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Environmental Aspects of Iron ORE Mining

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Abstract

Iron ore mining activities such as top soil stripping, drilling and blasting extraction of ore, waste rock dumping, loading and unloading of ore, crushing and screening, material transport etc., emit both fugitive and non-fugitive dusts into the environment. A direct effect of the mining and its activities deteriorate the quality of ambient air, which requires mitigation measures. Blasting causes very high noise and vibration at a very short duration. Surface water pollution occurs due to erosion of soil by precipitation in the form of runoff. Noise pollution occurs due to drilling and blasting operations. The impact of mining on socio-economic environment is positive (infrastructure development and employment opportunity). There would be a significant impact on biological environment. A green belt with dust-tolerant trees needs to be developed around the Iron ore digging and material storage yard to an extent of 30% of mine-lease area. An environmental management plan is highly essential to mitigate the adverse environmental impact of iron ore mining.

Keywords: Iron Ore Mining, Environmental Impacts, Air Quality Models, Mining Equipment noise, Environmental Management of Mining, Environmental Monitoring at Mine Site.

Introduction

The environmental issues have now become an integral part of any development activity. The growth of Iron ore mining industry significantly contributes towards economic progress (Goudie, 1986). However, any progress of mining industry brings along with it a number of environmental problems. These problems should be addressed at the beginning stage itself and equal priority should be given to evaluate the project from environmental angle apart from financial aspects. Mining industry exerts both positive and negative environmental impacts. Negative impact causes environmental degradation. It is the responsibility of Environmentalists to document these impacts separately so that these can be identified, quantified and attempts may be made to minimize negative impacts and maximize the positive impacts for better development with least environmental degradation.

. With the liberalization of economy, a number of sponge iron plants have come-up in Andhra Pradesh. The demand of iron ore for these industries needs to be satisfied for sustainable development. Moreover, there is heavy demand of iron ore from Japan, China and South Korea. The demand and supply gap has widened. To bridge this gap, new iron ore mines are coming up at a rapid rate to extract the ore wherever is feasible.

The activities at iron ore mine site in the operational phase involves opencast ore extraction, handling of ore and overburden, handling and transportation of ore and wastes. These activities may affect the environment in varying degree through natural resource depletion, water consumption, forest depletion etc. and pollution *is* released in all components of the environment. Positive impacts on socio-economic environment are expected due to employment, further infrastructural development and also due to socioeconomic development activities. (CEQ, 1973).

Pollution emissions sources

In the open cast mine envisaged, mining operations such as drilling, blasting, excavation, loading and unloading, movement of dumpers on haul roads, crushing and screening are expected to generate air-borne fugitive dusts. Smaller size dust particles (<2µm) may be transported to longer distance by wind and may cause impact on the people residing nearby villages.

Fugitive and non-fugitive dust emissions sources during the iron ore mining are presented in Table-1

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Table 1: Fugitive and non-fugitive dust emissions during iron ore mining

Sl. No	Source	Nature of emission	Frequency of emission	Nature of air pollution
1.	Construction of infrastructural facilities (building, roads)	Fugitive and area source	Infrequent and pre-mining	Dust
2.	Top soil stripping	Fugitive and area source	Infrequent and pre-mining	Dust
3.	Drilling	Fugitive and point source	Infrequent and pre-mining	Dust
4.	Blasting	Fugitive and point source	Frequent and post-mining	Dust, CO, NO_x, SO_2, H_2S (slurry explosives)
5.	Excavation of ore	Fugitive and area source	Very frequent and post-mining	Dust
6.	Waste rock dumping	Non-fugitive and point source	Very frequent and post-mining	Dust
7.	Loading and unloading of ore	Non-fugitive and point source	Very frequent and post mining	Dust
8.	Material transport	Fugitive and line source	Very frequent and post mining	Dust
9.	Wind erosion	Fugitive and area source	Frequent and post mining	Dust
10.	Conveyors and material transfers	Non-fugitive and line source	Very frequent and post-mining	Dust
11.	Crushing and screening	Fugitive and point source	Very frequent and post mining	Dust
12.	Heavy equipment exhaust	Non-fugitive and line source	Very frequent and post-mining	SPM, NO_x, SO_2, HC
13.	Fuel storage tanks	Fugitive and print source	Continuous	HC
14.	Stock piles	Fugitive and area source	Frequent and post-mining	Dust

Source: Ortolano, 1985 and warhurst and Noronha, 2000

Impact of mining activities on environment

Air Environment

Emission factors in open-cast mining: The fugitive emissions from a mining activity are most frequently determined from an emission factor method, although typical emission factors may be significantly less accurate. Despite this in accuracy, emission factors are widely used to estimate pollutant emission rates because there is at present no better quantification method. Silt content, moisture content, drop height, wind speed, wet days, precipitation evaporation index are the major factors governed in fugitive emission rates. Some of the emission factors of interest in iron ore mining are presented below (US. EPA, 1975).

1. Top soil stripping and dumping = 18.5 g/MT
2. Drilling = 10.8 g/hole (3 m depth)
3. Blasting

Table 2: Emission factors for blasting

Sl. No.	Nature of pollutant	Dust parcel size in µm	Gaseous pollutants	Emission factor (g/kg of explosive)
1.	Dust	< 2.5 2.5 – 15 15 – 30	- - -	5.1 41.0 49.9
2.	Gaseous pollutants	-	CO NOx SO_2 H_2S*	34 8 1 12

* Slurry explosives only

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4. Excavation of iron ore = 25 g/MT
5. Waste rock dumping = 20 g/MT
6. Haulage emissions = 980 g/ VKT (uncontrolled) (Material transport) = 98 g/VKT (controlled)
7. Crushing and screening = 1000 g/MT (uncontrolled) including transfers = 100 g/MT (controlled)
8. Heavy mine equipment exhaust (grams per litre of diesel)

Table 3 Emission factors for heavy equipment

Sl. No	Pollutant	Wheeled dozer	Scraper	Grader	Front-end loader	Haul truck
1.	CO	14.73	10.185	6.590	11.86	14.738
2.	HC	1.557	2.276	1.557	5.15	1.557
3.	NOx	34.27	31.03	30.43	38.46	34.27
4.	SO_2	3.714	3.714	3.714	3.714	3.74
5.	SPM	1.797	3.235	2.636	3.474	2.156

Prediction of Impacts: The worst scenario of simultaneous operations of mining includes (1) drilling, (2) excavation, (3) waste rock dumping, (4) material transport (haulage), (5) crushing and screening as shown in Table 4.

Table 4: Air quality model applicability

Sl. No.	Mine Operation	Nature of Emission	Air Quality Model
1.	Drilling	Point source	FDM
2.	Blasting	Point source	Puff model
3.	Excavation of ore	Area source	FDM
4.	Ore and waste rock transport	Line source	FDM
5.	Waste rock dumping	Point source	Puff model
6.	Screening and crushing	Point source	FDM

Source: Carey, 1990; Zannetti, 1990 and Turner, 1979

Fugitive dispersion model (FDM): The fugitive dispersion model (FDM) is a computerized air quality model specifically designed for computing concentrations and deposition impacts of fugitive dust sources. The model is based on the well known Gaussian plume formulation for computing concentrations and also the model specifically transfer deposition algorithm. Emissions for each source are apportioned into a series of particle size classes. Gravitational settling velocity and deposition velocity are calculated by FDM for each class. The model is designed to work on hourly meteorological data (Carey, 1990).

The main equation is the FDM model is:

$$C = \frac{Q}{Z\,\pi\sigma y.\sigma z.u}\, e\left[\frac{-\mathrm{Vg}\,(z-h)\sqrt{2}\,\beta}{\sigma z} - \mathrm{Vg}^2\,\beta^2\right]\left\{e\left[\frac{-(z-h)^2}{2\sigma z^2}\right] + e\left[\frac{(z+h)^2}{2\sigma z^2}\right]\right.$$

$$\left. -4\sqrt{\pi}\,\mathrm{V}_1\,\beta e\left(\frac{-z+h}{2\sigma z^2}\right).e\left(\frac{\mathrm{V}_1\sqrt{2}}{\sigma z u} + \frac{z+h}{\sqrt{2}\,\sigma y}\right)^2 \mathrm{erf}\left[\frac{\mathrm{V}_1\,\sigma z}{\sqrt{2}.\mathrm{k}} + \frac{z+h}{\sqrt{2}\,\sigma z}\right]\right\}$$

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where $\beta = \dfrac{x}{\sqrt{2}.\sigma z.\mathrm{u}}$; $V_1 = \mathrm{ug} - \dfrac{V_g}{2}$. K = $\dfrac{\sigma z^2.u}{2x}$

C = Concentration (g/m^3)
Q = Emission rate (g/s)
σ_y, σ_z = Standard deviation of concentration in Y and Z direction (m)
x, y, z = Receptor coordinates (m)
V_g = Gravitational settling velocity (m/s)
h = Plume center line height (m)
k = Eddy diffusivity (m^2/s)
Ug = Deposition velocity (m/s)

b. Puff model: This model can be employed when the dust and gaseous pollutants are released instantaneously into the atmosphere (Zannetti, 1990). The main equation in the puff model is

$$C_{(x,y,t)} = \frac{Q_m^1}{\sqrt{2}\,\barwedge\,\sigma_x.\sigma_y.\sigma_z} \quad \exp.\left\{-\frac{1}{2}\left[\left(\frac{x-ut}{\sigma x}\right)^2 + \frac{y^2}{\sigma y^2}\right]\right\}$$

Where,
$C_{(x,\,y,\,t)}$: The pollutant concentration of coordinates x and y at time t (mg/m^3)
Q_m^1 : The mass of pollutant released (mg)
U : Wind velocity (m/s)
σ_x, σ_y, σ_z : The dispersion coefficients in the x, y an z directions respectively (m)

Table 5: Dust contribution by drilling operations at mine site.

S. No	Nature of Dust	Unit	Concentration
1	Settle able dust (dust fall)	Mg/ m^2. day	4.8 – 6.7
2	Suspended particulate matter (SPM)	Mg / Nm^3	1.8 – 2.0
3	Particulate matter (PM_{10})	µ g / m^3	80 - 95
4	Particulate matter ($PM_{2.5}$)	µ g / m^3	38 - 50

Table 6: Air Quality (PM10) Prediction using FDM Model.

S. No	**Distance (KM)**	**Direction**	**Background Level (µg / m3)**	**Predicted concentration µg/m^3**	**Resultant concentration µg/m^3**	**Air Quality**
1	1.0	NE	6.50	3.65	70.15	100
2	1.5	SE	6.20	2.90	10	100
3	2.6	SW	80.55	1.91	82.46	100
4	3.1	W	81.20	0.24	81.44	100
5	4.3	NE	86.0	0.35	86.35	100
6	5.1	ESE	90.0	0.28	90.28	100

Source: SRKMIOM, 2014

The predicated dust pollution levels in the ambient air when the mine is under operation indicate that the particulate matter (PM10) remains well below the National Ambient Air Quality standards prescribed by Central Pollution Control Board. The maximum concentration was within the mine is µg/m3 (Background: 69.0 µg/m3 and predicted level: µg/m3).

Impact on Noise Environment

Noise will be produced during operational phase of mining due to drilling, blasting, ore extractors, compressors, movement of trippers and other heavy machinery. Table-6 shows the noise produced by various mining equipment.

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Table 7: Noise levels (dB (A)) by mining equipment

Sl. No	Equipment / Process of mining	Noise in dB(A)
1.	Drilling	92– 100
2.	Blasting	180 – 220
3.	Shovel loading area	80 – 90
4.	Compressors	84 – 92
5.	Trippers	90 – 95
6.	Scrapers, graders	85 – 90
7.	D.G. set	88 – 98
8.	Crushing plant	82 – 90
9.	Screening plant	80 – 88
10.	Dumper plant form (crushing plant)	78 – 84

Source: U. S. Environmental Protection Agency, 1972.

The noise generated by the mining activity is dissipated within the core zone. Since, the mining and allied activities will take place only during day time, the increase in noise levels will be only during day time.

Noise levels in the work zone varies from 88 to 90 dB(A), except during blasting, which is carried out after the end of working shifts, personal exposure is less than 90 dB(A), because operators sit in closed cabins.

Noise contribution from work zone to the nearby buffer zone villages will be insignificant because (a) at 2 to 3 km distance contribution level is in the range of 20-22 dB(A) and (b) the villages are situated at lower level, whereas mining is carried out on hill top. The development of green belts will further reduce noise in both core zone and buffer zones.

Blasting effects: In accordance with DGMS regulations, the lease area will maintain a safety belt of 500 m distance from the quarry. However, keeping in view the presence of villages beyond the core zone and presence of office buildings within the core zone, adequate measures will be followed during blasting.

An empirical equation has been used for assessment of peak particle velocity (PPV) values at nearby locations.

$$PPV = 113.062\left[\frac{D}{\sqrt{Q}}\right]^{-1.2704}$$

Where

PPV = Peak particle velocity in mm/s

D = Distance between location of blast and gauge point (m)

Q = Quantity of explosives per delay (kg)

Table 8: Limiting values of PPV by CMRI, Dhanbad

Sl. No.	Structure	Max. PPV (mm/s)
1.	Steel or reinforced converse	25
2.	Good residential, commercial structure	10
3.	Mud wall and temple structures*	8.00
4.	Old buildings with brick masonry and R.C.C or tiled roofs**	12.5

* German standard (DIN 4150, 1983)

** USBM standards

Impact on Water Environment

Impact on Ground Water Environment: The groundwater withdrawal for the project will have some impact on water availability in the near by villages. However, due to the creation of mine pits as water storage bodies, there would be an increase in ground water potential due to infiltration and percolation.

Surface Water Environment: Storm water from mining and waste dump areas is the major source of pollution of surface water bodies with excess silt, turbid particles (colloidal matter) and soluble iron (Fe^{+2}) (Kamat and Sankaranarayanan, 1974). The impact on surface water bodies is temporary, since oxidation of soluble iron is precipitated as bottom sediments. The reactions are systematically represented as:

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FeS_2	+	$7O_2$	+	$2H_2O$	$\longrightarrow$	$2\,Fe^{+2}$	+	$4\,SO_4^{-2}$	+	$4\,H^+$	--------	(1)
Pyrite		Dissolved oxygen ion		Water		Ferrous		Sulphates		Hydrogen		
Fe^{+3}	+	$\frac{1}{2}\,O^2$	+	$2H^+$	$\rightarrow$	$2\,Fe^{+3}$		+		H_2O	--------	(2)
Fe^{+3}	+	$3\,H_2O$			$\leftrightarrow$	$Fe\,(OH)_{3(solid)}$		+		$3H^+$	--------	(3)

(Flora and Fauna)

The vegetation will disappear in areas where mining, dumping of waste rock, over burden, road formations and infrastructural facilities. Settleable dust pollution is a major threat to vegetation in the ML area, which impairs photosynthesis of grass and shrubs (Canter, Risser and Westcott, 1991). However, the loss will be more than compensated by compensatory afforestation and also green belt development planned in and around the mine which will rather increase the green cover and vegetation diversity.

The fauna in the vicinity of the mine may be restricted to common small species. All these species will be displaced from mine area and form new habitations away from mine. Much of the fauna scared away during blasting operations.

Impact on Topography and Landscape

The topographical impact will be mainly one of colour contrast between the mined rock surfaces and surrounding vegetation (trees, shrubs and grass) (Marsh, 1991). However, the topographical impact will remain localized, given that the site is contained. The pits created will lower the topographic level by 20 to 30 m at various places (Canter, 1996). As such, change in topography will have appreciable impact on drainage and aesthetics, which requires the Environmental Management Plan (EMP)

Impact on Land Environment

The top soil in the mining area is scanty. Whatever is available will have to be excavated during the development of the mine pits. Most of this soil is boulders in nature and will get mixed with the over burden. Temporary storage of top soil over burden may cause some loss of nutrients and this cannot be avoided (Warhurst, 1992).

The top soil will be subjected to water borne erosion during rainy season from reclamation areas when in unconsolidated state. A combination of diversion ditches and garland drains will be constructed to minimize soil loss. A large amount of soil loss can be arrested in catch pits/settling pits, which will be collected and put back to the reclamation areas (Marsh, 1991)

Impact on Socio-Economic Environment

Operation of mining and associated activities will result in some positive socioeconomic impacts of direct and indirect in nature (Hegadoren and Day, 1981).

- Impact on human settlements
- Population growth
- Impact on literacy and educational facilities
- Impact on civic amenities
- Impact on employment
- Impact on economic aspects
- Impact on industrial establishments

Impact on Drainage Pattern

The natural drainage channels (gullies) may be subjected to some degree of impact, due to formation / enlargement of quarries and dumps. However, the overall drainage of the core zone hilly region may not be affected. Preservation of directional flow in the gullies is important to regulate water flow in the disturbed area. Drainage management schemes as described in EMP will help to regulate rainwater flow in drainage channels / gullies(Canter, 1996)

Impact on Transportation

Ore is transported to buyers by road. The trucks carrying the ore from crushing plant to consumers' plant shall increase the existing traffic density marginally. Because iron ore lumps are hard lumpy in nature and trucks carrying fines and blue dust ore shall be covered to present the, dust release during transportation. To assess the impact due to this additional traffic (No. of trucks/hour), a simulation model shall be applied, to predict the rise in SO_2, NOx, CO and HC pollution in to the atmosphere.

Impact Summary

Legend: 0 = Insignificant / No impact,
1 = Marginal,
2 = Moderate
3 = Significant;
Positive sign = Beneficial;
Negative sign = Adverse and
U = Unpredictable

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Table 9: Summary of environmental impacts as predicted

Project Activities	Mine Development stage-1	Mine Operation stage-2	Post-mining stage-3
Duration (years)	1	20	-
I. Physic-chemical			
Land use	-2	-2	-2
Soil cover	-2	-2	-2
Land form	-1	-2	-2
Mineral resource	-1	-3	-3
Surface water resource	0	0	0
Ground water resource	0	0	0
Surface water quality	-1	-1	-1
Ground water quality	0	0	0
Ambient air quality (dust)	-2	-3	-1
Ambient air quality (gaseous)	0	0	0
Ambient noise level	-1	-1	0
Vibration	0	-1	0
Traffic density	0	-1	0
Climate	0	0	0
II. Biological			
Terrestrial vegetation	-1	-1	-1
Terrestrial fauna	-1	-1	0
Aquatic ecology	0	0	0
III. Human			
Displacement of human settlements	0	0	0
Infrastructure	+1	+2	+2
Employment opportunity	+1	+1	U
Economic growth	0	+2	U
Social set up	-1	-1	U
Health and safety	-1	-2	0
Aesthetics	-1	-2	-2

Environmental management plan (EMP)

Ideally, an environmentally sound project should have zero adverse impact, which for all practical purpose is difficult to achieve for a developmental project like the present one. The interpretation of EIS of the proposed project activities made in the earlier chapter reveals that the overall impact of the project on the environment, though negative, is only marginal. With some remedial measures of the proposed project activities, it is possible to further mitigate the potential impacts.

Scope of EMP

The EMP has considered for the aspects relating to physical, biological and human environment which are subject to potential impacts as predicted earlier. The area considered are land, air, noise, eco-restoration and human environment at mine development, mine operation and post mining stages (AEPA, 1995).

Applicable regulations

The following regulations on environmental management plan have been considered in formulating this EMP.

- Section 21 of the air (prevention and control of pollution) Act, 1981.
- Section 25 and 26 of the water (prevention and control of pollution), Act, 1974.
- The Hazardous Wastes Management Rules, 2000.
- The Noise Pollution (Regulations and Control) Rules, 2000.

NEP, 2006 and EIA notification, 2006

Land Management

Land management is required in the key areas like land use scheme within the ML area, calendar plan, mine bench advancement to arrest indiscriminate degradation of landform, top soil preservation, overburden management, soil erosion control and the

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restoration of the mine pits(AEPA, 1995 and Banerjee and Rangachari,1995).

Land Use: The core zone landscape can be improved by tree plantation, scrub growth etc., which are outlined separately under eco-restoration.

Calendar Plan: The calendar plan for such surface mining operation depicts the excavation planning of overburden as against raising of minerals in each year up to a specific period of mining. It ensures the landform change in a planned manner, one of the essential tools for land management.

Mine Bench Planning: Mine bench planning shall be developed taking into safety aspects, movement of excavation equipment and scale of operation. It is regulated by the provision of mines act 1952 and the metaliferrous mines regulations, 1961

Mine Roads: Roads for haulage and access to different locations would be laid as per the statutory regulations stipulated in the Metaliferrous Mines Regulations, 1961. Some of the basic features of laying the haul roads at the mine site as required from environmental and safety angle should cover the following:

- The road layout would be generally followed as per scheme shown in mine general layout. The main haul road and feeder roads would be generally of 12 m wide keeping provisions for arboriculture.
- The corners and bends would be made in such a way as to offer the vehicle operator, a clear visibility of atleast 30 m along the road.
- Road gradient would be maintained at 1 in 16 except in cases of ramps, where gradient of 1 in 10 may be provided.

The alignment of haul roads and feeder roads may require alteration with the progress of mining work.

Storage and Preservation of Top Soil: The topsoil stored and preserved for early utilization on waste dump and mine pit rehabitation for the purpose of vegetation growth.,

Overburden Dump Management: The mine would produce considerable quantities of overburden. The major problems with this overburden are its storage or dumping at proper location, slope stability of the dump and stabilization or disposal. Top soil preserved would be spread over the slopes of the dump for vegetation growth. The dump sites are biologically stabilized.

Soil Erosion Control: Soil erosion can be controlled by tree-plantation on the slopes The overburden and topsoil dumps would be provided with check dam/bund wall to prevent carry over of soil particles/silt to the drainage channels on the slopes during monsoon period.

Land Restoration: During the course of mining, the original land form would get disturbed. It would be preferable to take up the backfilling of the mined out block after exploitation of the iron ore.

There would be some left out pits and depressions of varying depth which can serve as a pond by the impounding rain water.

Water Pollution Control Measures

Raw Water Treatment: The ground water is used for drinking and sanitation shall be chlorinated.

Waste Water: Sanitary and canteen waste are treated by septic tank followed by soak pit. Repair shop effluent is treated by oil and grease trap and treated water is used for plantation.

Silt Water Control: The run-offs from the overburden dump and top soil dump would be checked at the check dam during the monsoon period.

Air Pollution Control Measures

Air pollution control measures would be of three types namely (i) dust suppression system (DSS), (ii) dust extraction system (DES) and (iii) vehicular emission control (VEC).

Dust Suppression System (DSS): Adequate water sprinkling arrangement would be provided to suppress dust emissions from the haul roads, mine working faces, r.o.m. stockpiles and other areas susceptible to dust emissions due to surface wind.

Dust Extraction System (DES): Crushing and screening plant and conveyor transfer points would be provided with dust extraction system. It is proposed to install dust extraction system complete with aspiration hoods, bag filters and extraction fans of adequate capacity. Particulate levels in the DE stack emissions will be limited to 100 mg/N cu.m.

Vehicular Emission Control (VEC): Vehicular emissions from diesel operated transport equipment can be contained, by avoiding idle running and overloading of the engine. In addition, the engines shall be periodically serviced to ensure proper using and exhaust gases monitored on a regular basis to check smoke and CO levels.

Noise Pollution Control

Noise control measures at the mine can be broadly classified into three types, namely (i) administrative control, (ii) engineering control and (iii) personal hearing protection (Cowan, 1994)

Administrative Control: Administrative control techniques include providing proper noise· proof enclosure for the workers separated from the noise source and noise prone equipment.

Engineering Control:

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- Selection of quieter mining equipment and machineries
- Retrofitting additional noise control device as required
- Installation of anti-vibration devices in crushing and screening equipment
- Housing of the crusher separately to contain noise
- Covering by casing of the crusher internal elements to reduce transmission of impact noise.
- Carrying of blasting during day time. Blasting shall not be carried out in stormy and rainy weather and during lighting.
- Provision of noise proof cabin for operators and exhaust silencers for all mine transport equipment.

Personal Hearing Protection:

Personal hearing protection devices include earplugs with glycerin soaked cotton and earmuffs

Greenbelt Development

- Greenbelt development and afforestation of the vacant land within the leasehold area by planting diverse plant species and maintaining them.
- Biological stabilisation of overburden and top soil dumps.
- Tree plantation on the roadside.
- Post-mining land development with tree plantation.

Setting up a nursery for growing different variety of plant saplings

Socio-Economic Development

The main objective of any iron ore mining programme is to make the project environmental and society friendly as part of sustainable economic development measures (Becker, 1997). About 5% of profits shall be allocated on society developmental activities in surrounding villages

Occupational Health and Safety

Legislation in Indian Mines requires care for occupational health care and safety of mine workers as an integral part of the mine production management.

- Workers exposed to high dust levels would be provided with dust masks.
- First aid medical kits would be made available at the work spots.
- Drinking water would be supplied in rest shelters, canteens, workshops, etc.

Water flushed latrines and urinals would be provided at conveniently accessible points at the scale of one seat for every 50 (or part) persons, with the associated facilities for disinfection.

Environmental monitoring programme

Table 10: Suggested environmental monitoring programme

S. No.	Monitoring activity	Location	Frequency of monitoring	Major parameters to be monitored
1.	Micrometeorology	At hill top	Daily	Temp., R.H., rainfall wind speed and directions.
2.	Ambient Air Quality (AAQ)	At least 3 fixed locations in the ML area and 2 fixed stations at the foot hills/ near by villages (one down wind and the other at upwind direction)	Preferably monthly once for 24 hours period during dry seasons of the year.	SPM, RPM, SO_2 and NOx
3.	Particulate Matter (PM_{10})	At one of the AAQ stations in ML area.	Monthly	Total dust fall rate MT/sq.km/month.
4.	Work zone noise	Noise levels within Mining area .	Bi-monthly once	Leq. noi.
5.	Drinking water	From drinking water tap	Monthly once	As per IS:10500 (91)
6.	Land erosion	Core and relevant area of buffer zones	Rainy season	Erosion potential

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7.	Drainage	Garland drains of dump sites, gullies	Post monsoon	-
8.	Blasting effects	Core zones	During blasting	Noise, fly rock fragments, vibration.
9.	Inventory of flora	Core zone	Every year	Plantation status, survival rate.
10.	Soil quality	Core zone	Every year	Soil fertility for growth of plants
11.	Socio-economic condition	Local population of buffer zone	Once in 3 to 4 years	Per capita income, diseases, living conditions health camps.

Conclusions

- Dust is the major air pollutant emitted into the atmosphere by mining activities.
- Change of drainage pattern would likely occur in core zone (Minesite).
- Surface water pollution with excessive silt and soluble Iron occurs from mine run-off
- Noise pollution is highly associated with drilling and blasting operations.
- Soil erosion occurs likely, if environmental management plan is not exercised in the form of greenbelt on waste dump sites, reclamation of mine pit and provision of check dams across the nallah to arrest silt carry over.
- Retaining wall shall be constructed at down stream of dump site to arrest sliding of waste material.
- A green belt around the mining and material storage shall be around at least 30% of mine – lease area.
- Blasting shall be carried during day time only with prior intimation by siren.

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