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Assessment of Environment Management Plan in Tawa Coal Mines of Western Coal Fields Limited

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Abstract: The present study was carried out as a dissertation work during January to May 2015 for Assessment of Environment Management Plan in Tawa Coal mines of Western Coal Fields Limited. The impact of underground mining on Environment was studied by analyzing primary data and secondary data collected from the mine area. The effectiveness of Environment management plan in Tawa Coal Mines was studied on the ground and the pollution levels of Air, Water, Noise and Land was measured and analyzed according to the standard testing procedures. It was found out that EIA of the study area was conducted with the norms of EIA regulations formulated in 1994 and EMP was implemented satisfactorily .
Keywords: Madhya Pradesh, Underground Mining, Environment Management Plan, Tawa Coal mines, Environmental impact, Pollution measurement.

I. INTRODUCTION

A. Coal Mining and Demand Pool in India

India has the fifth largest coal reserves in the world. Of the total reserves, nearly 88% are non- coking coal reserves, while tertiary coals reserves account for a merger 0.5 % and the balance is coking coal. The Indian coal is characterized by its high ash content (45%) and low Sulphur content.

The power sector is the largest consumer of coal followed by the iron and steel and cement.

The country‘s coal production has increased from~431 million tonnes in 2006-07 to ~554 million tonnes in 2011-12 (an increase of 28.5%). On the other hand, the demand for coal has grown at a CAGR of more than 7% in the last decade and has reached around 600 MT. The India Energy Book, 2012 pegs the country‘s total demand-supply gap (including coking coal) at about 98 million tonnes. Out of this; India imports about 85 million tons of coal.

Coal is by far the most abundant fossil fuel on earth. It is essentially carbon and is mainly used as a combustion fuel. It is the product of plants, mainly trees that died tens or hundreds of millions of years ago. Due to water logging in low-lying swampy areas or in slowly linking lagoons, dead trees and plants did not decompose as they normally would. The dead plant matter was covered with water and protected from the oxidizing effect of air.

The action of certain bacteria released the oxygen and hydrogen, making the residue richer and richer in carbon. Thick layers of this carbon-rich substance, called peat, built up over thousands of years. As more material accumulated above the peat, the water was squeezed out leaving out carbon-rich plant remains. Pressure and temperature further compressed the material. This aided the process of producing coal as more gases were forced out and the proportion of carbon continued to increase. The carbon slowly metamorphosed into coal over millions of years.

Growth in coal production in India in first 25 years of independence was very slow, from around 30 million tonnes (Mt) in 1947 to 73 Mt in 1970-71. However, post nationalization period experienced a rapid growth in coal production from 81 million tonnes in 1973-74 to 493.90 Mt in 2008- 09. Coal production crossed 100 Mt in 77-78,200 million tonnes in 89-90, 300 Mt in 99-2000 and 400 million tonnes in 05-06(Dixit, 2009).

It shows the shift of share of coal production from opencast mines from below 30% until nationalization to above 88% in 2008-09. And this trend is expected to remain heavily tilted towards opencast mines because of higher demand of coal in future to support the growth of the economy. As projected in ―Coal Vision 2025‖document, based on approach made by The Energy and Research Institute (TERI), demand at 8% Gross Domestic Product (GDP) will be 1267 Mt and at 7% GDP will be 1147 Mt by 2025 (MOC, 2005).The coal is distributed in almost all part of India (Figure 1).

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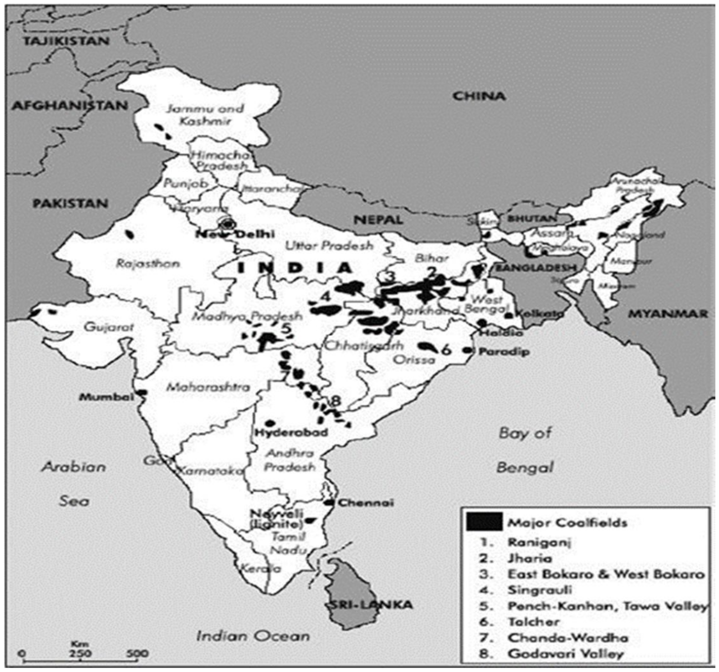

Figure 1: Showing distribution of Coal deposits in India Source: GSI

1) *Coal Production:* Through sustained programme of investment and greater thrust on application of modern technologies, it has been possible to raise the production of coal from a level of about 70 million tonnes at the time of nationalization of coal mines in early 1970's to 565.64(P) million tonnes (All India) in 2013-14.Coal India limited and its subsidiaries accounted for 462.42 million tonnes during 2013-14 as against a production of 452.21 million tonnes in 2012-13 showing a growth of 2.3%.
2) *Import Of Coal:* As per the present Import policy, coal can be freely imported (under Open General Licence) by the consumers themselves considering their needs based on their commercial prudence. Coking Coal is being imported by Steel Authority of India Limited (SAIL) and other Steel manufacturing units mainly to bridge the gap between the requirement and indigenous availability and to improve the quality. Coal based power plants, cement plants, captive power plants, sponge iron plants, industrial consumers and coal traders are importing non-coking coal. Coke is imported mainly by Pig-Iron manufacturers and Iron & Steel sector consumers using mini-blast furnace. Details of import of coal and products i.e. coke during the last five years is as under in Table 1:

Table1: Import and export of coal (Million tonnes)

COAL	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Total Import	75.60	70.40	105.21	140.63	168.44	49.45*
* Import upto June 2014						
Coking Coal	24.69	19.48	31.80	32.56	37.19	10.87
Non-Coking Coal	48.56	49.43	71.05	105.00	131.25	38.59
Coke	2.35	1.49	2.36	3.07	4.19	1.17

Source: Annual report Ministry of Coal 2015

B. Coal India Limited at a Glance

Coal India Limited (CIL) as an organized state owned coal mining corporate came into being in November 1975 with the government taking over private coal mines. With a modest production of 79 Million Tonnes (MTs) at the year of its inception CIL today is the single largest coal producer in the world. Operating through 81 mining areas CIL is an apex body with 7 wholly owned coal producing subsidiaries and 1 mine planning and consultancy company spread over 8 provincial states of India. CIL also fully owns a mining company in Mozambique christened as 'Coal India Africana Limitada'. CIL also manages 200 other establishments like workshops, hospitals etc. Further, it also owns 26 technical & management training institutes and 102 Vocational Training Institutes Centres.

Indian Institute of Coal Management (IICM) as a state- of-the-art Management Training 'Centre of Excellence' - the largest Corporate Training Institute in India - operates under CIL and conducts multi-disciplinary management development programmes. CIL having fulfilled the financial and other prerequisites was granted the Maharatna recognition in April 2011. It is a privileged status conferred by Government of India to select state owned enterprises in order to empower them to expand their operations and emerge as global giants. So far, the select club has only five members out of 217 Central Public Sector Enterprises in the country.

1) *Corporate Structure and Subsidiary Companies:* Coal India is a holding company with seven wholly owned coal producing subsidiary companies and one mine planning &consultancy company. It encompasses the whole gamut of identification of coal reserves, detailed exploration followed by design and implementation and optimizing operations for coal extraction in its mines. The producing companies are:

a) Eastern Coalfields Limited (ECL), Sanctoria, West Bengal
b) Bharat Coking Coal Limited (BCCL), Dhanbad, Jharkhand
c) Central Coalfields Limited (CCL), Ranchi, Jharkhand
d) South Eastern Coalfields Limited (SECL), Bilaspur, Chattisgarh
e) Western Coalfields Limited (WCL), Nagpur, Maharashtra
f) Northern Coalfields Limited (NCL), Singrauli, Madhya Pradesh
g) Mahanadi Coalfields Limtied (MCL), Sambalpur, Orissa
h) Coal India Africana Limitada, Mozambique

C. Western Coal Fields Limited

Western Coalfields Limited (WCL) came into existence after nationalization of coal mines and was incorporated on 29th October, 1975 as a public limited company upon takeover of assets and liabilities as on 1st November, 1975 with Coal India Limited as its holding company, vested with the Western Division of Coal Mines Authority Limited. The headquarters of WCL is located at Nagpur, in the state of Maharashtra. WCL (a Mini Ratna Cat – I Company) undertakes coal mining under the leaseholds in Wardha Valley, Umrer – Bander and Kamptee Coalfields (located in Chandrapur, Yavatmal, Nagpur districts in the State of Maharashtra) and in Pench – Kanhan&Pathakhera Coalfields (located in Chhindwara&Betul districts in the state of Madhya Pradesh). WCL carries out its coal mining operations through 82 coal mines/projects spread over 10 administrative Areas (7 in the State of Maharashtra and 3 in the state of Madhya Pradesh).(Table 2)

Table 1: Mining sites of WCL

S.No	Area	District	State	Mines as on 31.03.2013		
				Under-ground	Opencast	Mixed
1.	Nagpur & Umrer	Nagpur	Maharashtra	10	5	---
2.	Chandrapur, Bal-larpur, Majri, Wani & Wani North	Chandrapur & Yavatmal	Maharashtra	12	27	----
3.	Pench & Kanhan	Chhindwara	Madhya Pradesh	13	7	1
4.	Pathakhera	Betul	Madhya Pradesh	7	---	---
	Total Numbers of Mines – WCL - 82			42	39	1

Source: CIL website

In order to sustain the current high growth rate of Indian economy, we need to augment our power generation capacity, as presently the country faces 12% shortage of peak power demand. In order to bridge the gap of power generation, we have to produce more coal, as it is the primary energy mineral. Keeping this core objective in mind, we have set our vision to emerge as a key player in primary energy sector with a view to provide energy security to the country. However, this objective shall be attained only through environmentally and socially responsible growth practices.

1) *WCL Areas*
a) *Madhya Pradesh:* Pench, Kanhan, Pathakheda
b) *Maharashtra:* Nagpur, Umrer, Wani, Wani North, Majri, Chandrapur, Ballarpur.(Figure 5)

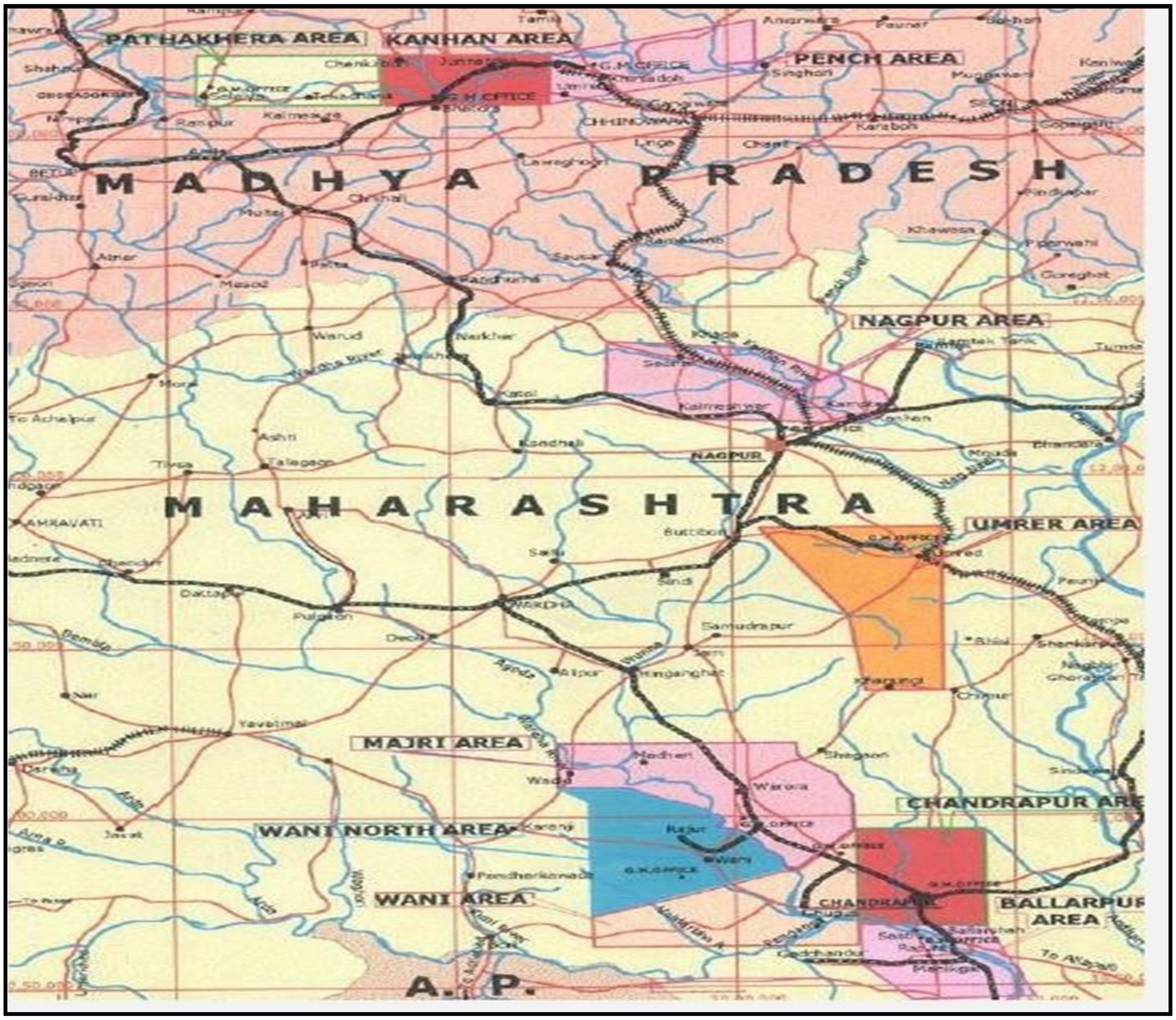

Figure 2: Mining sites of WCL
Source: CIL website

2) *Coal Reserves:* The command areas of WCL has coal inventory of 14,503 million tonnes, against all India coal inventory of 2, 98,914 million tonnes. The distribution of coal reserves (in million tonnes) is as follows (Table 3).

Table 2: Coal reserve under WCL

State	Non-Coking coal	Coking coal	Total
WCL in Maharashtra	10964		10964
WCL in Madhya Pradesh	2813	666	3539
Total WCL	13837	666	14503
All India	264853	34061	298914
WCL reserves as percentage	5.22	1.95	4.85

Source: CIL website

With 4.85% of coal inventory WCL contributes about 9.35% towards CIL coal production and about 7.58% to-wards national coal production.

3) *Major Product Types:* Coal (multiple grades) is the major product handled at WCL. WCL contributes about 10% to the total coal production of Coal India Limited and produces coal of non-cooking grades (about 98%) and medium cooking coals (about 2%). WCL supplies coal mainly to power plants and other industry sectors.
4) *Operational Structure:* WCL is a Central Public Sector Enterprise and is governed by Coal Ministry. The President of India and his nominees owns 100% equity share in our company through Coal India Limited (CIL).The company is primarily operated by Chairman Cum Managing Director, along with four Functional Directors namely Director (Technical) Operations, Director (Technical) Project and Planning, Director (Personnel) and Director.

D. *Coal Mining & Its Effects*

1) *Atmospheric Pollution:* Environment of underground mine working in India has been extremely dangerous because of the constricted geometry, darkness around, suffocating mine atmosphere, heat and humidity. Working under poor light in past caused miners mustangs practically is unknown now because of the improved lighting. Heat humidity and thermal stress often extreme under deep mines have been responsible for poor efficiency of the miners (Kamens,1991). Air conditioning of the atmosphere in some of the deep underground mines has been realized in the interest of efficiency. For the safety risks, ill health and likely injuries and accidents can be minimized. In this exercise, optimization of the man, machines, and environment system- physical environment in terms of heat, humidity, air movement, illumination noise, vibration, toxic agent, dust and fumes are to be looked into. The environment of underground mines have been a subject of serious concern to the mine operators because of the liberation of methane with coal cutting, heat and humidity and generation of fumes with the blasting of coal (Saxena *et al.,* 2005). The opening of the seams with interconnecting galleries, coursing for intake and return air, creation of air draught and deployment of auxiliary or forcing Fans are some of the conventional means adopted to improve the environment of underground. The suppression of dust or suspended participate matter is trued by water spraying from the loading or transfer points. In the subsequent years water infusion in the seams and water jet mounting on the cutting edges is tried to minimize dust menace during cutting of the coal (Ghose *et al.*, 2001).The auto oxidation of the coal; a slow process is aggravated when large surface area of the fine coal particles come in come in contact of air. The oxidation of pyrite adds a new dimension to the problem and being an exothermic process causes spontaneous heating and fire underground under favourable conditions. The heating process generates SO_2, CO, CO_2 and higher hydrocarbons (Singh *et al.*, 2001). These gases reaching to the atmosphere through cracks and fissures make the underground atmosphere unsuitable for the miners and also pollute the surface atmosphere around the up cast channels. Similarly the blasting underground generates NO_x and other gases in addition to fine particulate matter (Ghose *et al.,* 2001). The atmosphere underground is affected by a number of mining activities like cutting, blasting, loading and transport and preparation to beneficiation on the surface. The factors responsible for generating and adding different pollutants in the atmosphere underground are shown in the following chart. The most amazing constituent among them are the suspended particulate, impurity attributed to be due to handling, transport and preparation of coal and the methane released from the coal seams (Bose *et al.,* 1991). Some of the pollutants are the natural product of the coal formation while a number of them are produced during the mining operation, preparation and handling (Singh *et al.,*2005). The underground mining technology has been developed in different parts of the world to improve the mine environment and to minimize hazards associated with different activities (Saxena *et al.,* 1996). Mining below the surface destabilizes the ground, while the process of mining particularly blasting under shallow cover causes vibration of the surface structures and noise menace. The transfer of the raw coal, its beneficiation and handling generates coal dust while open burning of coal for steam or other usage releases gaseous discharge to the surface atmosphere. The movement of coal from the pit head to the loading or consumption points in open leaky trucks or open wagons also adds coal dust to the environment all along the route. The leaches from the waste rocks, discharge of effluents from the machines and pumping out of the hard polluted water to the surface water sources make the water source unfit for mass consumption. The surface subsidence due to caving or fire damages, the surface structures endangers the surface dwellers. The underground mines are ventilated by large size fans discharging up to 12,000 m^3 /min. through fan evasive of 3m to 5m diameter at over 200 mm pressure (Saxena *et al.,* 2000). The air absorbing moisture from the underground workings often reduces the suspended particulate matter but the fumes of explosives, methane, SO_2, and Oxides of Carbon are added to the general body of air (Reshetin, 2004).

2) *Noise Pollution:* The noise is now being recognized as a major health hazard; resulting in annoyance. Cases of Partial hearing loss and even permanent damage to the inner ear after prolonged exposure are noticed. The problems of underground are of special importance because of the acoustics of the confined space. The ambient noise level of the underground mining area is affected by the operation of the cutting machines, tub/conveyor movement and blasting of the coal. The movement of coaling machines and transport units-conveyor, tubs and transfer points caused audible noise which becomes disturbing underground because of the poor absorption by the walls (Singh *et al.,* 2005). The mechanized mines have lower noise problem in comparison to the old conventional mines operational mines operating with haulage and coal cutting machines. The results covering wholly manual, partly mechanized with coal cutting machines and partly mechanized with SDL loading Showed reduction in the noise level underground.
3) *Land Pollution:* The underground mining has caused land degradation because of surface subsidence, solid waste and coal dumping, fire underground and silting of the surface. The disturbance of the aquifers and subsurface water table followed loss of green cover and vegetable mass. The subsidence and disturbance of hydraulic regime has been dealt separately because of their importance. The bunker age in Indian coalfields have been very poor when the coal produce has to be stocked open along the railway siding. In the off seasons the pit head stock varied up to the production level of 15 days to a month covering a large area. The green cover over the patch is lost and the dust pollutes the area under the influence of underground mining and fire, affecting even the local non-mining population. The waste rocks picked and scattered around has created severe eye shore. Contaminated soils yield contaminated crops which give grasses having bio accumulated heavy metals. Mine fires also damage the land due to heat and additional subsidence. Mine water contains contaminants oil, grease, heavy metals, bacteria which should be treated before discharge on land. The overburden originates from the consolidated and unconsolidated materials haphazardly mixed during mining activity. This is also called as mine spoils. There drastically, disturbed mine spoil ecosystem are usually, physically, chemically, biologically and nutritionally recalcitrant media for plant growth (Hopke,2009). Mine spoils present undesirable condition for both plant and microbial growth because of low organic matter content, unfavourable pH, coarse texture, low water retention, poor water drainage and compact structure (Bose *et al,* 1998). Leaseholds for the underground mines are procured from the landlords who granted them the right for underground coal. The land for houses, dwellings and the associated activities are purchased piecemeal from different sources while large portion of the surface right remained under the control of farmers and landlords. Underground mining in these areas is conducted with full responsibility of the surface protection by the operators who normally maintained pillars as the natural support to the surface features. In geologically disturbed areas, deep pothholes are formed through which valuable fertile soil drained underground and many a time surface structures are damaged distorted or spoiled.
4) *Water Pollution:* Coal mining requires large quantities of water for dust control, fire protection and coal washing. When the water drain through large area of the mine it carries with it any soluble minerals that may be present either in the coal or associated rocks, thus causing severe degradation of water quality. Coal-processing (washing and benefaction) also causes serious water pollution. Water pollution can be controlled in adequate care is taken to ensure that the fluids discharged from coal refuse disposal areas does not have a total acidity in excess of its total alkalinity contain more than 7.0 ppm total of iron and suspends solids in excess of 200 ppm and its pH value is not below 6.0 and above 9.0 (Singh *et al.,* 2012).
5) *Dust pollution:* The dust concentration in the coal mining area is one of the worst menace affecting the common residents and miners alike. The miners from the organized sector get health support and other medical facilities while the common citizens suffer without any such insurance. Major portion of the menace is indirect; associated with open stock burning of coal, dumping, of the waste rock and road transport of coal and sand. The suspended particulate matter in mining atmosphere of Katras coalfield is revealing in this respect. The predominant air emission source in most of the coalfields is road generated dust and vehicular exhaust. In some of the areas road transport is the only mode of coal movement where open, leaky, inefficient trucks and dumpers carry coal on ill maintained roads and pollute the region. In Jharia coalfield, the vehicular movement contributed nearly 47% of total SPM load while the direct contribution of the underground mining is estimated to be 6% only (Lal *et al.,* 2012). Coal mining is the process of extracting the coal from the deep underground mines in the earth crust. Coal mining is one of the most illegal activities going on in the country. At the same time it totally neglects the role of EIA in its pre-operational, during mining and post operational plans. Here various case studies of coal mining are done and the impact of coal mining to the environment is looked into with some measures to mitigate this problem with proper use of technology and generation of awareness. The impact of coal mining on land, water, health of workers, air and social impact on surrounding villages and cities is evaluated and environment management plan of coal mining is developed. Therefore, the coal has to be used sustainably as coal reserves are depleting rapidly. All these activities are assessed in this process by the government before

such activities are started. Environment clearance is granted only them after stipulating appropriate environmental management plans. These plans are also strictly monitored for the compliance. The government sets up various committees under the change of experts to evaluate the impacts of various projects on environment. Even people participation has been made compulsory. EIA represents a systematic process that examines the environmental consequences of the development actions, in advance. The emphasis of a EIA is on prevention and, therefore, is more proactive than reactive in nature, EIA is a planning tool that is now generally accepted as an integral component of sound decision-making. The objective of EIA is to foresee and address potential environmental problems/concerns at an early stage of project planning and design. EIA/EMP should assist planners and government authorities in the decision making process by identifying the key impacts/issues and formulating mitigation measures. Ministry had issued sectoral guidelines some time ago. A compendium of the procedures and questionnaires entitled application form and questionnaire for Environmental Clearance was published in September 1999 in association with the Confederation of Indian Industry. As part of the continued efforts to ensure transparency in the procedures of environmental clearance and to assist the project authorities in improving the quality of EIA documents, this manual is now being brought out by the Ministry. The manual has been designed to cover the whole gamut of issues like regulatory requirements, the EIA methodology including baseline studies, identification of key issues and consideration of alternatives, impact analysis and remedial measures in a systematic way. It also delineates the process of reviewing the adequacy of EIA and EMP reports and post-project monitoring. No doubt coal produces pollution instead its production is necessary for boosting of national economy but side by side environmental production in coal mines area is equally important for that the environmental plan is prepared and based on that environment clearance is given to the mine owners. Due to lack of timely and frequent monitoring by the regulatory body. Most of the company become reluctant in implementation of management plan resulting disturbance in the environment. Keeping the safeguard of environment I decided to assess the implementation of management plan by Tawa Coal Mines of Western Coalfields with the following objectives:

a) Review of management plan of Tawa Coal Mines.
b) Assessment of implementation of management plan in Tawa Coal Mines.
c) Suggestions for improvement of environmental conditions inTawa Coal Mines.

II. LITERATURE REVIEWII.

Ghose *et al.* (2002) reported on Air Pollution due to Opencast Mining and its control in India. Opencast mining dominant the coal production scenario in India. It creates more serious air pollution the areas. The study revealed that there has been no well defined method or assessing the impacts on air quality due to mining projects. An Investigation is conducted to evaluate the impacts on air the environment due to opencast mining.

Emission factor data are utilized for computation of dust generation due to different mining activities. Approach for the selection of work zone and ambient air monitoring stations are described. Wok zone air quality, ambient air quality, and seasonal variations are discussed, which shows high pollution potential due to SPM. The status of air pollution due to opencast mining is evaluated and its impact on air environment is assessed. Characteristics SPM show a great concern to human health, Air pollution control measures involve planning and implementation of a series of preventive an supportive in addition to dust extraction system. The study reveal that there is a need for wider application of dust control chemicals and an in depth techno-economic survey is essential. Different abatement measures for control of air pollution are enumerated. Air pollution control by trees, trees tolerant to different air pollutants.

Ghose *et al.*(2006) had worked the area of generation and quantification of hazardous dusts from coal mining in the India. They found that increasing trend of opencast coal mining in India tends to release huge amounts of dust. But there is no well-defined method of estimating dust emission due to different coal mining activities. This paper examines the sources of dust emission due to coal mining activities, and focuses on the quantification of dust emission with the development and use of emission factors. Because of their site-specific nature, emission factors developed for one site may not give the correct results for another site. In the present investigation, prediction equations are utilized for the development of emission factors. For the applications of this concept, one large opencast coal project of Bharat Coking Coal Ltd. (BCCL) was investigated, and the total amount of dust emitted due to different mining activities was calculated by the utilization of emission factor data, which was estimated to be 9368.2 kg/day.

The significance of this study in the field of environmental protection and likely impacts of such study. The paper concludes that once the amount of dust generation is estimated, the impact on air quality can be assessed appropriately and a proper air-pollution control strategy can be developed.

Singh, Gurdeep carried out a significance study on environmental issues with best management practice of coal mining in India, Coal is one of the most important fossil fuel in India is vital for its energy security. It is India's least-cost source of primary energy and currently meets two- thirds of the country's energy needs. The power sector is the largest consumer, followed by the industrial sector—the major consumers being steel, cement, and brick-manufacturing units. Coal therefore remains essential in achieving a diverse, balanced and secure energy mix. While coal is poised for significant growth, it faces significant and mounting social and environmental challenges. Environmental concerns will be the key to the coal industry‘s future. Relative to other fossil fuels, coal is less energy efficient and pollutes more. The primary concerns at the regional levels have to do with the environmental impacts on air, water, land, forest, biodiversity, climate and the costs of mitigating these. Even with its major hurdles, coal will remain a future mainstay, a foundation and fundament of our economy. Coal has a crucial role in meeting current needs and is a resource bridge to meet future goals through the enhancement of knowledge and technology. The challenge is to apply the right technology in the most efficient and environmentally friendly way.

Chaulya *et al.* (2003) had examined the chemical properties of particulate matter (PM) in diesel vehicle exhaust at a time when emission regulations, diesel technology development, and particle characterization techniques are all undergoing rapid change. The aim is to explore how changes in each of these areas impact the others. Particle composition is of central interest to the practical issues of health effects, climate change, source apportionment, and aerosol modelling. Thus, the emphasis here is to identify the emerging questions and examine how they can be addressed. As regulations drive down the allowed tailpipe emission levels, advances in engine and after treatment technology have made it possible to substantially reduce PM emissions. Besides the reduction in level, new technologies such as diesel particulate filters (DPFs) and selective catalytic reduction (SCR) can also affect the physical and chemical properties of PM. This in turn introduces new analytical demands that must address not only the issue of sensitivity, but also of specificity. New methods of aerosol chemical analysis are described that address these needs, improve our understanding of particle composition, and provide critical insight into the current issues surrounding motor vehicle PM emissions and their environmental impact.

Tiwari *et al.*(2001)had founded that exploitation of coal and related industries in Damodar River Basin have exerted a great impact on environment of the basin. Hydro-chemical analyses of mine water were carried out for all the major coal fields. They reveal that total dissolved solids, sulphate, hardness and iron content are high. Biological contaminations are also observed in terms of MPN in the mine water. As a consequence of underground mining high volume of polluted water, flooded in the mines, are channelled into the stream of river which in turn gets chemically polluted. Activities other than mining like coal beneficiation and preparation also generate huge amount of water effluent which effect the aquatic ecosystem and reducing biodiversity. Bindhu and Tripathy (2012) had worked on the field of Prediction of dust concentration in open cast coal mine using artificial neural network. The study revealed that coal dust is a major pollutant in the ambient air of coal mining areas. The pollution due to open cast mining is more severe than pollution due to underground mining. Prediction of ambient concentration of pollutants should be known to implement any control techniques to reduce their concentrations. In this paper, three models were developed to predict the concentration of dust particles at various locations away from the source of pollution. These models are developed using Multilayer Perception Network and learning is done by back–propagation algorithm. The data for training and testing the network is collected from the field work done in North Karanpura Coal Mine in Jharkhand, India, which is an open cast mine. The meteorological data (wind velocity, dispersion coefficients, rain fall, cloud cover and temperature), geographical data (distance of the receptor point from the source in the direction of wind and distance of the receptor from source in the direction perpendicular to wind direction) and emission rate are used as inputs in the formation of models. The number of inputs for Model 1, Model 2, and Model 3 are six, seven, and nine, respectively. The output (dust concentration) is same for all the three models. The performance of the developed models was evaluated on the basis index of agreement and other statistical parameters i.e., the mean and the deviations of the observed and predicted concentrations, root mean square error, maximum deviation and minimum deviation, normalized mean square error, model bias and fractional bias. It was seen that the overall performance of Model 3 was better than Models 1 and 2. Artificial neural network (ANN) based dust concentration prediction model yielded a better performance than the Gaussian–Plume model.

III. MATERIALS AND METHODOLOGY

A. *Study Area*

1) *Location:* The proposed study area ‗TAWA underground mine‘ is located in the South side of the existing Pathakhera- II Mine of Pathakhera area of Western coal field. In terms of co-ordinates, Tawa Underground Mine is between latitude 22^o 03‘00‖ and 22^o 10‘00‘‘ N longitude 78^o08‘00 and 78^o20‘00 N. The proposed Tawa Underground Mine is situated at a distance of about 30 Kms from Maritha lying on Nagpur –Bhopal Highway. The nearest railway station is Ghoradongri at a distance of 71 kms. South of Itarsi Junction, which is 25 Km away from Tawa Underground Project TAWA underground mine is a project of

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Figure 3:Tawa Coal Mines of Western Coal Fields Ltd., Betul (M.P)
Source: Self

B. Methodology

The Assessment of environment management plan in Tawa coal mines‖ was basically based on the primary and secondary data collected about the mine area mainly from the EIA report, annual report, quarterly report, audit report. In addition to them the environmental clearance letter, mine surface area plan helped me a lot for assessing the environment prevailing in the site. The preliminary field visit in early stage for my work gave me a vivid account of the locality. The international and national journals gave me a vivid picture about how to assess such a vast topic in the prescribed time. The interaction with the different staff and workers during my second visit helped me a lot to collect the data for the site. For the assessment of pollution in the mines two separate visit in the month of April and May was made to know the procedure about the determination of SO_x, NO_x SPM, PM_{10},CO, noise level. In addition the basic understanding of mining was made me available through the staffs in the first visit. The detailed procedure for the assessment for the different parameters are as follows:-

C. Methodology of Pollutant Analysis

1) *Air:* 24 hourly air samples are collected with Respirable Dust Sampler at selected locations to monitor ambient air quality w.r.t. Suspended particulate matter (TPM). Respirable Particulate Matter (PM-10), Sulphur di-oxide (SO_2) and Oxide of nitrogen (NO_2,) etc.
2) *TPM:* Ambient air laden with suspended particulates enters the Respirable Dust Sampler through the inlet pipe of sampler by means of a high flow late blower. As the air passes through the cyclone, coarse, non-respirable dust (size >10 p) is separated from the air stream by centrifugal forces acting on the solid particles. These separated particles fall through the cyclone's conical hopper and collect in the sampling bottle placed at bottom. The fine dust forming the respirable fraction (size<10 p) of the Total Suspended Particulates passes through the cyclone -and is carried by the air stream to the Glass Microfiber Filter Paper. The Respirable dust (PM-10) is retained by the filter and the carrier air exhausted from the system through the blower. The mass concentration (ug/m^3) of Suspended Particulate Matter (non-respirable dust and respirable dust) and Respirable Particulate Matter a in the ambient air is computed by measuring the mass of collected particulates and the volume of air sampled.

3) *$NO_{x:}$* Determination of oxides of Nitrogen is based on the procedure of "Jacobs and Hochheiser method". In this method the air sample is collected 24 hourly in the field, and analysed in the laboratory using spectronic 20 D+ Spectrophotometer. Nitrogen oxides as Nitrogen di-oxide are collected by bubbling air through a Sodium hydroxide solution to form a stable solution of Sodium nitrite. The nitrite ion produced during sampling is determined calorimetrically (with the help of Spectrophotometer, measuring absorbance at 540 nm) by reacting the exposed absorbing reagent with Phosphoric acid, Sulphanilamide and (1-naphthyl) ethylenediamine dihydrochloride. The interference of Sulphur di-oxide is eliminated by converting it to Sulphunic acid with Hydrogen peroxide before analysis.
4) *$SO_{2:}$* Determination of SO_2 is based on the procedure of West and Gaeke method. Sulphur di-oxide from the air stream is absorbed in a Sodium tetrachloromercurate solution to form a stable solution of Dichlorosulphitomercurate. The amount of Sulphur dioxide is then estimated by the colour produced when P-Rosaniline hydrochloride is added to the solution. The colour is estimated by a reading of absorbance at 560 nm in the Spectrophotometer.
5) *Water:* Mine water discharge is collected on fortnightly basis in plastic zaricane and is transported to the laboratory for analysis. As per the Environment (Protection) Amendment for the parameters - pH, TSS, Oil & Grease and COD and once in a year for all Rules published vide Gazette dated 25.9.2000, water samples are analysed fortnightly parameters as per Schedule VI, Environment Protection rule.

D. Materials

The samples were collected from the different sites are illustrated below:-

Ambient Air Quality Monitoring location

S. No.	Location Details	Location Code
1	SAM office	PkTUA-1
2	Dy. CME office	PkTUA-2
3	MPEB Colony	PkTUA-3
4	Hirapalla	PkTUA-4

Water Quality Monitoring location

S.No.	Location Details	Location Code
1	Mine Water discharge	PkTUW-1

Noise level Monitoring location

S.No.	Location Details	Location Code
1	Fan house	PkTUN-1
2	Colony	PkTUN-2

The monitoring was done as per the procedure followed by CMPDI. All these components are measured fortnightly. All the location have been selected by the CMPDI after going through the EIA report prepared by the competent authority.

IV. RESULTS AND DISCUSSION

The data collected for SPM, PM-10,NO_x, SO_x ,CO, noise level during the work are as below:

A. Air Quality Monitoring Data

Name Of The Company: WCL Year : 2015
NAME OF THE AREA : PATHAKHERA Q.E. MAR NAME OF THE
PROJECT : TAWA UG

Table 5: Showing level of SPM, PM_{10}, NO_X, SO_2 of Tawa Coal Mines,WCL

1. SAM Office : P_k TUA-1

(24 hourly values in □g/m^3)

Month	Date of sampling		Parameters			
	From	To	SPM	PM-10	NO_X	SO_2
FEB 2015	07.02.15	08.02.15	271	122	3	79
FEB 2015	19.02.15	20.02.15	117	61	2	55
MAR 2015	13.03.15	14.03.15	189	65	5	20
MAR 2015	20.03.15	21.03.15	173	50	6	114
TLV as per Env. (Protection) Amendment rule 2000			600	300	120	120

2. Dy. CME Office- Pathakhera II UG : P_k TUA-2

(24 hourly values in □g/m^3)

Month	Date of sampling		Parameters			
	From	To	SPM	PM-10	NO_X	SO_2
JAN 2015	04.01.15	05.01.15	301	210	3	62
TLV as per Env. (Protection) Amendment rule 2000			600	300	120	120

3. MPEB Colony : P_k TUA-3

(24 hourly values in □g/m^3)

Month	Date of sampling		Parameters			
	From	To	SPM	PM-10	NO_X	SO_2
JAN 2015	03.01.15	04.01.15	121	105	2	55
FEB 2015	19.02.15	20.02.15	144	28	3	62
MAR 2015	12.03.15	13.03.15	82	30	4	30
Permissible Limit			200	100	80	80

4. Hirapalla/Bhagaikhapa Village : P_k TUA-3

(24 hourly values in □g/m^3)

Month	Date of sampling		Parameters			
	From	To	SPM	PM-10	NO_X	SO_2
JAN 2015	17.01.15	18.01.15	71	52	3	44
MAR 2015	21.03.15	22.03.15	674	243	6	101
Permissible Limit			200	100	80	80

Source: CMPDI

B. Co Monitoring

(All values are given in □g/m^3)

Table 6: Showing level of CO in Tawa Coal Mines,WCL

S.N.	Monitoring Location	Monitoring Date	Observed Value	NAAQ Standards (1 hour)
1	SAM Office	20.03.15	< 114.3	10000
2	Dy. CME Office-Pathakhera –II UG	20.03.15	< 114.3	4000
3	MPEB Colony	20.03.15	< 114.3	10000
4	Pathakhera Colony	20.03.15	< 114.3	4000

Source: CMPDI

C. Noise Monitoring

NAME OF THE COMPANY: WCL YEAR : 2015
NAME OF THE AREA : PATHAKHERA TAWA UG Q.E. MAR
NAME OF THE PROJECT :

Name of the Location : Near Fan House - P_k TUN-1

Table 7: Showing noise level of Tawa Coal Mines ,WCL

Month	Date of Data collection	Noise Level in dB (A)	
		Day Time	Night time
JAN 2015	04.01.15	69.2	70.5
JAN 2015	17.01.15	68.7	69.2
FEB 2015	06.02.15	69.3	67.8
FEB 2015	20.02.15	68.9	69.7
MAR 2015	14.03.15	69.2	70.1
MAR 2015	22.03.15	68.9	69.5
Noise Level Standard as per Env. (Protection) Amendment rule 2000		75	70

Name of the Location: Colony -P_k TUN-2

Month	Date of Data collection	Noise Level in dB (A)	
		Day Time	Night time
JAN 2015	04.01.15	44.1	42.4
JAN 2015	17.01.15	43.5	44.3
FEB 2015	06.02.15	43.5	42.4
FEB 2015	20.02.15	44.5	42.9
MAR 2015	14.03.15	44.1	43.9
MAR 2015	22.03.15	45.2	42.7
Permissible Limit		55	45

Source: CMPDI

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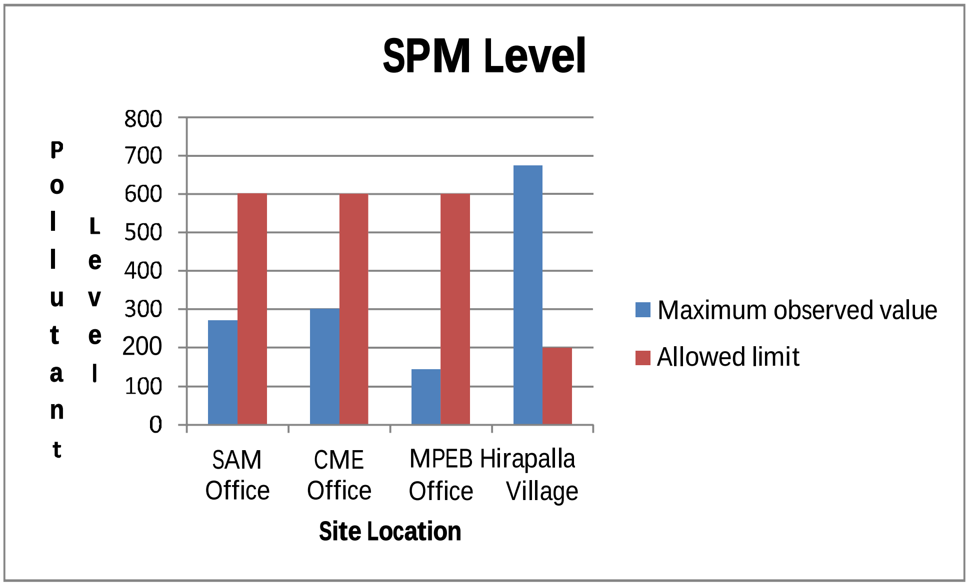
D. Analysis of Pollutant level

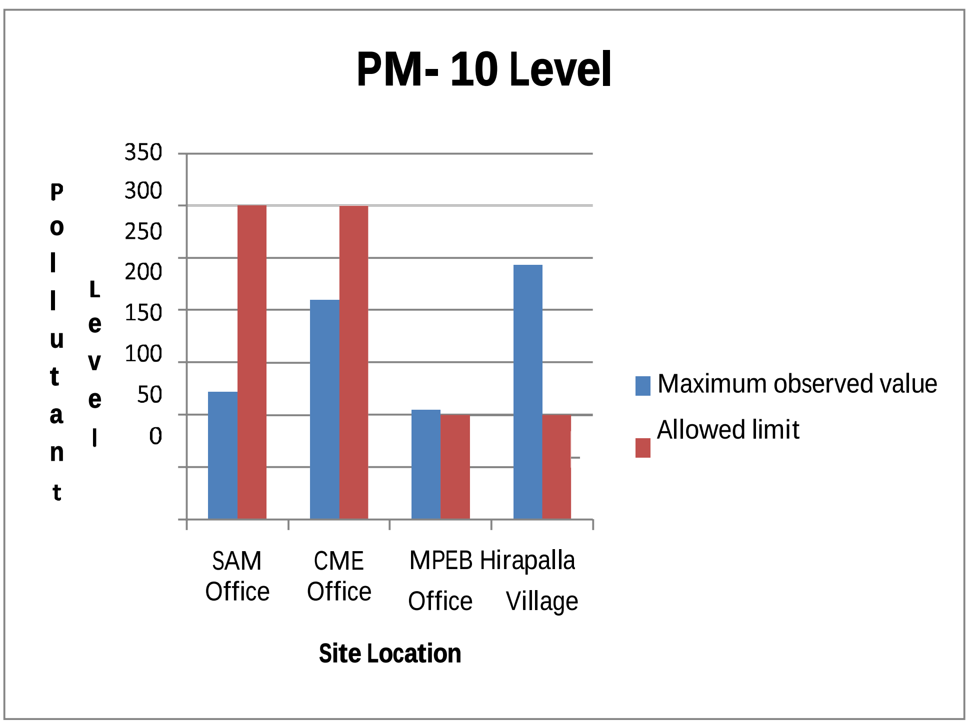
The maximum amount of pollutant level monitored to the allowed limit are compared below (Chart 1).The constrains were seen in the Hirapalla Village which is closely situated to the mine area in SPM level, PM-10 level and SO_2 level (Chart 3 and 4).The rise in the pollutant level of PM-10 level were also seen in the MPEB Colony (Chart 2).These constrains need to be checked very soon. Although the rise in PM-10 level in MPEB Colony was not too much significant.

Chart 1- Showing maximum SPM level monitored to the allowed limit of different sites



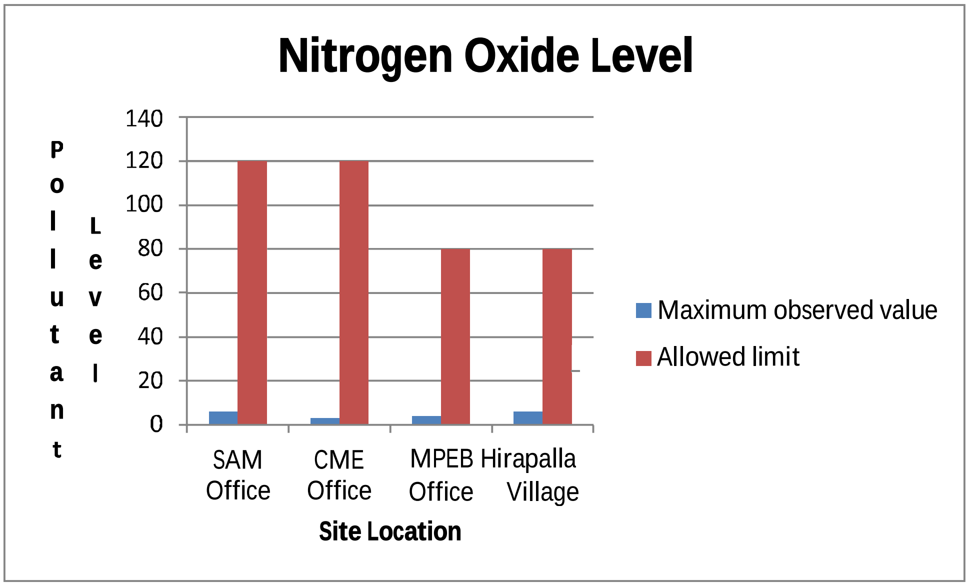
Source : CMPDI

Chart 2- Showing maximum PM10 level monitored to the allowed limit of the different sites



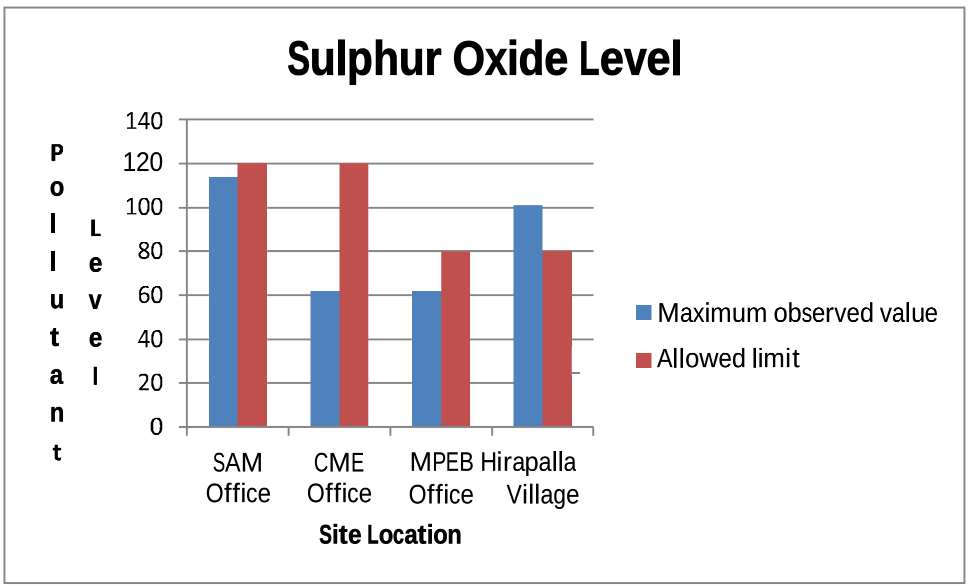
Source : CMPDI

Chart 3- Showing maximum nitrogen oxide level monitored to the allowed limit of the different sites



Source : CMPDI

Chart 4- Showing maximum Sulphur oxide level monitored to the allowed limit of the different sites



Source : CMPDI

V. DISCUSSION

The study was conducted in January-May has brought to the fore a few issues pertaining to air, CO, and noise pollution. It has been found out that in SAM office the pollutants of SPM, PM-10, NO_x and SO_2(Table 5) are all within the desired values as per the study conducted in February 2015. The Deputy CME office and MPEB colony also have pollution levels within the limits. However the Hirapalla/ Bhagaikhapa village has overshot the permitted pollution levels by manifolds and it is a cause for concern for environmentalists. The reason behind this is because the village is nearby to the mining site. Also when we focus our attention on CO levels in the area in question it is found that CO level is well within the stipulated levels as shown in the results .All the locations have CO levels less than 114.3(Table 6) which is far below NAAQ standards.(1000 CO is the level).

Noise level data in Patarakhera (near fan house) area has been recorded for 3 months (once in day and once at day). Excepting a few occasions in January and March the data recorded has never been raised from the standard limit of 75db during day and 70 db (Table 7) at night whereas the values of noise pollution away from the fan house is considerably below the limit.

A. Assessment of Environment Management Plan

1) Air Pollution

It is caused mainly from two sources:

a) By the exhaust of machine in the mine area.

b) By dust from coal handling plant.

In addition to the blasting operations, drilling operations, loading & transportation of coal and OB results in air pollution.

Since the mine falls under degree III (gassy mine), methane & other hydrocarbon gases may be evolved during the activity. Carbon dioxide may also be evolved as by product of oxidation. Nitrous dioxide fumes are also expected to be liberated due to blasting. Problems of suspended particles are also common.

Control measures so far adopted

Following measures generally, are practiced for prevention and control of air pollution in Tawa mine areas:

- Dust suppression through heavy dust sprinklers/road watering trucks at various sensitive points such as haul roads, mineral handling plants, crushing and screening plants etc.
- Dust extraction facilities are provided with HEMM, crushing, screening and mineral handling plants.
- Water sprays, hoods, dust collectors are to be used to control dusts from drilling.
- Measures such as adoption of hoods a transfer points, proper design of chutes, vulcanizing conveyer belt joints, under belt cleaning devices apart from dust suppression and/or dust extraction system for conveyers are usually introduced to minimize dust pollution.
- Mineral handling plants are mostly covered with proper enclosures.

Mitigative measures adopted for air pollution controls are based on the baseline ambient air quality of the area. From the point of view of maintenance of an acceptable ambient air quality in the region, it is desirable that air quality should be monitored on a regular basis to check compliance of standards as prescribed by CPCB. In case of non-compliance, appropriate mitigative measures are needed. As per the results of ambient air quality monitoring data, the background concentrations of SPM, RSPM, SO_2, CO and NO_x are within the stipulated CPCB standards for most of the samples.

2) Dust Pollution: It is very common in all types of mining. When it operates or CHP operates there occurs dust pollution due to dust fall .The following steps have been taken to reduce the dust fall effects to a minimum:-

- Development of green barrier around mine entrance, CHP, Workshop, Colony areas etc.
- Water spraying where dust is produced.
- Use of dust extractors and dust filters in drills, CHP etc.

Dust is generated during blasting, mining, crushing operations, and also during handling and transportation of the material. The control measures adopted are:-

a) Mines

- Dust suppression systems (water spraying) in practice.
- Dust extraction systems are used in drill machines
- Use of sharp drill bits for drilling holes and drills with water flushing systems (wet drilling) to reduce dust generation is in use.

b) Haulage

- Regular water spraying on haulage roads during transportation of coal and waste by water sprinklers.
- Transfer points for transporting coal are provided with appropriate hoods/chutes to prevent dust emissions.
- Dumping of coal and waste is done from an optimum height (preferably not too high) so as to reduce the dust blow.

c) Crusher: Crusher is provided with Bag Filters to arrest any dust emission. The dust emission level is maintained within the prescribed standard of 150 mg/Nm^3.

d) Belt Conveyor: Close conduit type belt conveyor is mostly used for transportation of coal. The belt and idlers are maintained in proper condition so as to avoid spillage of material and prevent any fugitive emissions.

3) Water pollution

The sources of water pollution are as follows:-

a) Discharged from underground sumps

b) Discharge from domestic & sewerage system

No major water pollution cases can be seen as water is not directly used during mining operation. It percolates in to working area during mining operation. However, water is consumed for other purposes mainly for domestic & industrial supply. The problem of water accumulation in rainy season can be seen, for that purposes pump of 200 LPS has been installed. More ever experience of an existing mine in this area show that there is no chemical pollution of water since the underground mine water in the adjoining mine is not acidic in nature. The only pollutant is suspended coal particles. Control measures so far adopted:-

- Sedimentation tank
- Water treatment plant
- Domestic Effluent Treatment plants

Domestic Effluent Treatment plants. – The Domestic effluent from major residential colonies of Tawa coal Mines WCL is treated in Domestic Effluent Treatment Plant (DETP) installed in Colonies of Tawa Coal Mines. The treatment process includes activated sludge method or Extended Aerated Lagoon for the domestic effluent of the area.

4) *Soil /Land Pollution:* In underground operations, there are not much changes on the top soil. However for the distortion for there is provision of compensatory afforestation. As the total area is covered by forest it is not possible to avoid the utilization of forest land. It is already proposed to plant as many trees as possible on both sides of forests in EMP compensate the trees which had been cut during the project activities. The practise is well in use .Adequate data were not available but it was being in practise along the road sides and the office premises area. The area being hilly and devoid of alluvial, the water table is deep seated except in rainy season. Therefore, the question of upsetting water table affecting the vegetation does not arise. This fact is sustained by continued growth of forest cover caved areas of neighbouring mines.

a) *Land Subsidence:* An amount of two lakh has been provided to fill up the crack which has took place due to subsidence in the project. The subsidence of the ground has no any deleterious effect on the ecology of the areas due to control measures taken. Proper land filling practices are being followed at the subsidence sites. As the coal is being extracted from all three seams it has been expected by the competent authority that nearly 2.32 m land would be subsidised. This much of subsidence is not too much harmful for the vegetation area. However, deleterious effects have been seen in some of the areas. The trees along the forest areas were slanted. So, proper assessment of the problem is needed to be done by the competent authority in no time.

5) *Noise Pollution Sources*

- Drilling operations
- Ventilation system

a) *Noise Pollution Control:* The ambient noise level monitoring carried out in and around the proposed mine shows that the ambient noise levels are well within the stipulated limits of CPCB. Within an operational mine, major noise sources are operation of mine machineries and equipment, blasting, crushing units and belt conveyor. Noise generation may be for an instant, intermittent or continuous period, with low to high decibels. Noise generation is although common in the mine areas. As per the EMP, measures are taken but to keep noise generation in control.

To keep the ambient noise levels within the permissible limits of 65 dB(A), the following measures are adopted:-

- Innovative approaches of using improvised plant and machinery designs, with in-built mechanism to reduce sound emissions like improved silencers, mufflers and closed noise generating parts.
- Procurement of drill, loaders and dumpers and other equipment with noise proof system in operator's cabin.
- Confining the equipment with heavy noise emissions in soundproof cabins, so that noise is not transmitted to other areas.
- Regular and proper maintenance of noise generating machinery including the transport vehicles and belt conveyors, to maintain the noise levels;

Although, it was seen that workers in the mine areas are not aware that it causes impairment of ears. They are not using the mufflers properly. So, proper training and awareness is needed to be disseminated among them else it would affect the productivity and the health of the workers too.

b) *Green Belt Development:* Even with the various dust suppression measures in place, dust generated from mine faces, fine dust produced during blasting operations are difficult to control. Therefore, in addition to the above mitigative measures, it is in progress to develop dense green belt in and around the mine site, crushing, loading and unloading facilities, corridor of belt conveyor route and mine colony and in abandoned mine area during reclamation process. It is expected that plants with 10, 20 and 30 m height can reduce dust pollution by 50, 70 and 80% respectively. A combination of these plants are planted along the 7 m radius along the leased mine areas.

B. Assessment of Emergency Management Plan

Following is the emergency management plan for Tawa mine containing Plans for dealing emergencies in different situations of mine workings.

1) *Explosion:* Tawa mine is classified as degree two gassy mine, Methane is found in drill holes occasionally & at general body, near the geological disturbances. Though the possibility is very-very rare but explosion hazard of both methane & coal dust cannot be ruled out. To prevent the hazard following precautions are regularly being taken:

a) Regular gas testing by supervisors & officers with Miniwarn and methanometers in addition to FSL.
b) Coursing or, ducting of the auxiliary fan always kept extended up-to 7.5m of the face.
c) FLP features of all electrical installation maintained & monitored regularly.
d) Dust generation kept at minimum, regular water spraying is being done at face, bunker & transfer points etc.
e) Stone dust barriers are provided in all working districts.

2) *Fire:* The coal of Tawa Mine is not prone to spontaneous heating. The crossing point and ignition point of the coal is 154^0 C & 182^0 C respectively. The goaved out panels (E1,E2,E6,W4) UWS & (E1,E2,E3,E4,E6,E7,E8,W7XC) LWS are completely sealed off and the dip portion is submerged in water. There are several development panels with sectionalisation in the mine and Development panel without sectionalisation stopping are inspected at regular intervals. Regular inspection is being done in all sections to detect spontaneous heating .Apart from spontaneous heating, fire may be possible due to friction, electricity, explosive etc. But sufficient care is being taken to avoid any type of fire risk.

a) *Inundation by Surface Water:* Surface water can enter in entered to the mine through following entrances.

- Haulage Incline, Belt Incline
- Air shaft
- Prospective and pumping bore holes.
- Subsidence crack.

3) *Following Preventive Measures Have Been Taken*

a) Garland drains are provided at the entrance of the mine to carry away the rainwater.
b) The RL of the openings are kept above 3 m of the HFL of nearest nallah.
c) All prospecting bore holes are plugged at Surface.
d) All bore holes which are not sealed are grouted with pipe to raise the entry point up to 3 m above the ground level.
e) Crack-filling is being done as & when required and at the time of rains, guards are appointed at subsidence area.
f) Sufficient sump capacity is provided to deal with any electrical or mechanical breakdown of pumps.

4) *Major Roof Fall:* The roof of the lower as well as upper seam of the mine is classified as good roof and there is no possibility of roof fall in the mine. However, S.S.R. is being implemented in the mine to prevent any such occurrences. At present development work in few districts of Bagdona and depillaring in some section of lower mine seam are being carried out.

VI. CONCLUSION

The above dissertation work was conducted in Tawa M.P. about the effects of underground mining had assessed the ill effects of mining in the study areas and measures that should be undertaken to mitigate its negative effects. Tawa coal mine, an underground coal mine, having three seams namely upper seam, lower seam, Bagdona seam which is located in Betul district of M.P. The purpose of selecting this site goes to the award which it had achieved, the President Award which adhered to practice of safe mining. It had achieved this award twice earlier also in the year 1995 and 2006.

The following points are concluded from the above study :-

1) Noise pollution during blasting process.
2) Non-compliance of few rules were also seen like not keeping the machinery in enclosure as machinery failures are normal.
3) There was lack of awareness among the workers about the issue of noise pollution. They don‘t use earmuffs regularly especially the staffs involved in blasting and drilling operations.

Instead of above-mentioned constraints there were still few positive notes. Some of them are as follows: -

a) Regular meeting among the workers and Head.
b) Boosting the workers through prize distribution.
c) Celebrating festivals more specifically the days related to the protection of environment.

Almost the major parts of EMP was taken in consideration but the high levels of pollutants in the mine adjoining areas have been noted down. Such rise in pollutant level were also seen during last year annual report too. So, certain measures are suggested which should be taken care for bringing the pollutant level below the limits. They are as follows: -

A. Air Pollution

1) Transportation (trucks/dumpers & railway wagons) are to be properly covered and leak proof.
2) Suitable spraying agents to be sprinkled to prevent dusts from being airborne.
3) Consolidation of haul roads & other roads are sprayed with suitable chemical additives for effective check of dust emissions.
4) Stabilization through vegetation at various critical dust generating points/dumps.

B. Noise pollution

Provision should be made for noise absorbing pads at foundations of vibrating equipment to reduce noise emissions.

C. Dust Pollution

1) More automatic water spraying mechanism inside CHP, at transfer points, crushers, feeder breakers etc. are needed to install.
2) Development of black topped rods which produces less dust.

D. General Suggestion

1) Creating more awareness among the workers about the noise pollution.
2) Making the relevant education qualification for the employees.
3) Putting a benchmark for filling the cracks are some measures which need to be taken to deal with the above-mentioned problems.

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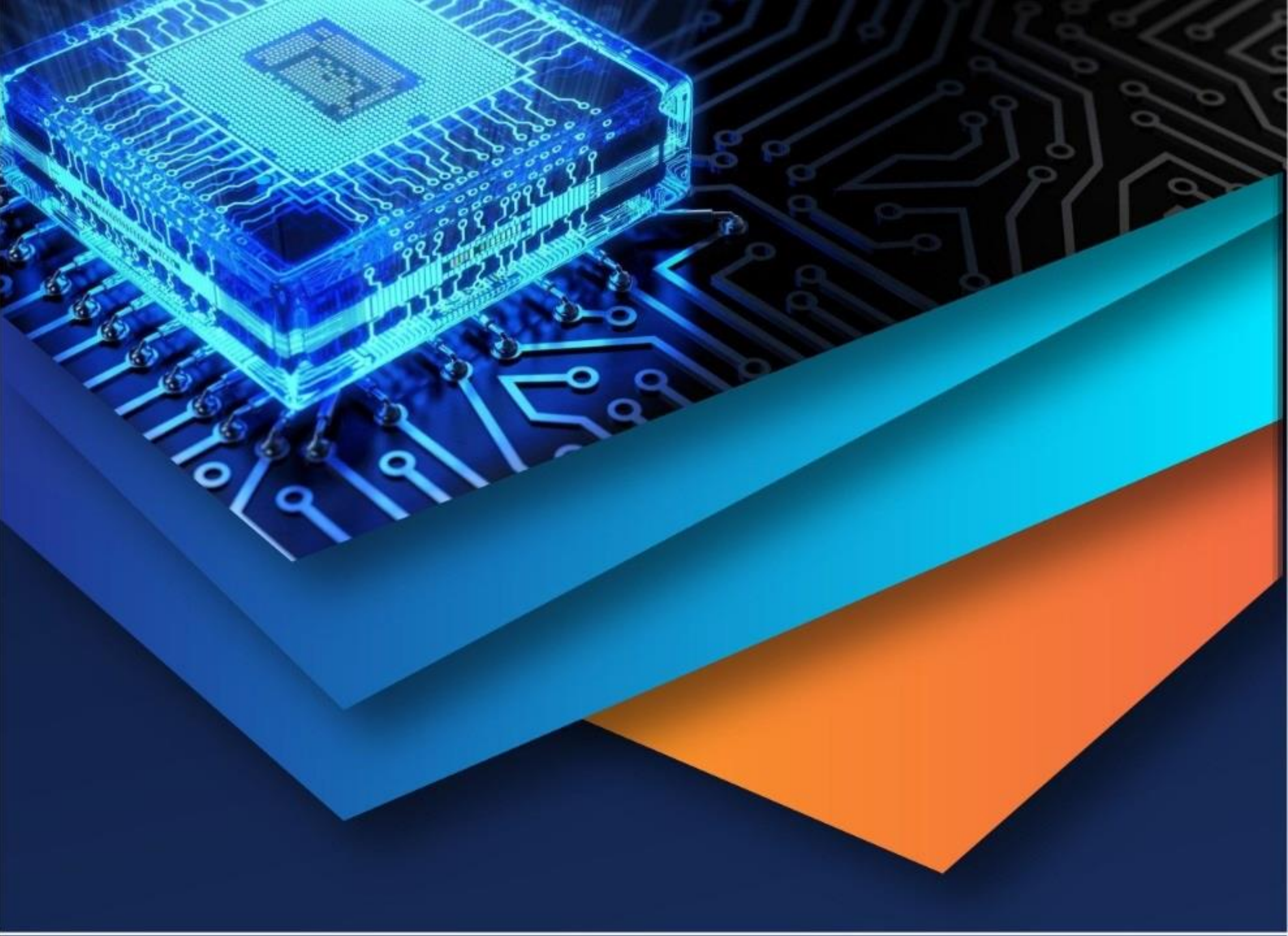

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