobile sprinklers.

Fig 7.1: Static water sprinkling system in an Australian opencast mine

(http://australianminingreview.com.au/central-control-system-making-dust-control-easy/)

With frequent watering, newly spilled material is moistened at close intervals. When chemicals are applied with infrequent watering, newly spilled material could go for long periods before being moistened. Therefore, in mines where spillage cannot be controlled, watering alone is better for dust control.

Black topping of permanent roads: Haul roads and light vehicle roads having a reasonably long life (say 10 to 15 years) can be metalled and topped with asphalt or bitumen to provide a better road surface and to reduce the generation of fugitive dust.

Binding and agglomerating agents: Binding agents are used when dust control by water is not feasible. They are classified as humectants and adhesive formulations. ***Humectants,*** maintains surface moisture to keep the dust wet, like calcium and magnesium chloride. ***Adhesives***, maintain fine dust particle agglomerate in absence of surface moisture, like oils and polymers. The performance of binding agent depends on physical and chemical properties of substrate, the application technique and storage and handling conditions (Rosbury and Zimmer, 1983). For example, EK35, is synthetic resin binder which captures fines and keep them locked in surface, it works effectively on all types of soil and aggregates and are biodegradable in nature (Midwest Industrial Supply Inc., 2010).

Wetting agents: Wetting agents are surfactant formulations that improve the ability of water to adhere and spread on dust particles thereby increasing the bulk density of particle and leads to agglomeration. These are mainly useful in unloading and conveying operations. Considerable research has been done on the use of wetting agents and has found to have increased dust control effectiveness ranging from 0-25% (Chander et al., 1991).For Example-3M Dust suppressant LSP-1000C is water soluble, alcohol free formulation. It penetrates and agglomerates fine dust particles; dries to form a thin, flexible film that suppresses dust for extended periods.

Surfactants are sometimes used in wet spray applications because they lower the surface tension of the water solution, which has the following effects:

- Reduced droplet diameter.
- An increase in the number of droplets for a given volume of water; and
- A decrease in the contact angle defined as the angle at which a liquid meets a solid surface.
- Despite the effectiveness of chemical additives, it must be noted that they are not often used in the metal/non-metal mining industry based upon several limitations.

- Surfactants are significantly more expensive than a typical water application. They can alter the properties of the mineral or material being processed. Surfactants have limited usefulness in the metal/non-metal mining industry, as opposed to in the coal industry, since ore or stone are much easier to wet than is coal due to its hydrophobic nature.

The effectiveness of chemical additives depends on:

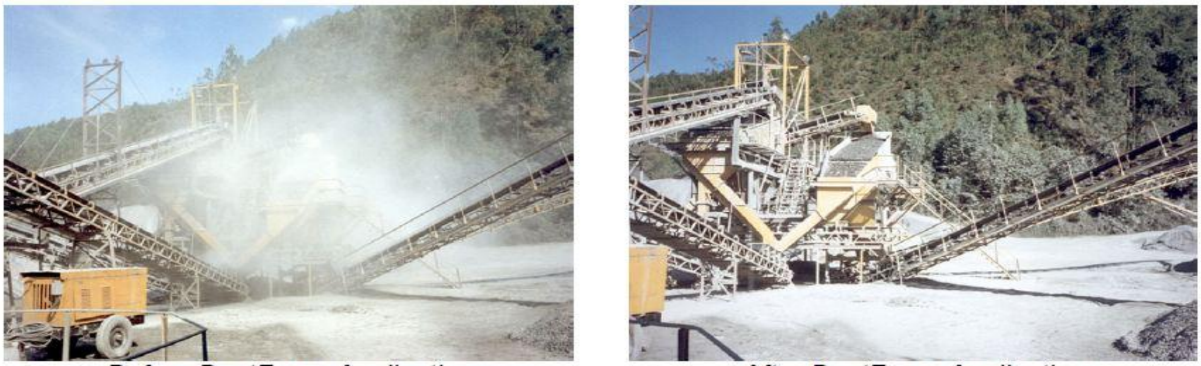
1. the type of wetting agent
2. hydrophobic nature of the mineral particles
3. dust particle size
4. dust concentration
5. water pH
6. minerals present in the water used

Examples:

- 3M™ SDS4 Polymeric Dust Suppression
- 3M™ SDS-2 Surfactant Based Dust Suppression
- Enviroseal LDC PLUS 12™

Foam suppression: Foaming agents are high foaming surfactants containing wetting and binding agents which convert water and compressed air mixture into foam. The foam suppression technology, gives a heavy spray of foam which blankets the dust before a dust cloud can rise. It works by reducing the surface tension of dust particles. This minimizes the amount of water used. Foams used for dust control are dry, stable, small-bubbled and consistent. Use of foam has better efficiency as compared to water as the foam liquid wets and agglomerates fine dust particle, it can reduce 20-60% more dust as compared to water. These dust particles penetrate the foam bubble, causing the bubble to break and wet the particles. Large particles are not a problem, as the small micro-foam bubbles wet the larger particles without affecting the bubble. Micro-foam can be injected at material transfer points in order to obtain optimum dust control, requiring approximately 0.4 gallons of water for each ton of bulk material treated for dust control.

It is effective as it use lesser water as compared to that used in water sprays. Use of foam has increased dust reduction (Mukherjee and Singh, 1984). They can be used at transfer points and crushing operations. It provides best way of suppressing dust with minimum addition of moisture. The major drawback in use of this system is its high cost.



Before DustFoam Application　　　　After DustFoam Application

Fig 7.2: Application of foam near crusher area

(Ref: http://www.envirofloeng.com/foamexample.html)

Micro-foam is another method for controlling dust from fugitive dust sources, particularly load-out stockpiles. Typical foams used in fire fighting (large 5-mm bubbles) are not effective at dust control, unlike micro-foam (small <100-µm bubbles). Micro-foam is stated to be better than water for dust suppression, because the water droplets, to be effective for dust control, must be similar in size to the dust particles which micro-foam can replicate. In addition, the velocity of the water must be high to break its surface tension upon contact with the dust particle. Highly concentrated foam dust control agents are formulated to produce resilient, low surface tension foam for the control of fugitive dust throughout the plant material handling system. The most cost-effective performance generally occurs in waters containing total hardness between 100 to 1000 ppm (mg/L).

Dust hood/collectors: Dust collection hoods and flanges capture dust at the source and provide easy connection to the duct system. Most Dust Hoods and Flanges can be double faced taped to a machine cabinet or drilled and mounted as need. Dry collection can be performed most efficiently by maintaining an appropriate dust collector to bailing airflow ratio.

Dust collection systems work on the basic formula of capture, convey and collect.

- First, the dust must be captured. This is accomplished with devices such as capture hoods to catch dust at its source of origin. Many times, the machine producing the dust will have a port to which a duct can be directly attached.
- Second, the dust must be conveyed. This is done via a ducting system, properly sized and manifold to maintain a consistent minimum air velocity required to keep the dust in suspension for conveyance to the collection device. A duct of the wrong size can lead to material settling in the duct system and clogging it.

- Finally, the dust is collected. This is done via a variety of means, depending on the application and the dust being handled. It can be as simple as a basic pass-through filter, a cyclonic separator, or an impingement baffle. It can also be as complex as an electrostatic precipitator, a multistage bag house, or a chemically treated wet scrubber or stripping tower.

Green belt: Plantation of trees is one of the best measures for controlling air pollution. Trees act as wind breaks and the leaves as dust filter. Much of the dust produced in permanent roads in and around mines can be trapped by having trees with dense foliage planted on both sides of the roads. Maiti and Banerjee (1992) found that a 8m wide green belt between roads and buildings can reduce dust-fall by two to three times, and conifers reduce dust-fall by up to 42% in temperate urban areas. They also indicated that evergreen plants with shiny leaves like *Alstoniascholaris*, *Ficuslunea, F. Benghalensis*and *Magniferaindica*are the best dust catchers. Therefore, major dust producing areas such as stockyard, transfer points, material handling plants should be surrounded by a green belt. At least 30-40 meter green belt should be created on either side of the transportation road passing through populated areas.

Table 7.1: Comparison between different particulate matter control measures

Particulate Matter control methods	Effectiveness	Cost and Drawbacks
Dilution ventilation	Moderate	High- more air may not be feasible
Displacement ventilation	Moderate to high	Moderate - can be difficult to implement
Wetting by sprays	Moderate	Low - too much water can be a problem
Airborne capture by sprays	low to Moderate	Low - too much water can be a problem
Airborne capture by high pressure sprays	Moderate	moderate- can only be used in enclosed spaces
Foam	Moderate	High
Wetting agents	Zero to low	Moderate
Dust collectors	Moderate to high	Moderate to High - possible noise problems
Reducing generated dusts	low to Moderate	Moderate
Enclosure with sprays	low to Moderate	Moderate
Dust avoidance	Moderate	Low to Moderate

7.2 CONCLUSION

Mining, because of the very nature of operations involves disturbing the ground, removing and handling soil and rock, and the subsequent transport, dumping, crushing and processing of this material. At all stages there is some potential to produce particulate matter. It has become more serious and alarming due to increased production and mechanization in opencast as well as underground mines. It is seen that in mining industry, right from the soil handling to the final transportation, dust is generated resulting in air pollution.

In the present study, it was found that the AQI values for Joda East Iron ore mines ranges from 0 to 50, which lies in the ‘Good’ category. The AQI value of Bhulbeda Iron ore mines varied from 100 to 150, indicating that it belongs to ‘Unhealthy to sensitive group’ category. Rest of the mines, viz. Khondbond Iron and Manganese mines, Jilling Langalota Iron and Manganese mines have their AQI value within ‘Moderate’ category.

The PM_{10}values of most of the mines under observation were found to be close to the standards prescribed by NAAQS, whereas $PM_{2.5}$ values are well within NAAQS. The concentration of gaseous pollutants e.g. NO_x, SO_2, CO were found to be negligible with respect to NAAQS limits.

Several suggested mitigation measures which has been suggested, if followed, can bring down the level of particulate matter concentration considerably. These days, a number of dust dispersion modelling software’s are also available to predict the dust concentration, which can be utilized to plan for precautionary measures in advance. Best practice dust management can be achieved by appropriate planning in the case of new or expanding mining operations and by identifying and controlling dust sources during the active phases of all mining operations.

Chapter 8

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8. REFERENCES

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