3. Air Pollution

3.1 Preamble

Anthropogenic sources of air pollution due to mining are divided into two categories - 1) mobile sources which include automobiles, transport trucks, etc. and 2) stationary sources which include loading and unloading points, blasting sites, crushing and grinding plants, stack emissions from the grinding and metallurgical plants and power generation plants attached to mines.

The above sources emit a variety of particle and gas pollutants into atmosphere. The quality of air at a receptor is determined by the type and amount of pollutants emitted and the extent of atmospheric interactions that have occurred during the transport from the source to the receptor. Public generally judge air quality by visibility. But most of the pollutants in the ambient air are the suspended particles and gases that can not be seen. Besides the effect on the respiratory system, causing pneumocosis due to the release of airborne dust, according to some farmer's report, a reduction in yield of some of the crops due to dust precipitation over the leaf foliage released from adjoining Limestone mines with captive cement plant are also noticed.

Air pollution adversely affects man and his environment in many ways. It soils his home, clothes, creates imbalances in metabolic activity and interferes with the growth of vegetation. It diminishes the yields of his agricultural products. It obscures his view and adds unpleasant smell to his environment. Most importantly, it endangers his health. It is well established that air pollution contributes to the increasing incidence of such chronic diseases as bronchitis, emphysema and other respiratory ailments. Higher mortality rates from other causes inclusive of cancer and arterio-sclerotic heart disease are also attributed to exposure of polluted air in urban and industrial areas. It may be noted that smokers living in polluted cities/industrial areas are more prone to lung cancer than their rural counterparts.

3.2 Air Pollution Laws

In the United Nations Conference on the Human Environment held in Stockholm in June 1972 in which India participated, decisions were taken to initiate appropriate steps for the preservation of natural resources of the earth which, inter alia, include the preservation of the quality of air and control of air pollution. World Health Organisation (WHO) has defined 'air pollution' as the presence in the air of 'air pollutants' in concentration sufficient to cause harmful effect on health, vegetation, property and which interferes with the enjoyment of his property.

The Air pollution defined under the Air (Prevention and Control of Pollution) Act, 1981, means the presence of any air pollutant in the atmosphere. Air pollutant means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment.

The objectives of the Air (Prevention and Control of Pollution) Act 1981 are to provide for the prevention, control and abatement of air pollution, for the establishment, with a view to carry out the aforesaid purposes, of Boards for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

The Act defines 'air pollutant' as any solid, liquid or gaseous substance present in the atmosphere in such a concentration as may be or tend to be injurious to human beings or other leaving creatures of plants or pro perty or environment. Subsequently, with effect from 1st April 1988, 'NOISE' has also been declared as an air pollutant vide Sec. 2 of, Act 47 of 1987. This Act, vide Sec. 19, has empowered the State Government to declare any area or areas within the State as 'air pollution control area'. An up-to-date list of such 'air and water pollution control areas' of the country is furnished at Annexure-1.

The Act has imposed restrictions, vide Sec. 21, to establish or operate any industrial plant in such 'air pollution control areas' without previous consent of the State Pollution Control Board. The important provisions of the Act and Rules on air pollution, as applicable to mining industry are placed at Annexure-2.

On the basis of land use and other factors the various areas of a State may be classified into three categories by concerned State Pollution Control Board – (a) Industrial and mixed areas, (b) Residential and rural areas and (c) Sensitive areas.

Category (a) will become self evident on the intensity of industrial activity in an area and is bound to have somewhat inferior quality of air compared to other categories. The category (c) will cover hill stations, tourist resorts, sancturies, national parks, national monuments, health resorts, and other such areas where the nation would wish to conserve it as clean environment even if that implies some curbs on economic activity. All areas not specifically declared by the concerned State Pollution Control Board to be classified in category (a) or category (c) will be automatically deemed to fall in category (b). Based on this, the ambient national air quality standards with adequate margin of safety, to protect the public health, vegetation and property, developed by the Central Pollution Control Board are given below. The monitoring is to be done uniformly over the three seasons (except the monsoon season) of a year with frequency of not less than twice in a week, for 3 months in each season, with a sampling time of 24 hourly for any sample and analysed according to procedures specified by the Central Board.

Pollutant	Time Weighted Average	Concentration in micro gms per cubic metre		
		Industrial Area	Residential/Rural & Other Areas	Sensitive Areas
Suspended Particulate Matter (SPM)	Annual Average* 24 hours**	360 500	140 200	70 100
Respirable Particulate Matter (RPM) size < 10 microns	Annual Average* 24 hours**	120 150	60 100	50 75
Sulphur Dioxide (SO_2)	Annual Average* 24 hours**	80 120	60 80	15 30
Oxides of Nitrogen (As NO_2)	Annual Average 98 Percentile	80 120	60 80	15 30
Carbon--monoxide (CO)	8hours** 1 hour	5000 10000	2000 4000	1000 2000
Lead (Pb)	Annual Average* 24 hours**	1.0 1.5	0.75 1.0	0.75 0.1
Ammonia	Annual Average* 24 hours**	0.1 0.4	0.1 0.4	0.1 0.4

* *Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.*

** *24 hourly/8 hourly values should meet 98% of time in a year. However, 2% of the time, it may exceed, but not on consecutive days.*

3.3 Air Pollutants

For effective control of air pollution by the pollutants namely Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), SO_2, CO, NOx, (and also HC), one would naturally like to know their genesis in greater detail.

(i) **Particulate Matter (PM)** :

Particulate matter includes particles of solid or liquid substance in a very wide range of sizes, from those that are visible as soot, and smoke to particles too small to detect except under a electron micrscope. Particulates may be so small that they remain in the air for long periods and can be transported great distances by the winds. The particulate matter is divided in two parts the SPM having sieve above 10 microns and RPM having sizes less than 10 microns.

Both 'SPM' & 'RPM', may be present in air as solid (dust, smoke, fumes, fly ash) or liquid (mist, spray) and smog (both solid and liquid) form. 'Smoke' mostly consists of soot fly ash and other solid or liquid particles of sizes as small as three millionth of an inch. 'Ash' is an unburnable solid material that is set free when a fuel is burnt. "Fumes" are synonymous with 'dirt' and are mostly composed of solid particles. Fumes are generally less than one micron in diameter and mostly consist of metals and metallic oxides and chlorides from the metal industries.

Dust generated may also contains metallic compounds and causes a widespread contamination of soils and the sources of water in the vicinity. It also creates nuisance for the nearby industrial communities and monuments. Some of the metals commonly found in variable quantities around smelters and other processing centres include copper, iron, mercury, cobalt, zinc, lead and arsenic.

Dust can be arisen from natural dust storms or released from mining activities like drilling, blasting, crushing, screening, transport, etc. The dust particles act as centres of catalysis for many of the chemical reactions taking place in the atmosphere, particularly when the dust is finely divided.

(ii) **Sulphur Dioxide (SO_2) & Sulphur Oxides (SOx)** :

Sulphur dioxide is a gas with a pungent smell. It is generated in large quantity when coal, coke or certain fuel oils are burnt. The burning of coal produce about 60% of sulphur oxides emissions and oil about 40%. Though it is not chemically active as sulphur trioxide, hydrochloric acid and fluorine compounds which are also liberated during the combustion of coal is emitted in much greater quality and thus capable of doing more harm. The average burnable sulphur content of Indian coal and coke, is about 1 percent. When the fuel is burnt, only a small amount of sulphur remains with the ashes and the rest is released as sulphur dioxide.

It is estimated that an average of 3 tons approximately of sulphur dioxides are emitted from every hundred tons of coal burnt. Sulphur dioxide is soluble in water, and it attacks, paint, metals, stone work and slates. It gets oxidised into

sulphuric acid, which has corrosive action. Effect of various levels of SO_2 on human health is given in the following Table :

Concentration of SO_2 in ppm	Exposure time	Effects
Up to 0.6		No detectable response.
0.14-0.25	1-4 days	Cardiorespiratory response/imbalance.
1.0-2.0	3-10 minutes	Cardiorespiratory response/imbalance.
1.0-5.0	1 hour	Detectable responses, feeling of tightness in chest.
More than 5.0	1 hour	Chocking and increased lung resistance to air flow
More than 10.0		Severe distress, uneasiness. Nose bleeding in some cases. Digestive tract affected.
More than 20		Eye irritation feeling
400-500		Dangerous even for short period of time.

A conclusion can be drawn from the above that sulphur dioxide is harmful even in low concentrations.

Sulphur dioxide emission also contributes to acid rain when the gaseous materials come down with rain drops. The acid rain has a number of potential effects on terrestrial ecosystems. On soil it may cause acidification of soils, altering the supply of soil-nutrients, increased mobilisation of aluminium, shift from arid sensitive to acid tolerant species, and may change the rate of nitrogen fixation and decomposition of organics. In vegetation, may create foliar damage to crops and forests, interference with productive processes, leaching of nutrients and other substances from leaves. In agriculture, it may increase or decrease seed germination depending on sensitivity to acidity, and fertilisation by nitrates and sulphates promoting growth. In forests, it may develop acidification of forest soils and reduce forest productivity. Acid rain adversely affects the aquatic biota. It may reduce productivity of amphibians and fishes during heavy rains and increased fish-kill may occur.

Apart from sulphur dioxide, there can be other oxides of sulphur generated during the process of burning of about 66% of the natural sulphur oxides (SOx) which are emitted in urban areas, where both industry and population are concentrated. Sulphur Oxides (SOx) can cause temporary and permanent injury to human respiratory system. If 'SPM' is also associated with sulphur oxides, the effect multiplies. If the annual mean concentration of sulphur oxide in air rises beyond 0.04 ppm, causing danger to general

health and if accompanied with smoke concentrations of about 0.06 ppm, incidence of death from lung cancer and bronchitis may increase.

(iii) Carbon Monoxide (CO)

It results from incomplete combustion of carbonaceous matter in all combustion processes and can cause death at high concentrations. Concentrations of carbon monoxide from 10 to 70 mg/m^3 are common in busy streets, concentrations of 120 milligrams per cubic metre or more are considered dangerous.

When carbon monoxide is inhaled, it displaces the oxygen in the blood, combines with hemoglobin and reduces the amount of oxygen carried to the blood tissues. It has been observed that an exposure of 10 ppm of CO for approximate 8 hrs may dull mental performance. At higher concentration, it causes unconsciousness and even death. It may be noted that effect of CO, in different concentrations, on human health varies.

(iv) Nitrogen Oxides (NOx)

Oxides of nitrogen mostly comprises different oxides of nitrogen such as NO, NO_2 and N_2O. During any process of combustion, specially at very high temperature, some atmospheric nitrogen which is otherwise an inert gas, combines with oxygen to form nitrogen oxides (NOx). Stationary combustion plants produce about 49% of nitrogen oxide emission transportation vehicles 39% and all other sources 12%. Therefore, exhaust gases from engine and effluents of furnaces always contain some NOx when they combine with olefin hydrocarbons to form proxy nitrates and ozone. However, Nitrous oxide N_2O is a comparatively stable gas and less toxic. Nitrogen dioxide (NO_2) a red brown gas produced from manufacture of nitric acid-nitration and combustion processes, result in severe irritation of respiratory system by 3 ppm.

(v) Other Agents of Air Pollution

(a) **Hydrocarbons :** The aromatics, napthenes, olefins and paraffins constitute the hydrocarbons that originate from numerous sources. The most predominant source being the unburnt or partially burnt gasoline. Concentrations of hydrocarbons in 100 ppm and above affects the nervous system.

(b) **Inorganic Acids :** The commonest is sulphurous acid (H_2SO_3) produced by the combination of SO_2 and water (H_2O). It is also produced in small amounts during the combustion of coal and petroleum, oxides of nitrogen also form into acids when combined with the water, though less rapidly.

Other inorganic acids of lesser importance are hydrochloric (HCl), hydrobromic (HB) and hydrofluoric (HF). They are produced by certain industrial process. Hydrogen fluorine is particularly hazardous for vegetation even at very low concentration.

(c) **Organic Acid** : They result chiefly by incomplete combustion processes. An appreciable fraction is also contributed by industries. Chief among these are acetic acid, furmaric acid and tannic acid; the latter being extensively used in leather tanning industry.

(d) **Fluorine** : Coal contains up to 0.7 per cent of chlorine and upto 0.01 per cent of fluorine. When coal is burnt both these elements probably escape to the atmosphere in gaseous form, forming hydrochloric acid. HF (hydrogen fluoride) and SiF (silicon tetrafluoride). The concentrations at street level as result of chimney emissions from the burning of coal is likely to be about 0.04 mg/m^3 of chlorine compounds and 0.004 mg/m^3 of fluorine compounds. Fluoride can be accumulated by vegetation from air borne gases and can pollute water & soil.

3.4 Influence of Meteorology and Topography on Air Sampling

- The climatic conditions that can influence the air quality are wind speed and direction, temperature inversions, mixing height, atmospheric pressure, humidity and precipitation. Wind speed & directions are the most important factor and must be constantly monitored during air sampling activities.

- The physiological conditions of the area that can influence the dispersion of mountains, hills, valleys, lakes and seas can significantly affect the wind direction and the amount of mixing or dispersion of contaminants in the air.

3.5 Location of Air Sampling Stations

Air pollution due to mining are divided into following two categories.

I) Mobile sources like automobiles, transport trucks, etc.
II) Stationary sources like loading and unloading points, blasting sites, crushing and grinding units of ore beneficiation plants and power generation units.

Environmental Import Assesment (EIA) guidelines on minium. number of stations in core zone are:

Leaschold Area	Greenfield Site	Working Minc
Up to 200 ha	2	2
201 – 650 ha	3	4
Over 650 ha	3	5

Further a minimum of one station is to be located in the buffer zone. Locations of stations are to be based on the distribution of the emitters, pathway and receptors and on physiography and climatic conditions of the area.

3.6 Adverse Effects of Air Pollution

Anthropogenic sources of air pollution due to mining are divided into two categories. i) Mobile sources which include automobiles, transport trucks, etc. and ii) stationary source which include loading and unloading points, blasting sites, crushing and grinding units of ore beneficiation plants and power generation plants attached to mines. Sources emit a variety of

particle and gas pollutants into atmosphere. Many elements of interest (pollutants) in air are rather reactive compounds and mostly present in very low concentrations. They may be distributed between two or more phases, e.g. gases and solids or gases and liquids.

Once the pollutant enters the atmosphere, many interactions occur. Initially the pollutants are diluted upon injection into the atmosphere, with a resultant decrease in concentration. Winds then act to transport the pollutants and promote additional mixing. Some pollutant while in transport may participate in chemical reaction. As a result, the quality of air at a receptor is determined by the type and amount of pollutants emitted up and the extent of atmospheric interactions that have occurred during the transport from the source to the receptor.

Generally, the air quality can be judged by visibility. But most of the pollutants in the ambient air are the fine suspended particles and gases that can not be seen. The dust generated has to be analysed in two forms, one is the respirable dust below 10 microns, which affects the respirable system through inhalation and above 10 microns which affects the digestive and blood circulation systems through ingestion. These particulate matter particles easily penetrate into the airways and lungs where they may produce harmful effects on health such as the worsening of heart and lung diseases, also affects lung tissues leading to cancer. The risk of these health effects is greatest in elderly and the very young person. Exposure to elevated concentrations of particulate matter is also associated with increased hospital and doctor's visits and increased numbers of premature deaths. In exposure of high particulate matter levels, scientists also observed the worsening of both asthma symptoms and acute and chronic bronchitis. Scientists have found a relationship between high PM levels and reductions in various aspects of the healthy functioning of people's lungs. The dusts contaminated with heavy metals and trace elements adversely affect the human beings, either through inhalation or through ingestion. Free silica & asbestos fibre contents in the respirable fraction of the dust lead to lung diseases. Similarly the gaseous pollutants like SO_2, NOx and CO are toxic and they have harmful effects on human beings. Gases like SO_2, NOx have also toxic effects on vegetation growth and on animal life. Presence of excessive content of SO_2 gives rise to what is known as "Acid Rain". Oxides of nitrogen (NOx) are toxic, affects lungs and causes bronchitis. Photo-oxidation affects vegetation. Carbon monoxide which is what is very much harmful to human being, affect respiration.

The dust fall is defined as the particulate matter, collected from air-borne particles settled by sedimentation into dust fall gauges. The dust when settled over the leaves of trees affect their growth as well as their yields, also affects the soil quality. The dust containing toxic substances affect the entire Eco-system. The total chromium and hexavalent chromium, nickel (occupational exposure limit is 0.1-1.0 mg per cubic metre), titanium, barium (causes respiratory disease), cobalt (occupational exposure limit is 0.02 mg per cubic metre) and cadmium (causes cardiovascular diseases and hyper tension USEPA listed as hazardous air pollutant) are carcinogenic in nature. Copper is toxic (maximum biological exposure limit for liver 250 micrograms per cubic metre). Arsenic causes acute and chronic cancer (maximum limit at work place 0.05 ppm or 0.2 micrograms per cubic metre). Manganese affect the nervous system, presence of excess lead leads to excretion of porphyries, precursors of hemoglobin with the urine and affects children's brain and excess of aluminium effects the nervous system. The long term effects of these airborne metal particles over the vegetation are yet to be established firmly. However, the results of some of the studies carried out, like that of Cannon (1980) and

Travethick have indicated changes in plants because of the presence of heavy metals. The symptoms of toxicity of various metals on plants have been summarised in Annexure-3.

Similarly, the emissions released from the stacks located in captive power and in the mineral processing plants are spread over long distances before they finally settle on the ground, thus affecting the eco-system of the entire area. Some farmers have complained reduction in yield of some of the crops due to dust settling caused by limestone mining.

The Ambient Air Quality Standards (AAQS) for particulate matter define the maximum amount of airborne particles that can be present in outdoor air without threatening the public's health. Particulate Matter (PM) is a complex mixture consisting of varying combinations of dry solid fragments, solid cores with liquid coatings and small droplets of liquid. These tiny particles vary greatly in shape, size and chemical composition, and can be made up of many different materials such as metals, soot, soil and dust. PM may also contain sulphate particles. These sulphate particulate matter mixed with rain, will also give rise to "Acid Rain". Common toxic metallic air pollutants observed in different metalliferous mines and their harmful effects are given in the Annexure-4.

3.7 Abatement Measures for Control of Air Pollution

From the above narration, a conclusion can be drawn that the pollution must be contained within permissible limits by adopting certain pollution control measures. Some of the measures which can be adopted are enumerated in the following table.

Sr.No.	Dust Generating points	Control measures to be adopted
1.	Drilling	1. Dust may be collected by dry cyclone and filters. 2. Dust may be suppressed by water sprinkling and by mixing with detergent.
2.	Blasting	1. Dust may be suppressed by water sprays. 2. Before charging and blasting consider expected atmospheric conditions.
3.	Loading & unloading	1. Suppress dust by automatic or manual water sprays or with detergent mixed water. 2. Enclose the loading or unloading area, wherever possible.
4.	Mobile equipment	1. Internal roads may be surfaced. 2. Exhaust fans may be directed upwards. 3. Dust may be suppressed by water sprays. 4. Proper routes may be selected. 5. Covering of loads of fine material. 6. Dense plantation along mine roads.
5.	Fixed Plant (Crushers, Screens, Conveyors, etc.)	1. Enclosures may be provided. 2. Water sprays may be used to suppress dust. 3. Dust collectors (bag, wet or dry contrifugal, electrostatic, etc.) may be used. 4. Dense plantation all around.
6.	Dust blow	1. Enclosure of stock piles. 2. Waste dumps may be vegetated. 3. Water may be sprayed to suppress dust. 4. Road sweepers may be used to collect dust. 5. Dense plantation may be carried out.

To erect a green barrier around fixed plants, roadsides and stock piles of ores rejects or waste rock the following guidelines may be useful in containing dust pollution

i) Trees should be planted in beds arranged perpendicular to the direction of prevailing winds.

ii) Trees should be planted in a concentric fashion around the source of pollution.

iii) Peripheral plantations may also be used as wind brakes on the dry tailings.

iv) A judicious mixture of open and permeable plantation with dense planting should be made.

v) Plants & trees of different heights may be planted on both sides of the mine roads.

vi) While selecting plant species the special properties of some specific species, as below, may be kept in view.

3.8 Useful Plant Species to Control the Spread of Air Pollution

Plant species useful for controlling air pollution are given below with their characheristics.

Sr No	Special Properties	Name of the Species
i)	i) Pubescence on leaves to entrap & hold dust particles.	Guazama, Nyetanthes, Trema, Holopetelia, Terminalia Putranjiva, Heterophragma.
ii)	ii) Leaves and branches to slow wind :	Albizzia, Samania, Peltophorum, Tamarindus, Dallerjia
iii)	iii) Blossoms and Foliage that provide pleasant smell to mask odour :	Morinda, Cestrum, Artabor-tyrs, Lantona, Anona, Michelia, Murraya exotica, Jasminum, Quisqualis, Plumeria, Pterospermum, Magnoli, Citrus, Nyetanthes.
iv)	iv) Leaves and branches to slow the action of rains :	Azardirchta, Nelia, Acacia auriculae formia Delonix Cassia.
v)	v) Plants that absorbs SO_2 :	Lichens, fagus, acer.

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