THE INDIAN MINING & ENGINEERING JOURNAL

(Incorporating Mineral Markets: The Founder Publisher & Editor: J.F. De. Souza, Mumbai)

www.theimejournal.com

VOLUME 61: No.08 **AUGUST 2022** ISSN 0019-5944

Publisher : Anita Pradhan, IME Publications
Editor-in-Chief: Prof. S.Jayanthu, National Mineral Awardee, Deptt. of Mining, NIT, Rourkela Mob. 9938303259
Email: sjayanthu@nitrkl.ac.in

Editor: S.K.Mahanta, Mob.: 9437002349
Email: sushantamahanta2349@gmail.com

Technical Editor (Hony.): Prof. T.N. Singh, National Mineral Awardee, (Deptt. of Earth Sciences, IIT- Bombay), Director, IIT, Patna
Prof. G. K. Pradhan, National Geoscience Awardee, Prof. of Mining and Dean, Faculty of Engineering & Technology, AKS University, Satna (M.P) , Mob.: 8120003355 Email: gkpradhan58@gmail.com

Principal Consulting Editor: Prof. Manoj Pradhan, NI T, Raipur
Prof. Khanindra Pathak, National Geoscience Awardee, Deptt. of Mining & Dean, Indian Institute of Technology - Kharagpur

Consulting Editors
Dr. D S Rao, CSIR-IMMT
Dr. K.C Brahma, Director, OMC Ltd.
Dr. A K Sarangi, Formerly Executive Director (Projects), UCIL, National Geoscience Awardee (Geology), Bhubaneswar
Prof. S.S.Rathore, Expert on Dimensional Stone, Udaipur
Prof. N.R.Thote, Dept. of Mining, VNIT, Nagpur
Er. V. Srikant, Managing Director, Uttam Blastech, Hyderabad
Dr. M. Ramulu, National Geoscience Awardee, Sr. Principal Scientist, CSIR-CIMFR, Nagpur
Dr. K Ram Chandar, NITK, Surathkal

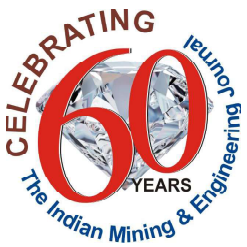
Overseas Consultants
Japan: Prof. Hideki Shimada
Nordic Countries : Prof. Uday Kumar, Lulea Technical Univ., Sweden
Thailand: Dr. Thitisak Boonpramote, Asst. Prof., Head of Mining & Petrolelum Engineering Deptt., Chulalongkorn University, Bangkok
The publishers and the editorial team do not necessarily individually or collectively, identify themselves with all the views expressed in this journal.

Qualified recipients : Selected members of IMMA/MEAI/MGMI/ SGAT,CEO's, Mine Managers, Maintenance Engineers, Processing Engineers, Govt. officials and Scientists etc.

Published Monthly by IME Publications.
Annual Subscription : Rs.650/- (Incl. Postage), Unit Price: Rs.50/-
FOREIGN: £ 75 OR US $ 150 (By Air Mail)
*Payment by Cheque/Draft. Cheques drawn outside Bhubaneswar must include Rs.50/- (Overseas £1 or US$2) as bank charges and should be drawn in favour of "**The IM& E JOURNAL"** payable at Bhubaneswar*

IME PUBLICATIONS

Corresspondance Address
The IM& E Journal 1457, Fishery Tank Road, Chintamaniswar, Laxmisagarpatna, Bhubaneswar - 751006, Odisha
Mobile: +919861008387, **Mail:** indianminingjournal61@hotmail.com
Branch office:Near TV Tower, JODA, Dt. Keonjhar 758034
Phone: 06767-273173
Associate Editor: A.Sahoo, Mob. 9861008387



Contents

Technical Papers

The IME Journal Readers' Forum

Regd. Office : IMEJournal, Laxmisagarpatna, Bhubaneswar 751 006
E-mail : indianminingjournal61@hotmail.com Mobile: +919861008387

Prof.(Dr.) S. Jayanthu

Persons in the News

Ms Ahuti Swain presently General Manager, Bharat Coking Coal Ltd, has been selected post of Director (Personnel), Eastern Coalfields Limited.

Shri Nilendu Kumar Singh, General Manager of South Eastern Coalfields Limited has been selected for the post of Director (Technical), Eastern Coalfields Limited.

Sri G Srinivasan is set to be the next Director (Finance) of South Eastern Coalfields Limited (SECL), a subsidiary company of Coal India Limited (CIL) under the Ministry of Coal. Presently he is General Manager in Coal India Limited. Joined Western Coalfields Ltd. in 1987. He has over 35 years of rich experience and expertise in cost budget, taxatation, treasury management & corporate accounts. He played a vital role in implementing the FICO model in Enterprise Resource Planning of Coal India Ltd.

Dr. Ranjit Rath an alumnus of IIT Bombay & IIT Kharagpur, took over as the new Chairman & Managing Director (CMD) of Oil India Limited (OIL). Dr. Rath is a proud recipient of the prestigious National Geosciences Award from the Hon'ble President of India. A Geoscientist with impeccable experience and expertise of more than 25 years in the field of geosciences. Dr. Rath

prier to joining at the helm of affairs of OIL, the Navratna PSU under the Ministry of Petroleum & Natural Gas, Govt. of India, was the Chairman cum Managing Director of Mineral Exploration & Consultancy Limited under the Ministry of Mines; Chief Executive Officer of Khanij Bidesh India Limited; Managing Director of Bharat Gold Mines Limited and also held additional charge of the Director General of Geological Survey of India under Govt. of India. Dr. Rath has rich portfolio of diverse roles spanning from strategy formulation, business development and upstream asset management to application of geosciences & exploration geology in several important projects including creation of Strategic Petroleum Reserves (SPRs) a first of its kind initiative of Govt. of India entailing underground rock caverns for strategic storage of crude oil - An intervention towards Energy Security.

Shri Ajit Kumar Behura has assumed the charge as Director (Finance) of Mahanadi Coalfields Limited (MCL), a leading coal producing company under the Ministry of Coal. Before taking over the charge as Director (Finance), he was serving as the Deputy General Manager (Finance), MCL headquarters. He was in-charge Corporate Treasury Management, Corporate Cost & Budget, SAP-FICO Module (ERP), Project monitoring (Financial Review), Member (Innovation Cell, Diversification Cell), MDO contracts, Finance Manual Committee at MCL. Shri Behura was also the Chief Finance Officer of MNH Shakti Limited, a subsidiary of MCL. A post-graduate in Commerce from Utkal University and a member of the Institute of Cost Accountants of India. He has more than 29 years of rich experience in dealing with financial matters. Shri Behura, who had started his professional career with NHPC Limited in 1993, had joined the service of Coal India Limited as Accounts Officer in 1996.

Indian Mining Industry News

COAL NEWS

COAL INDIA TO ENGAGE MDOS IN 14 MINES

In a bid to ramp up its production, Coal India is implementing a plan for operationalising 14 mines through the engagement of mine developer and operators (MDOs), a top official said. These mines have a combined capacity of 165.58 million tonne per annum. Addressing its shareholders in the company's latest annual report, Coal India Chairman and Managing Director Pramod Agrawal said, "These mines would contribute in sizable quantities towards production in the coming years. Of these, 10 are opencast projects with a total projected capacity of 161.50 million tonne per annum and four underground projects with a total capacity of 4.08 million tonne a year." Elaborating on the plan, he said a letter of acceptance has been issued to six of the successful bidders for these MDO projects, having a total capacity of 96.74 million tonne per annum. Tenders for seven more projects (five opencast and two underground) with a combined capacity of 58.84 million tonne per annum have been floated, Agrawal said.

Coal India has set a target of 700 million tonne production in the 2022-23 fiscal and proposed a capital expenditure of Rs 16,500 crore. The miner also informed its shareholders that 42 projects are running behind schedule due to delays in statutory clearances and related issues.It had undertaken 117 coal projects with a sanctioned capacity of 918.86 million tonne and a capital of Rs 1,32,634 crore. These are in various stages of implementation. Out of which, 75 projects are on schedule and 42 are delayed, the company said in its annual report for 2021-22 (FY'22).

The largest coal producer in the world completed five projects with a sanctioned capacity of 12.60 million tonne and a capital investment of Rs 1,769 crore during FY22. Agrawal stated that Coal India has remained committed to provide energy security to the country by attaining environmentally and socially sustainable growth through best practices from mine to market and will emerge as one of the global players in the primary energy sector.

MINING NEWS

HINDALCO EARMARKS ABOUT $8 BILLION CAPEX OVER NEXT 5 YEARS

Hindalco Industries Chairman Kumar Mangalam Birla said the company has earmarked a total capital expenditure of about USD 8 billion over the next five years in its arm Novelis and India. Novelis has found potential investment opportunities of USD 4.5 billion. Birla was speaking at the Hindalco's AGM. He said the company has identified potential investment opportunities of nearly USD 3 billion in India. Birla further said that 70 per cent of the company's consolidated cash flows will be allocated towards high-growth downstream segments , including EVs, mobility, batteries and Consumer durables. "On the back of solid financial performance and a strong balance sheet, your company is well-positioned to drive a new wave of transformational growth fuelled by organic expansion." The company plans to achieve a renewable capacity of 300 MW by FY'25, including 100 mw solar power capacity with hybrid storage.

NMDC TARGETS 46 MN TONNES OF IRON ORE PRODUCTION IN FY23

NMDC Ltd targets to achieve 46 million tonnes of Iron ore production in the current fiscal, 10 per cent higher than that of last year, Chairman and Managing Director, Sumit Deb said. The company achieved production of 42.19 MT and sales of 40.56 MT in FY22 with a turnover of Rs 25,882 crore. "On the back of the developments mentioned above at the Bacheli mine, Kumaraswamy mine and other mines, we target production of 460 lakh tonnes of iron ore in FY23. This volume is about 10 per cent higher than in FY22 and would provide a cushion against possible pressure on pricing and we hope to maintain and surpass the top line again in FY23," Deb said in the latest annual report.

He also said the company expects the demerger of its three-MT Steel Plant in Chhattisgarh to complete in the current year as its application for demerger has been accepted by the Ministry of Corporate Affairs and as directed by them, NMDC also held the meetings of Unsecured creditors and Shareholders of our company in June 2022. We have obtained the No Objection Certificate from the stock exchanges. We expect to complete the demerger within FY23," he said. He further said NMDC

has appointed new consultant for the fifth line of screening and the downhill conveyor augmentation project at Bacheli mine, which is expected to be ready in the current year and add about 2.5 MT of production. Though the outlook for the iron ore market is not encouraging in short term, long-term demand for iron is expected to be positive, he said on the global demand for iron ore. In terms of output of a country in 2021, with 900 MT, Australia continued to be the largest producer of iron ore. Whereas, India's production was 240 MT and emerged as the fourth largest country after Brazil (380 MT) and China (360 MT), he added.

ESSAR SIGNS RS 19,000 CRORE SALE PACT WITH ARCELOR MITTAL NIPPON STEEL

Essar announced signing definitive agreements with Arcelor Mittal Nippon Steel (AM/NS) for certain Ports and Power infrastructure assets which are primarily captive to Hazira steel plant operations. This is one of the largest post-pandemic M&A deals in India. It envisages a 50-50 Joint Venture partnership, for building a 4 MTPA LNG terminal at Hazira, Gujarat, between Essar and ArcelorMittal. Rewant Ruia, Director, Essar Ports & Terminals Limited, said, "With this deal, which yields a multifold return on our investments, Essar Ports & Terminals has unlocked value for all its stakeholders and will continue to focus on building new and modern core infrastructure assets in India and overseas."

Essar will conclude its planned asset monetisation programme with this deal and will complete the debt repayment plan of $25 billion (Rs 2,00,000 crore) with the Indian banking sector being almost fully repaid. Essar's aggregate revenues will stand at $15 billion (Rs 1.2 lakh crore) and an AUM (Asset Under Management) of $8 billion (Rs 64,000 crore) comprising of various assets spread across India and overseas. These assets under Energy sector include a 10 MTPA refinery in the UK, 15 TCF reserves (including some producing fields) of Unconventional Hydrocarbons in India & Vietnam and a 1,200 MW Power Plant in India; Infra sector assets include a storage terminal in UK of 3 million m3 capacity and a 20 MTPA Port in India; Metals & Mining sector assets include a major iron ore mine and pellet project in the US; Technology & Services sector assets include Global EPC business and IT solutions provider with centres across 30 plus countries.

By monetizing assets in a planned and strategic manner, that were built with earlier technologies over the last several years, Essar is now poised to reinvest in new assets with the latest, more efficient and ESG-compliant technologies to last the next several decades. Essar has planned significant investments in its core sectors of energy, infrastructure, metals & mining, and technology & services. While ongoing businesses will provide operational stability, our renewed focus will be to transition existing assets to green and invest in sector-transforming clean businesses around the investment themes of decarbonisation and digitisation.

TATA STEEL GETS LAND ALLOTMENT LETTER TO SET UP RS 2,600 CRORE PLANT IN LUDHIANA

Punjab chief minister Bhagwant Mann handed over the land allotment letter to the Tata group for setting up its maiden scrap-based steel plant at an investment of Rs 2,600 crore in Ludhiana. The move is aimed at giving further fillip to industrial development in the state. "We are committed for making Punjab a front runner in industrial sector and this maiden investment by Tata group in state is a step forward in this direction," IANS quoted Mann as saying during meeting with delegation led by Global CEO & Managing Director, Tata Steel Ltd, T.V. Narendran. Welcoming the Tata group to the state, he said that this is a 'Red letter' day in the history of the state as this is maiden investment by this globally leading company in the state.

He expressed hope that investment by this major industrial group will further put the state on high growth trajectory of industrial development. Mann further said that this is a proud moment for Punjab and the state government will extend fulsome support and cooperation to Tata group for setting up and operationalising the plant in state. Mann asserted that the youth of state will be immensely benefited from this project as it will open new employment opportunities for them. He said the Tata Group will invest around Rs 2,600 crore in the first phase of the project which will be located at Ludhiana, adjacent to Hi-Tech Valley Industrial Park of the government.

Mann said that this is the first investment by the Tata Group in Punjab adding that it will prove to be a milestone in propelling industrial growth in state. The chief minister also patted team of Invest Punjab which facilitated Tata Steel management in their endeavour to set up Tata Group's first scrap based integrated steel plant of India. He said that this electric arc furnace based plant will produce 0.75 MTPA finished steel adding that the raw material for the steel making process is 100 per cent scrap. Mann said that the plant will be spread over 115 acres of land adjacent to the state-of-the art Industrial Park developed by PSIEC.

CCI CLEARS PROPOSED MERGER OF JSW ISPAT, CREIXENT SPECIAL STEELS WITH JSW STEEL

Fair trade regulator Competition Commission of India (CCI) approved the proposal to merge Creixent Special Steels and JSW Ispat into JSW Steel. In May, JSW Steel announced the merger deal. JSW Steel and JSW Ispat are into manufacturing and sale of steel products while Creixent Special Steels (CSSL) is in the business of holding investments. In a tweet on Thursday, CCI said it has approved the "amalgamation of Creixent Special Steels and JSW Ispat Special Products with and into JSW Steel". CCI said it has approved the "amalgamation of Creixent Special Steels and JSW Ispat Special Products with and into JSW Steel". Separately, the watchdog has cleared the proposed acquisition of Varmora Granito Pvt Ltd and other entities by the Carlyle Group entity Katsura Investments. The combination involves Katsura's Investments' acquisition of up to 40 per cent stake in the Varmora Granito Pvt Ltd along with acquisition of certain rights in the company and certain other target entities.

The regulator has approved the "acquisition by Katsura Investments in Varmora Granito Pvt Ltd and certain other entities; and Varmora Granito Pvt Ltd in some of its group companies and other entities,". Katsura Investments is a special purpose vehicle controlled by CAPG-II investment fund, an affiliate of the Carlyle Group. The regulator also approved Varmora's acquisition of ownership interest in Renite and Simola and additional stakeholding in some of its group companies. Deals beyond a certain threshold require approval from the regulator, which keeps a tab on unfair business practices in the marketplace.

JSW STEEL CRUDE STEEL OUTPUT GROWS 14 PC TO 15.69 LT IN JULY

JSW Steel on Tuesday posted 14 per cent year-on-year growth in its crude steel output to 15.69 lakh tonne (LT) in July 2022. The company had produced 13.82 LT crude steel in July 2021, it said in a statement. The production of flat rolled products rose 15 per cent to 10.72 LT in July 2022, from 9.34 LT in the same month last year. Its long rolled products output also registered a 19 per cent rise to 3.65 LT against 3.06 LT a year ago. JSW Steel is the flagship company of the USD 22-billion diversified JSW Group. The group has presence in various sectors, such as energy, infrastructure, cement, paints, sports and venture capital. Its Chairman and Managing Director Sajjan Jindal has said the company will invest over Rs 48,700 crore over the next three years as part of its capex (capital expenditure) plan, of which Rs 20,000 crore has been earmarked for 2022-23.

PLF OF COAL POWER PLANTS TO HIT A 5-YEAR HIGH THIS FISCAL

The plant load factor (PLF) of Indian coal-based power plants will improve over 300 basis points (bps) to 62% this fiscal — the highest in the past five fiscals — fuelled by strong demand growth and limited capacity addition in the sector, a CRISIL Ratings estimate shows. This will help improve the credit risk profiles of one-third (25 GW) capacities of private generating companies (gencos) the most, with their operating profit expected to touch a five-year peak, it said. Annual power demand recovered sharply last fiscal, rising 8.2% on-year, tracking the 8.7% growth in gross domestic product (GDP) as the pandemic impact eased. This fiscal, with GDP growth expected at 7.3%, power demand is likely to rise over 6% year-on-year given the high correlation between GDP growth and power demand growth.

However, capacity addition remains low compared with demand growth. Coal gencos added just ~2% capacity annually in the past five years vis-à-vis annualised demand growth of 3.4% and may add 3.5% (~7 GW) this fiscal against demand growth of over 6%, it said. Manish Gupta, Senior Director, CRISIL Ratings, said, “Private players are averse to adding coal-based capacities (none in the past five years) with an eye on renewable power. This aligns with the government’s plan to ramp up renewable generation5 to meet 50% of the cumulative demand by 20306. However, renewable addition will meet barely a third of the incremental demand, in fiscal 2023, and the onus will be on coal gencos to fill the gap. This will power their PLFs to a five-year high of 62% this fiscal, building on their fortunes last fiscal.”

L&T BAGS LARGE CONTRACT FROM INDIAN OIL

The Hydrocarbon-Onshore division of L&T’s Energy Business has secured a large contract from the Indian Oil Corporation (IOCL). IOCL is implementing the Panipat Refinery Expansion (P-25) Project to enhance refining capacity from 15 MMTPA to 25 MMTPA to meet the growth in demand of petroleum products and to increase their profitability and competitiveness in the long run. The engineering,procurement,construction,and commissioning (EPCC) contract is for setting up a Residue Hydrocracker Unit (RHCU) for this P-25 Project. The RHCU is licensed by Axens (France) with a capacity of 2.5 MMTPA and will upgrade the Vacuum Residue (VR) to high-value commercial products (mainly diesel). The contract is awarded through international competitive bidding on a Lump Sum Turnkey (LSTK) basis.

L&T earlier bagged a significant EPCC Contract for setting

up the DHDT Unit (5.0 MMTPA, licensed by Shell) under the same P-25 Project of IOCL at Panipat-Refinery. Commenting on the win, Mr. Subramanian Sarma, Whole-time Director & Sr. Executive Vice President (Energy) said, "We are very delighted to be part of this large expansion project of IOCL-Panipat. I would like to thank IOCL for having trust in our capabilities. We are fully committed to delivering the complex process units with high standards of HSE and Quality." The Hydrocarbon business of L&T Energy organized under Offshore, Onshore, Construction Services, Modular Fabrication, and Advanced Value Engineering & Technology (AdVENT) verticals offer integrated design-to-build solutions to domestic and international customers. With over three decades of rich experience, the business has been setting global benchmarks in all aspects of project management, corporate governance, quality, HSE, and operational excellence.

HYGENCO SIGNS OFFTAKE AGREEMENT WITH JINDAL STAINLESS LIMITED

Global leader in deploying green hydrogen solutions, Hygenco India Private Limited, signed India's first long-term off-take agreement with Jindal Stainless Limited (JSL), one of the largest stainless-steel conglomerates globally. The first of its kind off-take agreement in India will see Hygenco Build-Own-Operate the Green Hydrogen facility for 20 years. It will also become the first multi-megawatt scale plant with long-term offtake in Asia to be commissioned in the next 12 months. The large-scale adoption and scale-up of Green Hydrogen across industries will be vital for India, which is significantly dependent on imports for its energy needs. This will provide a significant push to the Government's ambitious National Hydrogen Mission, which envisages the production of five million tonnes of green hydrogen by 2030.

The Green Hydrogen plant will help in reducing JSL's annual carbon emissions by about 2,700 Metric Tonnes per year, enabling decarbonization and pushing sustainable development. Hygenco is aiming to deploy more than USD 300 million in Green Hydrogen projects across the country in the next 3 years. Amit Bansal, CEO of Hygenco, said that "This is one of the most significant landmarks for the Hydrogen industry in India and globally as it demonstrates the competitiveness and cost-efficiency of Green Hydrogen. We are honoured to partner with one of the largest conglomerates globally and help in the decarbonization of steel production, one of the most energy-intensive industries." Hygenco has deep capabilities in designing, building, and operating Green Hydrogen projects. The state-of-the-art and fully autonomous plant will be controlled by an advanced Energy Management and Control System. The system monitors several parameters including hydrogen generation, renewable energy generation, states of charge, pressure, temperature and makes autonomous real-time decisions for achieving high efficiency. The technology enables the company to augment the hydrogen yield and deliver cost-competitive hydrogen to the end clients.

HINDALCO REPORTS HIGHEST NET PROFIT IN FIRST QUARTER AT RS. 4,119 CR

Hindalco Industries Limited, the Aditya Birla Group metals flagship, once again reported its highest net profit in Q1 FY23, surpassing its record performance in Q4 FY22. The company's consolidated PAT peaked to an all-time high of Rs. 4,119 crore, a 48 per cent growth YoY, and 7 per cent sequentially despite rising costs and inflationary pressures. The results were driven by an excellent performance by Novelis, and a robust performance by Aluminium Downstream and Copper businesses, supported by operational efficiencies and higher volumes.

Novelis reported its best-ever quarterly EBITDA and EBITDA per tonne, primarily due to higher product pricing, favorable product mix and recycling benefits. Commenting on the results, Mr. Satish Pai, Managing Director, Hindalco Industries, said, "After the record profitability of the fourth quarter, I am pleased to share that we delivered an even stronger first quarter despite rising input costs and inflationary pressures. Our performance was backed by strong operational efficiencies and pre-emptive sourcing of critical raw material, thus ensuring stable operations and higher margins. Our business model supports our position as an integrated aluminium producer with one of the world's best EBITDA margins. Our product mix enhancement strategy is working well with the Aluminium Downstream EBITDA growing four-fold YoY. Novelis reported its highest ever EBITDA per ton driven by higher product pricing, favourable product mix and higher recycling benefits. Looking ahead, we remain focused on riding all market cycles with our greener, stronger, smarter approach."

Consolidated Results

Hindalco reported an all-time high EBITDA of Rs.8,640 crore (vs Rs.6,790 crore) in Q1 FY23, up 27 per cent YoY. The excellent results were driven by better macros, robust performance of Aluminium Downstream and Copper businesses along with better operating efficiencies. Consolidated revenue for the first quarter stood at Rs.58,018 crore (vs Rs.41,358 crore), up 40 per cent YoY. Consolidated PAT in Q1 FY23 was at a record Rs.4,119 crore up from Rs.2,787 crore in Q1 FY22, a jump of 48 per cent YoY. Consolidated Net Debt to EBITDA remained strong at 1.40x on June 30, 2022 compared to 2.36x on June 30, 2021.

The Indian Mining & Engineering Journal, Vol. 61, No.08 August 2022, pp.08-21
Printed in India, @ IME Publications, ISSN 0019-5944

Quantifying the Performance of Resin Capsules and Comparison of its Efficacies vis-a- vis Mines Safety

Ayan Giri* Ms. Garima Ranka** Anuj Gupta*** Devendra Patil****

ABSTRACT

This article introduces the significance of various features of resin capsules and its efficacy in providing reinforcement and strata strength in underground rock bolting. The items discussed include underground loading conditions, selection of resin capsules, Testing procedure to assess the efficacy of resins during installation and compatibility between support elements basis the study conducted at Baroi Mine at Zawar Group of Mines of M/s Hindustan Zinc Limited. The article touches upon that not only the material quality of the Resin but also how the use of different gel and set time across the length increases the safety aspects.

INTRODUCTION

Resin capsules play a vital role in supporting any underground excavation. It is primarily used as an anchoring medium for rock bolts and provides necessary roof and sidewall support to the underground excavations. Resin capsules are multi-compartment capsule particularly adapted for mining roof bolting systems. It , has become common practice in mining to reinforce or stabilize mine roofs by drilling or boring a hole into the rock strata at the roof of the mine, inserting a resin capsule into the drilled hole and then inserting a specially designed bolt through the capsule into the hole. One compartment in the capsule contains a resin and the other compartment contains a catalyst or hardening agent for the resin. The bolt, as it is inserted, ruptures the capsule and the capsule compartments. The bolt is turned and distributes and mixes the catalyst or hardener with the resin. This causes the resin to cure and harden around the bolt in the drilled or bored hole and in the cracks and voids in the rock structure contiguous thereto. The cured and hardened resin and bolt reinforce and strengthen the mine roof. This is, of course, critical to the safety of the mine and the surface above.

Thus, it is very important to use best quality resin to ensure the safety of people working in underground environment. With the above idea in mind Minova has designed resin capsules "**Lokset™**" to enable full encapsulate mechanised resin bolting, The Lokset X2 system incorporates two resin capsules that are joined and folded in half for packaging . The Lokset resin capsule consists of a reinforced, thixotropic polyester resin mastic in one compartment and an organic peroxide catalyst separated by a physical barrier in the other. The rotation of the bolt during installation ruptures the capsule, shreds the skin and mixes the two components causing a chemical reaction and transforming the resin mastic into a solid anchor. The several advantages of above MRPL resin capsules are listed below

- Full encapsulation with pre-tensioning when using combination Toospeedie capsules
- Rapid insertion, easy and quick to use
- Protects bolt from corrosion, can be used in wet or underwater conditions
- No expansion stresses and can be used in weak strata
- Unique design of capsule configuration enabling extremely effective mixing of resin mastic and catalyst compartments

ABOUT MINES, GEOLOGY AND ITS SSR (SYSTAMATIC SUPPORT RULE)

About Mines

The Zawar group of mines, HZL is located 40 km southeast of Udaipur, Rajasthan State. The group consists of four underground mines: Mochia, Balaria, Zawarmala and Baroi that are being operated with Sub Level Open Stoping (transverse and longitudinal) method to min e zinc /lead /silver ore.

**Head Geotech Baroi-Zawarmala, HZL, BE Mining*
***Executive Commercial, HZL, Master's in commerce*
****Key Accounts Lead MRPL (India), ME and B.Tech. Mining*
*****Lead Quality Assurance MRPL (India), BE Mechanical, MBA (Fin)*

Regional Geology

- Complexly folded geological structure formed out of two distinct periods of tectonic activities (Post Aravalli & Post Delhi orogenies).
- Baroi occupies original northerly plunging structure generated out of Post Aravalli orogeny.
- Bara prospect is located on the south extension of dolomite limb of northerly plunging Zawarmala – Baroi folded structure. The host rock is subjected to intricate multi phased f olding.

Systematic Support Rule's Recommendation

To ensure additional safety all the level developments including that in the waste and ore are systematically supported with rock bolts /cable bolts as per Systematic Support Rule (SSR).

Systematic support system in the form of rock bolts, wire mesh is installed in the excavation drives and crosscuts to ensure long term stability of the strata and roof of development viz., drives and crosscuts, ramp, incline etc. If poor ground or any geological discontinuity plane is encountered like faults and shear zones etc., some additional support elements are used in the form of Dowels/Steel sets and concreting and/or anything else as per the scenario.

To avoid hanging wall failure leading to in-stope dilution, cable bolts are being installed extending into the hanging wall to arrest excessive wall rock failure, especially in areas where the wall rocks are having low RMR or low angle dipping of ore lenses.

The designed SSR has been validated by CIMFR, Dhanbad to ascertain better stability of the shaft and capital developments through field observations, physical inspection of the area and three-dimensional numerical modelling. Also, the study is aimed to suggest

Table 1.0: Designed support pattern for excavations with different dimensions by CIMFR

Stope	Size(m)		Empirical		Numerical Modelling						Remark
	W	H	Length of Bolt	Bolt spacing approx.	Rock Load Ht.	Bolt spacing in a row	Row Spacing	No. of Bolts	Support SF	Bolt Density	
Decline	5.5	5	1.77	1.64	1.25	1.20	1.20	5	2.42	0.69	2 rows side bolting
Ramp	4.2	3.5	1.64	1.45	0.75	1.20	1.20	4	3.53	0.69	Alt. side bolting
Haulage Drive	4.2	3.5	1.64	1.45	1	1.20	1.20	4	2.65	0.69	Alt. side bolting
Ore Drive	4.2	3.3	1.64	1.45	0.75	1.20	1.20	4	3.53	0.69	Alt. side bolting
Cross Cuts	4.2	3.3	1.64	1.45	1.25	1.20	1.20	4	2.12	0.69	Alt. side bolting
Loading Point	4.2	5.5	1.64	1.45	0.75	1.20	1.20	4	4.23	0.69	2 rows side bolting
UG Workshp/ Garage	5.5	4.5	1.77	1.64	0.75	1.20	1.20	5	4.04	0.69	2 rows side bolting
Washing Bay	8	5.5	2.00	2.00	1	1.10	1.20	8	3.33	0.76	2 rows side bolting; Cables @ 2mX2m
Passing Bay	8.5	5	2.05	2.07	1.25	1.00	1.20	9	2.82	0.83	2 rows side bolting; Cables @ 2mX2m
Sub Station	4.2	3.5	1.64	1.45	0.75	1.20	1.20	4	3.53	0.69	1 row side bolting
Conv. Haulage	3.6	3	1.59	1.35	1	1.00	1.20	4	3.09	0.83	
Conv. Ore Drive	3.6	3.2	1.59	1.35	0.75	1.00	1.20	4	4.12	0.83	
Conv. Cross Cuts	3.6	3	1.59	1.35	1.25	1.00	1.20	4	2.47	0.83	
Junctions 4 way	4.2	3.5			1.25	1.20	1.00			0.83	
Junctions 3 way	4.2	3.5			1.25	1.20	1.00			0.83	
Y Junction for Decline	5.5	5				1.00	1.00			1.0	2 rows side bolting; Cables @ 2mX2m
Brow Area	4.2	3.5	1.64		6						Addl. 3 rows of cable bolts (max. 8m length)

possible remedial measures to safeguard present and future ground stability. The major recommendation is attached below.

From the empirical and numerical modeling studies the estimated rock bolting parameters for various locations are tabulated below. The pattern of rock bolting and cable boltin g for various areas of the mine are shown in the table attached. Cable bolts are suggested only in the Ramp where "fair" rock mass of RMR <60 is encountered, at all the junctions occurring at a ramp section. Generally, 1.8 m long rock (full column resin) b olts are sufficient for the ground; however, for Ramp of 5.5 m width and for larger size excavations such as passing bays, washing bay, loading point and workshop, 2.4 m full column resin bolts are recommended by CIMFR.

STUDY PARAMETERS

For conducting the study, HZL Zawar Geotech team along with MRPL (Minova Runaya Pvt. Ltd) team finalized some key parameters which determines the performance of Rock Bolts. Following parameters were covered under this comparison study:

- Resin Bolt bond strength push test
- Physical properties of resin capsules

A summary of other tests conducted along with its results are tabulated below for reference:

Sr No	Test properties	Specification	MRPL Resin Capsule	Local Resin Capsule
1	Gel time & Setting time	- Slow resin capsule: 80 - 100 Sec & 20 Sec - Medium resin capsule: 40 - 45 Sec & 20 Sec - Fast resin capsule: 16 - 20 Sec & 20 Sec	- Slow resin capsule: 80 - 100 Sec & 20Sec - Medium resin capsule: 40 - 45 Sec & 20 Sec	- Single Speedie 45 Sec & 20 Sec
2	**Physical Properties of Resin**			
2.1	Colour	N/A	Fast Set Capsule : Yellow Slow Set Capsule : Green	Single Speedie - Brown Colour
2.2	Limpness	400 mm - 440 mm for 1200 mm Length	410 mm	220 mm
4	Shelf life (Storage @ 20^{O}C)		6 Months	2 Months
5	**Compressive Strength (Applicable for slow-set type of resin only)**			
5.1	After 30mins of cube formation	30 Mpa (min)	36 Mpa	29 Mpa
5.2	After 24 Hrs of cube formation	80 Mpa (min)	88 Mpa	81 Mpa
6	Flammability Test	The product should be of very low flammability.	Very low flammability travel.	Data not available
7	**Bond Strength Test**			
7.1	After 30 Mins	10.0 Tonnes	14 Tonnes	10 Tonnes
7.2	After 24 Hrs	15.0 Tonnes	18 Tonnes	16 Tonnes

MINOVA RESIN CAPSULES

Resin plays a crucial role in any underground environment and thus its quality is of utmost importance. With the above idea in mind, Minova has developed a unique product trademark as " Lokset*TM* Resin" for use in all strata conditions and environment of underground mines.

The unique characters of MRPL resin includes

- "**Speed**" i.e., gel and set time. Multiple speed options available to enhance mixing across bolt length.
- **"Viscosity"** helps with ease of insertion of bolt into hole and increases the shelf life of resin capsules
- **"Corrosion Resistance"** superiority over other locally available resins when rock bolts are fully encapsulated.
- **"Consistency"** for mastic to catalyst ratio across length, providing uniform strength across length

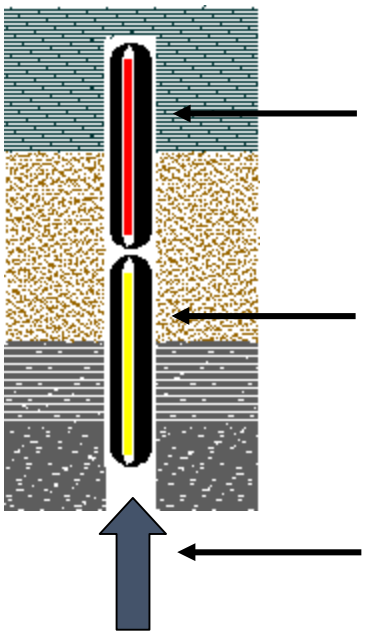
Thus, it is very important to use best quality resin to ensure the safety of people working in underground environment. With the above idea in mind Minova has designed resin capsules "**Lokset™**" to enable full encapsulate mechanised resin bolting, The Lokset X2 system incorporates two resin capsules that are joined and folded in half for packaging. The Lokset resin capsule consists of a reinforced, thixotropic polyester resin mastic in one compartment and an organic peroxide catalyst separated by a physical barrier in the other. The rotation of the bolt during installation ruptures the capsule, shreds the skin and mixes the two components causing a chemical reaction and transforming the resin mastic into a solid

anchor. The several advantages of above MRPL resin capsules are listed below

ADVANTAGES OF TWIN/TOO SPEEDY RESIN CAPSULES

With the advancement in technology and use of mechanized machines for loading, Minova developed Twin speedy Resin capsules, wherein a single resin capsules have 2 different set time and gel time. The process and benefits if using this type of capsules are as below

1) The fast set resin is inserted in the hole first followed by the slow set resin which is towards the hole collar
2) As the rock bolt passes through the slow set resin followed by fast set resins , the lower half (towards hole collar) of the resin spins for longer time as compared to upper half (towards hole toe) the fast set resins allows quicker tensioning while the slow resin is setting, without generating any cracks during setting time unlike single speedy capsules which might generate cracks in the lower half due to high spinning time



Fast Set:

1) As bolts take time for insertion in hole the upper half gets less spinning time.
2) With fast setting time the upper half is quicker thereby reducing cycle time for bolt installation

Slow Set:

1) As bolts first penetrates here, the lower half gets more spinning time.

3) Sets slower and thus no deformation takes place even when the resin is spined for a longer time thereby ensuring better

Rock Bolt Insertion end

PHYSICAL PROPETIES OF RESIN CAPSULES

Any resin which are used in mines, should have certain physical properties to ensure efficiency in operations. Some of these properties are listed below

Limpness: This helps to ensure that resin remain taught while getting installed in the holes. MRPL resins were found to be stiffer, bend at a length of 410mm vs 220mm for local resin for a length of 900mm and thus were easy to insert in the holes. MRPL resine

Figure 1: Limpness Test of Resin

Uniform Distribution of Mastic and Catalyst : To ensure efficient grouting of resin across the length of bolt, it is very important to have uniform distribution of catalyst and mastic across the length of resin. It was observed that in locally manufactured resins significant air bubbles were present across its length which might lead to lower st rength.

Figure 1: Locally Manufactured resin (Air bubbles observed throughout the length)

Figure 2: MRPL resin capsules were uniformly distributed across the length without any air gaps

RESING CAPSULE BONDING STRENGTH

For any rock bolt to perform, the uniform mixing of resin across the bolt length is of utmost importance. Additionally, the quality of resins and setting time is also a very cr ucial parameter. If the resin capsule is having a uniform set time across its length, the lower half of the resin capsules starts to get set while the bolts are installed. This may lead to cracks and loss of strength in the resin capsules. MRPL twin speedy capsules incorporates a unique design wherein the resin has a combination of 2 different set times (fast and slow) across its length. This allows that lower half which gets more spinning sets slower allowing it to retain its strength while the upper half sets quicker with less spinning and maintaining uniform strength across bolt length.

TESTING METHOD

To conduct the test, a 2.4m long threaded steel tube with one end sealed (33mm I.D. internally threaded 1 1/4', 9 mm wall thickness) MS was made. In these tubes, Rock bolts were installed with different resins (MRPL resin capsule and 1 local resin capsule) to analyze the mixing and bonding of resin with the bolts.

The installation of Bolts in the tubes was conducted at Zawar North Baroi Mines. A 64mm hole was drilled where the tubes were placed and anchored. The installation happened with usual method to resemble daily operational conditions in the mines.

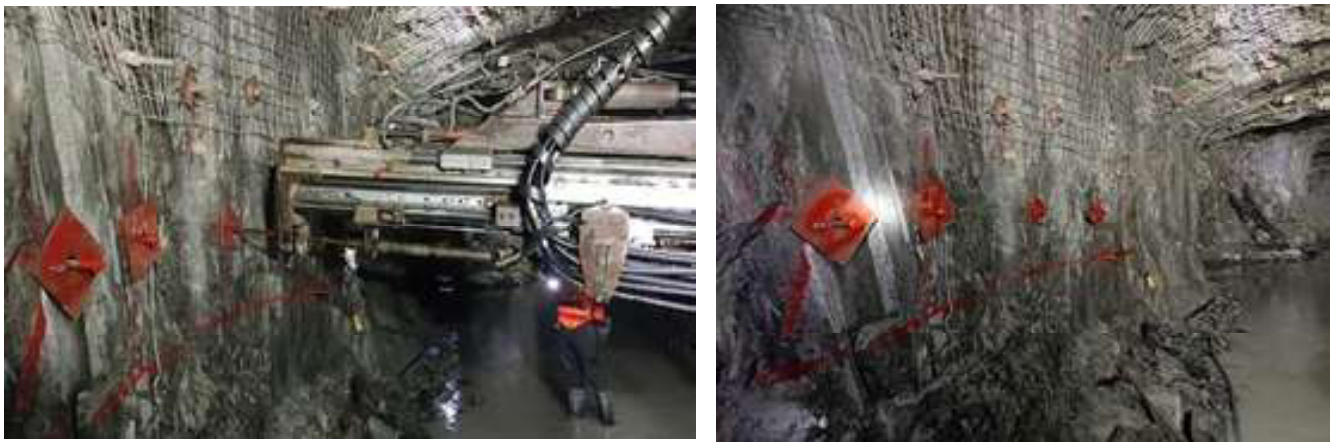
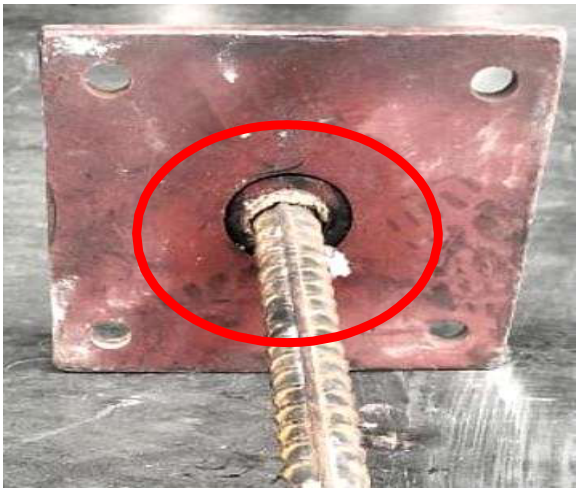


Figure 9: Complete Bolt Installation in Tubes at Mines

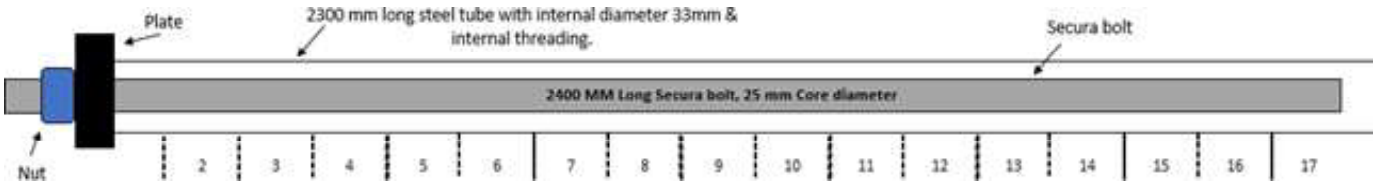
MRPL resin capsule at collar



Local resin capsule at collar

Figure 10: Tubes Post Installation

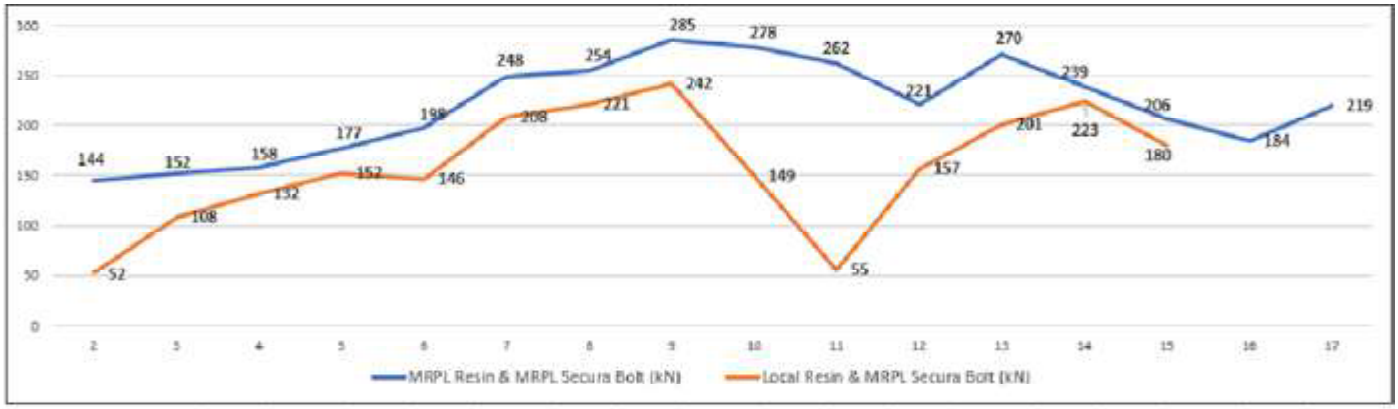
Post installation, each tube was cut into a section of 100 mm each and push test was conducted to check the bonding strength of bolt and resin, which each 100mm section at the end discarded.



CONCLUSIONS

- Twin speedy resins provides better and uniform encapsulation across the length of bolt resulting in average strength being 37% higher when compared with local resin (218 kN vs 159 kN)
- MRPL resin exhibited better strength at the bolt collar which will help reduce the formation of loose rocks from collar post blasting.
- MRPL twin speedy resin ensured that the lower half does not set before bolt is properly installed across full length of the hole whereas for local resin due to same set time across length, the lower half of resin set quickly which led to improper installation of bolt

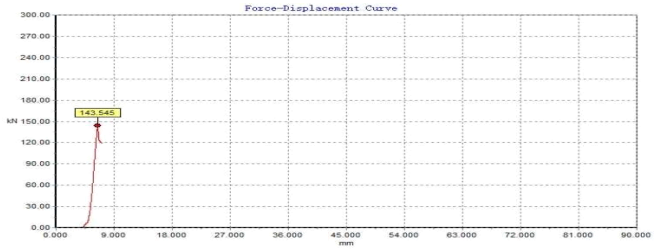
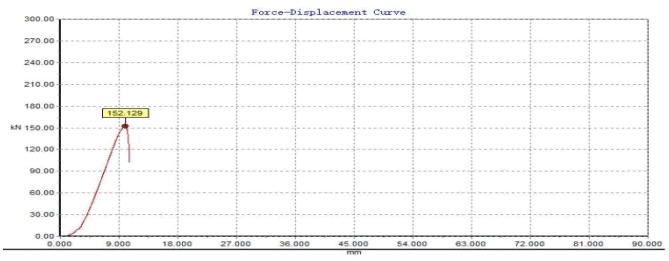
RESULT OF PUSH TEST

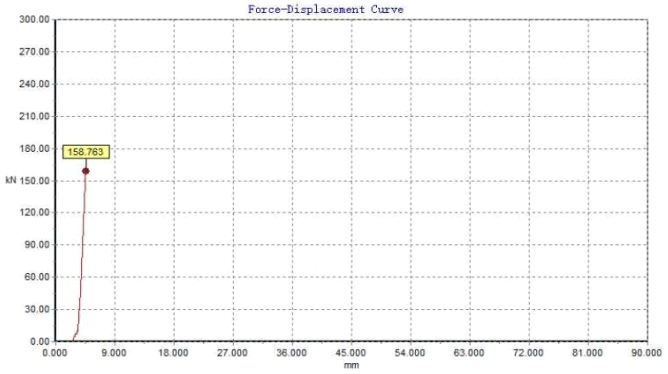
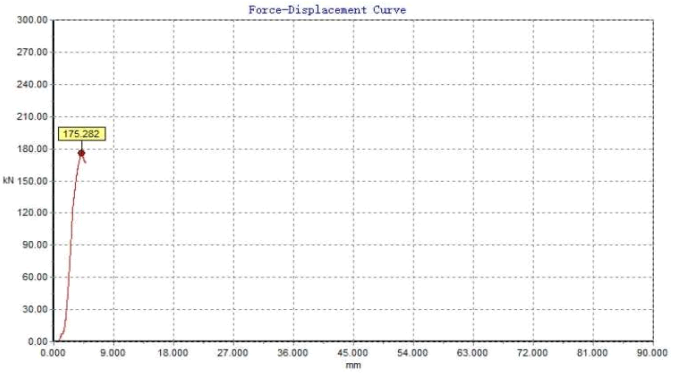
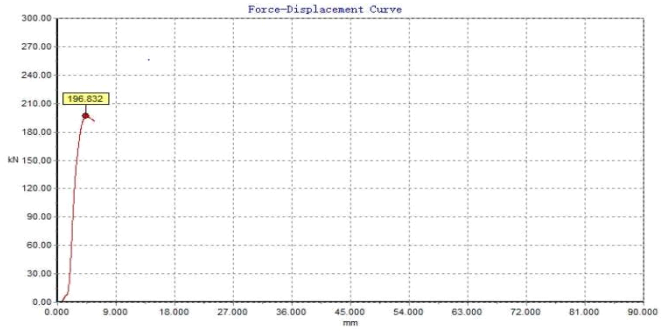


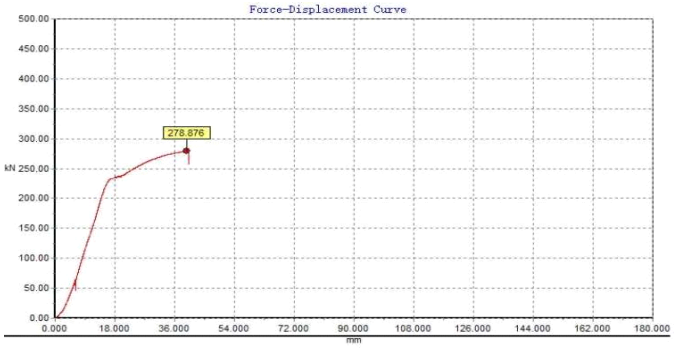
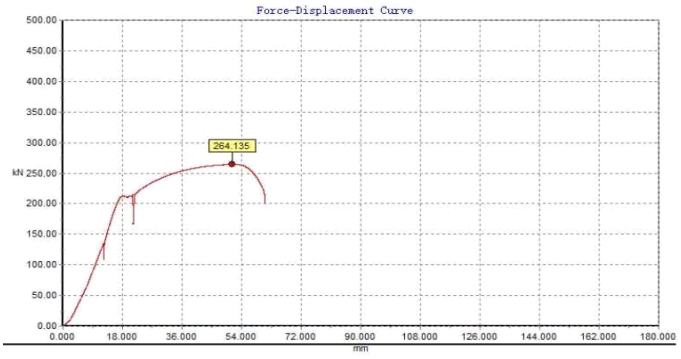
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Average
MRPL Resin & MRPL Secura Bolt (kN)	144	152	158	177	198	248	254	285	278	262	221	270	239	206	184	219	218
Sample length (mm)	101	99	98	99	100	96	99	98	98	100	97	97	100	99	96	99	-
Deformation (mm)	2	2	3	3	4	4	5	4	5	5	5	4	3	3	2	3	-
Local Resin & MRPL Secura Bolt (kN)	52	108	132	152	146	208	221	242	149	55	157	201	223	180	Bolt not installed properly (Shear pin broken early)		159
Sample length (mm)	100	98	95	100	102	98	99	95	100	99	101	95	98	101	-	-	-
Deformation (mm)	2	3	3	4	4	5	5	4	4	5	6	4	3	3	-	-	-

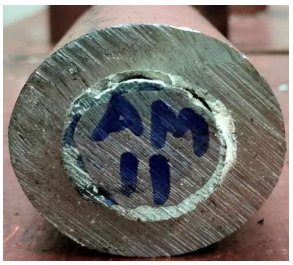
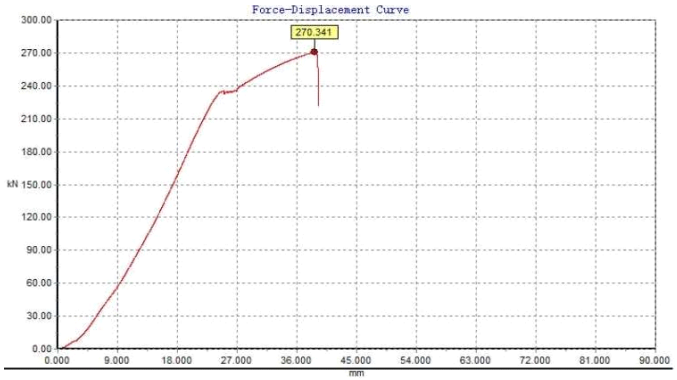
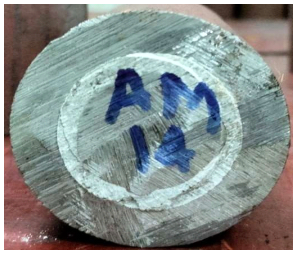
	MRPL Resin	Local Resin
Average Push Test	218 kN	159 kN

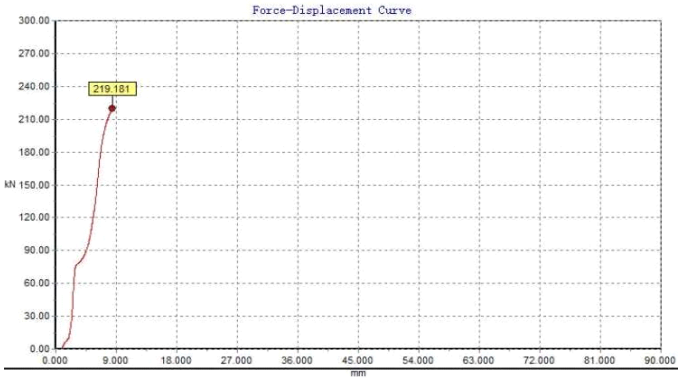
Note: Due to lower set time of local resin the bolt was not inserted to the complete length. Such installed bolts could prove a major safety hazard in the mines as they are not installed to their full length

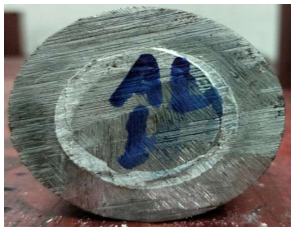
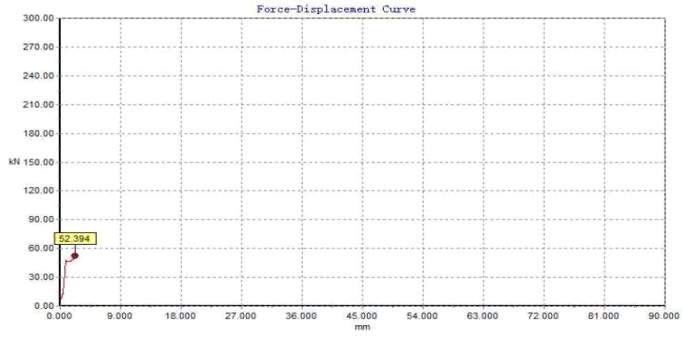
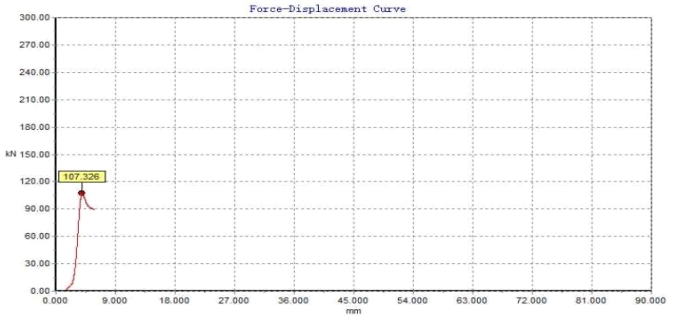
Section	Sample	Test Result	Remarks
1			Peak Load : 143.545 kN
2			Peak Load : 152.129 kN

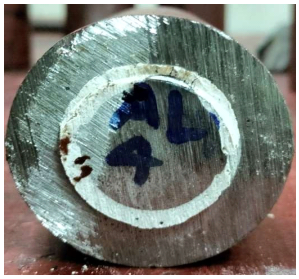
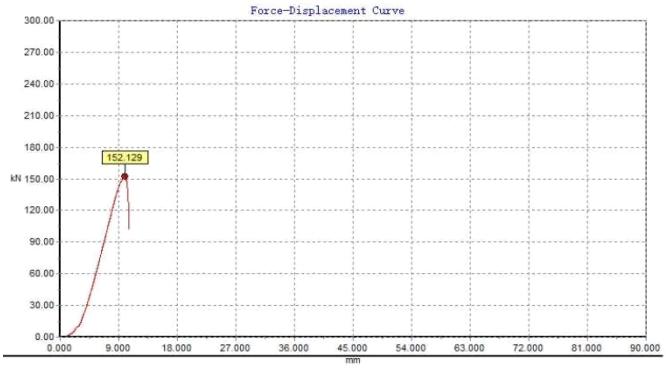
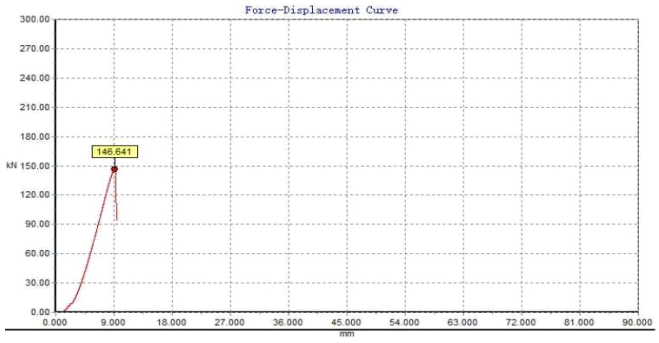
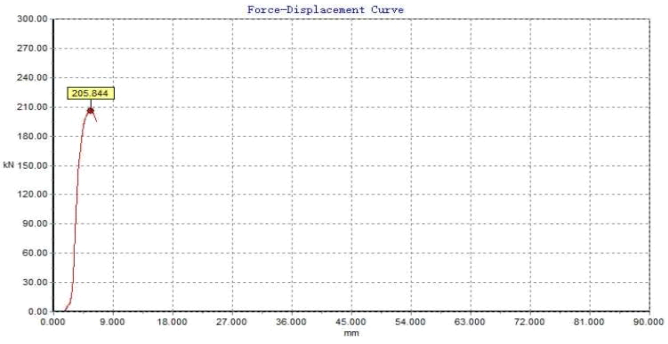
3			Peak Load : 158.763 kN
4			Peak Load : 175.282 kN
5			Peak Load 196.8 kN
6			Peak Load : 248.215 kN

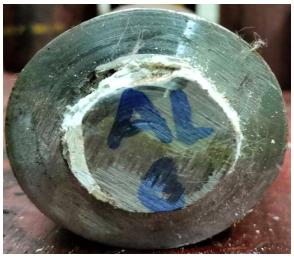
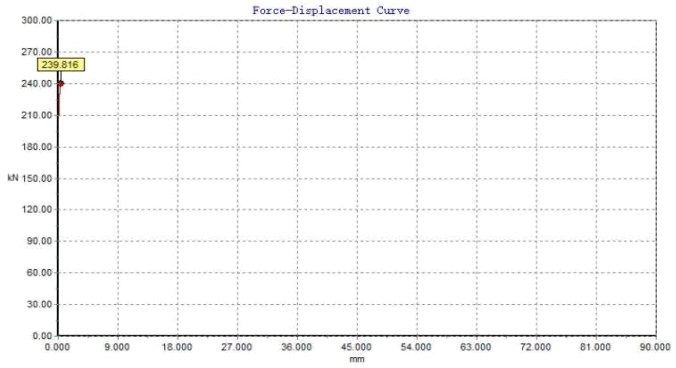
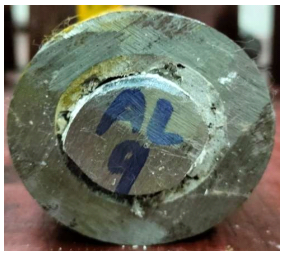
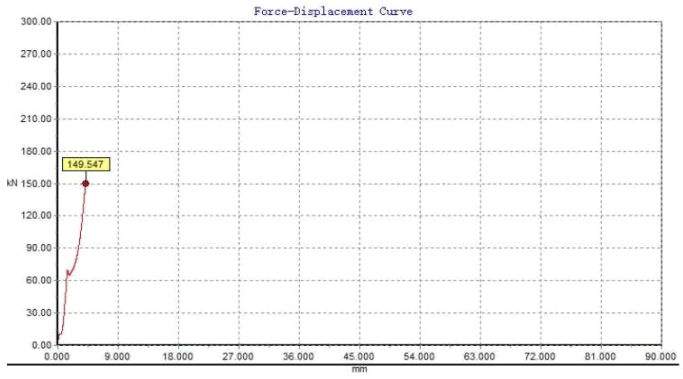
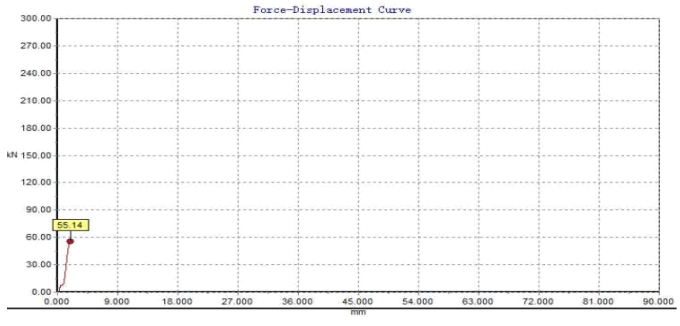
7			Peak Load : 253.546 kN
8			Peak Load : 285.126 kN
9			Peak Load : 278.876 kN
10			Peak Load : 264.135 kN

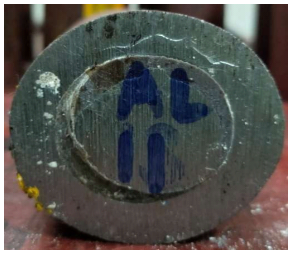
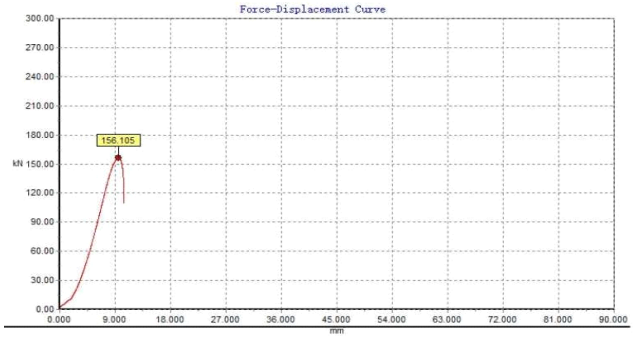
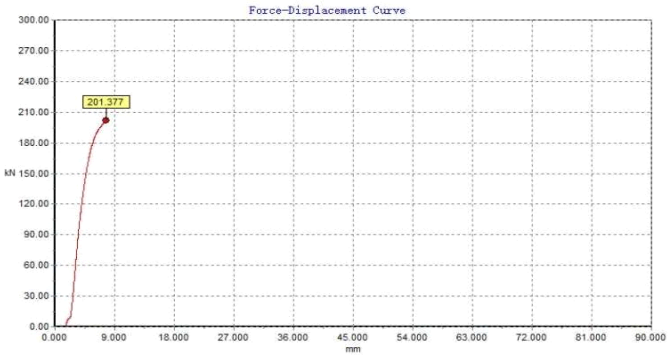
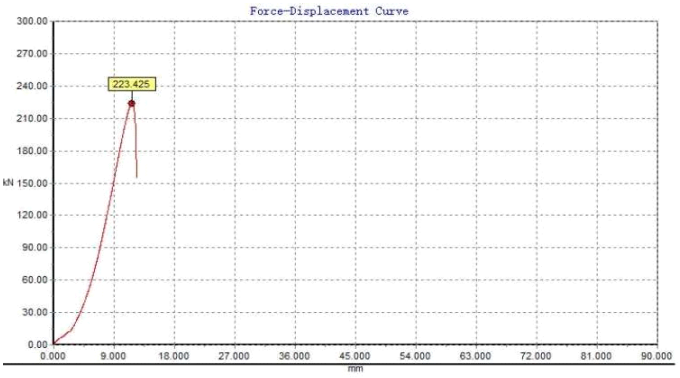
11			Peak Load : 220.739 kN
12			Peak Load : 270.341 kN
13			Peak Load : 239.433 kN
14			Peak Load : 206.954 kN

15			Peak Load : 184.728 kN
16			Peak Load : 219.181 kN

Section	Sample	Test Result	Remarks
1			Peak Load : 52.394 kN
2			Peak Load : 107.326 kN

3			Peak Load : 133.026 kN
4			Peak Load : 152.129 kN
5			Peak Load : 146.641 kN
6			Peak Load : 205.844 kN

7			Peak Load : 219.500 kN
8			Peak Load : 239.816 kN
9			Peak Load : 149.547 kN
10			Peak Load : 55.140 kN

11			Peak Load : 156.105 kN
12			Peak Load : 201.377 kN
13			Peak Load : 223.425 kN
14			Peak Load : 180.359 kN

The Indian Mining & Engineering Journal, Vol. 61, No.08 August 2022, pp.22-24
Printed in India, @ IME Publications, ISSN 0019-5944

An Investigation into Air Pollution Due to Mining by Open Cast Method, WCL, Madhya Pradesh

Kundan Singh* S. Dasgupta**

ABSTRACT

This investigation present the assessment of ambient air quality carried out at an opencast coal mining area in Madhya Pradesh state of India. Opencast coal mining creates more air pollution problem in respect of dust and the fines contain coal particles, benzene, soluble matters etc. To maintain the energy demand, opencast mining has been growing at a phenomenon rate in India. There is no well defined method for assessing the impacts on air quality due to mining projects. An investigation was conducted to evaluate the impacts on air quality and the characteristics of the air borne dust due to opencast coal mining in Indian context. The study area has been described and the sources of air pollution were identified. Methodology adopted for the selection of air monitoring to evaluate the impacts on air environment due to coal mining activities have been discussed.The ambient air quality survey was carried out in march 2022 , four different locations with respect to SPM, PM10, PM2.5, NO2 and SO2 was always found below the permissible limit at all the sampling site.

KEYWORDS – Pollutants, Particulate matter, Air pollution.

INTRODUTCION

Air pollution is the processes which the substance is not present in normal atmospheric composition reach the atmosphere, or is present but in much lower concentrations. Air pollution is introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment into the atmosphere. The link between environmental issues and the development is one of the leading issues of the present time. The development progression has customarily been accompanied by rapid increases in energy demand. Different sources of energy, from fossil fuels to nuclear , pollute the environment in different ways and at different levels (Omer,2008).Presently energy is largerly produced by burning of fossil fuels such as coal, oil and natural gas (Vezilogru and sachin,2008).Among all these energy sources , coal is a crucial resource ,most abundantly present , and is also the cheapest source of energy (Franco and Diaz,2009).

Coal provides 29.6% of global primary energy needs, generates 42% of the world's electricity, and global coal consumption has increased by by 46% during 2001 to 2010 (World coal Association, 2011).In order to meet the energy requirement, the overall coal production and coal mining have tremendously increased in India, which ranks third among top ten coal producing countries (World coal Association, 2011).

The health effects of particulates are strongly linked to particle size. The extent to which airborne particles penetrate into the human respiratory system is mainly determined by the size of the penetrating particles. Small particles, such as those from fossil fuel combustion, are likely to be most dangerous, because they can be inhaled deeply into the lungs, settling in areas where the body's natural clearance mechanisms cannot remove them. The constituents in small particulates also tend to be more chemically active and may be acidic as well and therefore, more damaging. Atmospheric particles with an aerodynamic diameter smaller than 10 μm (PM10) have been put under scrutiny in the past, are easily inhaled and deposited within the respiratory system. Studies show that PM10 plays a role in the incidence and severity of respiratory diseases;(Pope and Dockery,1999)7and have significant associations with a decline in lung function and cardiovascular pathologies.

Mining is one of the core sector industries, which plays a major and crucial role of the process of the country's economic development but the environmental impact of coal mining cannot be ignored and coal-based industries may be conveniently listed as the major polluters. Coal mining, it's processing, and utilization give rise to air pollutants, particularly suspended and respirable particulate matter. The operation of excavators,

**Mtech Mining **Professor Mining Engg.*
Aks University Satna (MP)
Corresponding Author:singhkundanpoly@gmail.com

transporters, loaders, conveyor belts, etc., result in massive discharges of fine particulates, which depends on individual sites due to differences in geology, mineral, terrain, and many other factors. The extraction stage primarily produces larger particles with limited dispersion, which have major effects on mine workers and occasionally on local residents. Similarly, operation of primary and secondary crushers in sizing the coal, handling and storing of crushed coal, operation of screens, dispatching of washed coals, etc. The mining activities contribute to the problem of air pollution directly or indirectly (Baldauf et al;2001).

The most important emissions during coal mining and through active mine fires

are particulate matter (PM), sulfur dioxide (SO2) and ,nitrogen dioxide (NO2) .These air pollutants deteriorate air quality and ultimately affect the human health, flora and fauna in and around coal mining areas (Singh et al; 1991)

STUDY AREA

One of the most important coalfields in India as well as in Madhya Pradesh and Maharashtra known as Western Coalfields has been selected for this research. The Pench coalfield is bounded by Latitudes 22°10'36"and Longitudes 78°44'46" and is located in the central part of India.

MATERIALS AND METHODS

The study was conducted for a period of two months at the interval of 15 days . At each site 4 hrs samples were collected in each 15 days in the afternoon 2 PM to 6 PM. Four sampling sites for ambient air monitoring were selected. These are New Sethiya OC, SAM Office , Chhinda Village and Chhinda Colony. Monitored parameters were SPM,PM10,PM2.5,SO2 and NO2 was used for air sampling and analyzed as per standard .

Table 01 Average air pollutants concentration (µg/m3) at sampling station in march 2022.

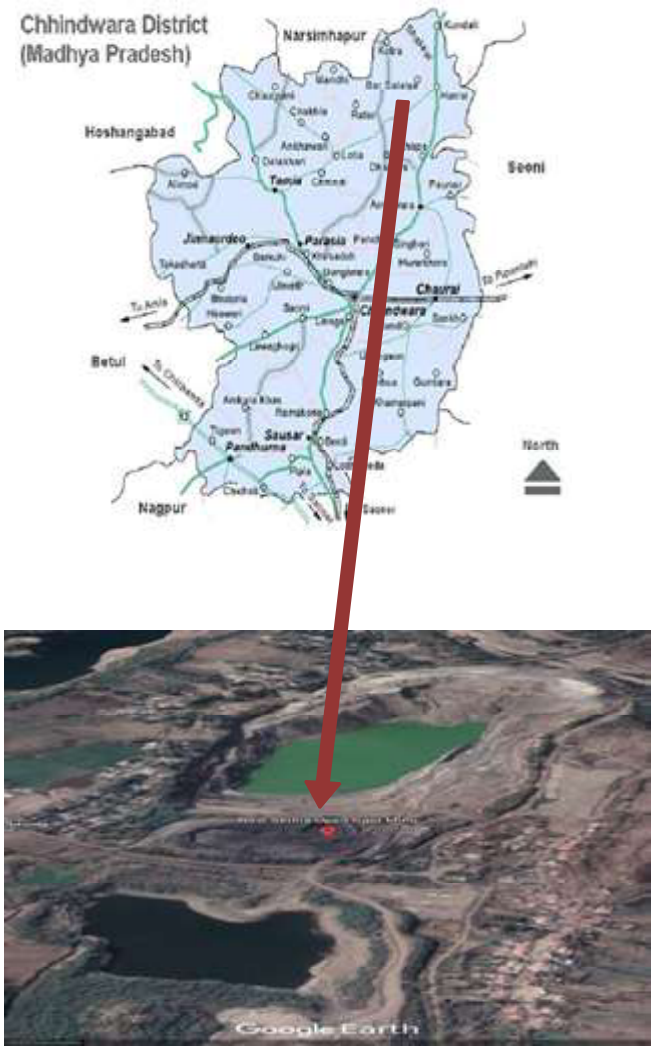


Figure1: Location of study area

Station	Parameters				
	SPM	PM_{10}	$PM_{2.5}$	NO_2	SO_2
New sethiya oc	273	176	52	20	00
SAM Office	292	196	60	22	00
Chhinda village	142	93	38	14	00
Chhinda Colony	136	74	34	13	00

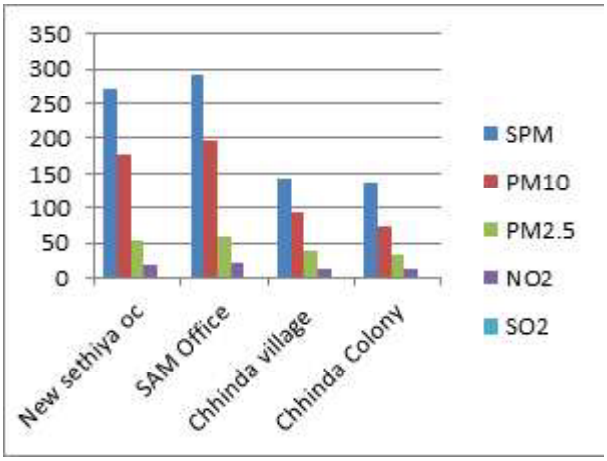


Figure 2: Showing concentration of various parameters in March 2022

RESULT AND DISCUSSION

As per the study (Table 1 and figure 2) the maximum value of SPM was found 292 µg/m^3 at SAM office and minimum value was observed 136 µg/m^3 at Chhinda colony. All values of SPM at all selected stations obtained below the permissible limit (500 µg/m^3) on studied months. The maximum value of PM_{10} was found 196 µg/m^3 at SAM office and minimum value was observed 74 µg/m^3 at Chhind colony . All values of PM_{10} all selected stations were obtained below the permissible limit(100 µg/m^3) on studied months. Similarly $PM_{2.5}$ was also observed below the permissible limits (60 µg/m^3) at all selected stations on both studied months. The maximum value of $PM_{2.5}$ was found 60 µg/m^3 at SAM office and minimum value was observed 74 µg/m^3 at Chhinda colony. NO_2 values were found within limits (80 µg/m^3) at all selected stations in study periods. The maximum value of NO_2 was found 22 µg/m^3 at office and minimum 13 µg/m^3 at Chhinda colony. SO_2 was absent in air during the study period.

CONCLUSION

Air pollution was opencast coal mining area in Parasia at Chhindwara distt. Indicates that SPM , PM_{10} and $PM_{2.5}$ always found below the permissible limit but SO_2 and NO_2 were always below the permissible at all the sampling site in the month. A management strategy is formulated for effective control of particulate matter at source and other mitigative measures are recommended including implementation of green belts around the sensitive areas.

ACKNOWLEDGMENTS

Author is grateful to Mr. D. K. Pandey, Manager, New Sethiya OC Mine WCL, Pench Area,Chhindwara , for necessary help in conducting the field study and providing mining data.

REFERENCE

- APHA, Method of Air Sampling and Analysis, Washington D. C., USA 1994.
- Baldauf, R.W., Lane, D.D., Marote, G.A., Ambient air quality monitoring network design for assessing human health impacts from exposures to airborne contaminants. *Enviro. Monit. and Assess. 66, 63–76,2001*.
- Chaulya , S.K. Air Quality status of an open pit mining area in India, *Environ. Monito. And Assess.105,369-389,2005.*
- Chaurasia, S.Ahmad ,I.Gupta, A.D. and kumar, S., Assessment of air pollution emission from cement industries in Nimbahera, Rajasthan , India, *Int.J.curr.microbiol.App.sci.3(3),133-139,2014.*
- CPCB (Central Pollution Control Board), National Ambient Air Quality Standards (NAAQS), Gazette Notification, New Delhi,2009.
- Franco, A., Diaz, A.R.,The future challenges for “clean coal technologies”: Joining efficiency increase and pollutant emission control. *Energy 34, 348–354,2009.*
- Ghose, M.K.,Air pollution due to opencast coal mining and the characteristics of air borne dust-An Indian scenario,*Inter.J. Environ.Stu.59(2),211-228,2002.*
- Omer, A.M.,Energy, environment and sustainable development. Renewable & Sustainable Energy Reviews 12, 2265–2300,2008.
- Pope C.A.,III and Dockey, D.W., Health effect of fine particulate air pollution , lines that contained , J. *air and waste management asso.56,709-742,2006.*
- Pio, C.A., Feliciano, M.S., Dry deposition of ozone and sulphur dioxide over low vegetation in moderate southern European weather conditions: Measurements and modeling. *Physics and Chemistry of the Earth 21, 373–377,1996.*
- Singh, J.S., Singh, K.P., Agrawal, M., Environmental degradation of the Obra Renukoot–Singrauli Area, India, and its impact on natural and derived ecosystems. *The Enviro.list 11, 171–180,1991.*
- Veziroglu, T.N., Sahin, S., 2008. 21st Century’s energy: Hydrogen energy system. *Energy Conversion and Management 49, 1820–1831,2008.*
- World Coal Association, 2011. Coal Facts 2011, http://www.worldcoal.org/

The Indian Mining & Engineering Journal, Vol. 61, No.08 August 2022, pp.25-31
Printed in India, @ IME Publications, ISSN 0019-5944

Sustainable Mining in India – The goal & Challenges : A Critical Analysis

Supratim Daschoudhury*

ABSTRACT

Mining can become more environmental friendly and sustainable by adopting and integrating the social, environmental and economic development that will minimize the environmental impact of mining operation. These include less usage of water and energy consumption, minimizing land disruption and waste production, preventing air, water and soil pollution at mine sites and conducting successful mine closure, reclamation and rehabilitation activities.

Sustainable mining is a process, a complete system which operate in compliance with the various norms/ rules being laid down by the Govt. keeping in pace with the technological changes. Sustainable mining not only provide relief from poverty, hunger and servitude for local communities but also take care of environment, ensures safety to the all categories of mining staffs, educating their children, providing adequate healthcare facilities and emphasizing on minimizing waste, recycle, reuse and upholding interest of local people even after mine closure.

KEYWORDS: Sustainability, sustainable mining, environment, scientific mining, mine closure.

INTRODUCTION

Mineral resources in India are mainly divided into five categories, fuel, metallic, non-metallic, atomic and miner with Ministry of Mines is the apex institutional organization. The Institutional Architecture of Mineral sectors in India (Fig.1) also engulfs and takes care of Mines and Minerals (Development and Regulation) Act, 1957, amended in 2015, and Natural Mineral Policy, 1993, revised in 2008, which not only emphasizes on conservation of minerals but also states that all mining shall be undertaken within the parameters of a comprehensive sustainable development frame work which includes guiding principles for a miner to leave the mining area in a better ecological condition after mining. (Ref.1)

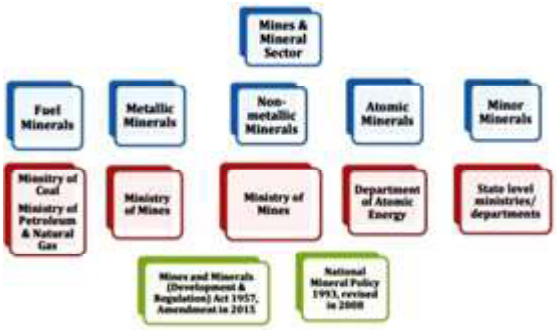


Fig. 1 : Institutional Architecture of Mineral Sector of India

Sustainable mining is a minimization of Negative environment, social and economic impact associated with mining and processing activities while limiting extraction to rates that do not exceed capabilities to establish new sources, substitutes or recycle any particular material so as to not compromise with potential.

Application of sustainability principle to mining is inherently challenging as mining is the act of remaining and consuming a limited sources. However consideration of sustainability, meeting present needs without compromising needs of future generation, increasingly being incorporated into mine development and operation as demand for minerals and product of mining such as metal, fuel and non fuel minerals and the environmental impact associated with mineral extraction activities continue to increasing.

A common sustainable mining frame work is focused on reducing environmental impact of mining. Strategies for assessing the sustainability of mining operations include measuring, monitoring and working to improve various environmental performance metrics and these are used to determine whether a mining operation is sustainable. The key metrics for environmental sustainability in mining relate to efficiencies in resources consumption, minimizing the land disturbance, pollution reduction and as well as closure and reclamation of exhausted mine land.

**Visiting Faculty, Department of Inorganic & Organic Chemistry*
Institute of Pure & Industrial Chemistry, Ichapur, Howrah, West Bengal
Corresponding Author : supratim_daschoudhury@rediffmail.com

Another sustainable mining frame work transition from the emphasis on the environmental footprint of mining operation to responsible management of non fuel mineral resources throughout their entire life cycle including use phase and end of life with attendant implications for reducing the quantity of mined mineral and preserving resources for future generation. (Ref.2)

SUSTAINBILITY IN MINING

A mining project normally has the following phases of mine life cycle (Fig.2)

1) Exploration
2) Mine Planning
3) Construction
4) Mineral extraction
5) Mine closure
6) Reclamation and Rehabilitation (Post closure)

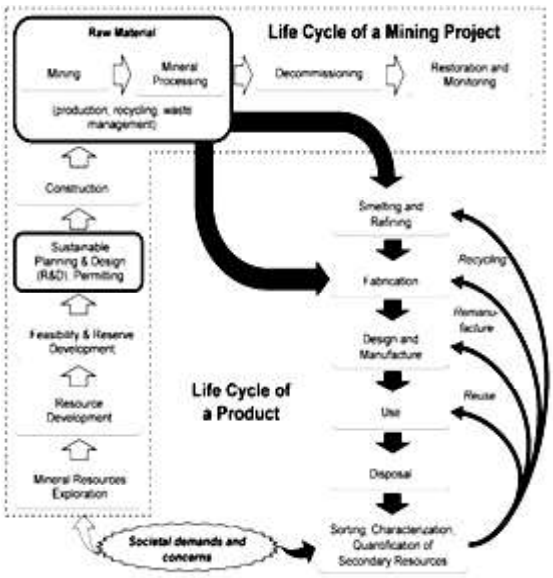


Fig. 2 : Life Cycle of a Mining Project

Sustainability means "the exploration, design, construction, operation and closure of mines in a manner that respects and responds to the social environment and economic needs of the present generation and anticipates those of future generation in the communities where the mining companies work."

The two main conditions for achieving sustainability are good governance and self regulating mining enterprise which are economically stable, financial profitable and technically efficient. Sustainability principals have application for all stages of mine life cycle, exploration, mine planning, construction, mineral extraction, mine closure, and post closure reclamation and rehabilitation. These principles includes elements such as intra and inter generational equity, the precautionary principles, scientific mining, management of environmental and socio economic impact, creation of substitute capital in the form of social and physical infrastructure and stakeholder engagement.

However, the following five ways can be taken into account to reduce environmental impact and to make the practice more sustainable.

i) Lower impact mining technique.
ii) Reusing mining waste.
iii) Eco-friendly equipments
iv) Rehabilitating mining sites.
v) Shutting down illegal mines and mining operations. (Ref.3)

Traditional mining techniques e.g., open pit and underground mining have a severe impact on the environment and present some of the most significant environmental risk. Hence by using alternative low impact mining techniques e.g. in-situ leaching, mining companies can reduce their environment impact with many of these techniques, companies can significantly reduce surface disturbance at mining sites, lower soil erosion and move less material that would need backfilled.

Reusing mining waste can greatly contribute towards sustainability in mining operations. Companies can use waste rocks in simple on sites construction, like back filling voids and reconstructing mined terrain in a way that prevents soil erosion.

If adequately treated mine water can be reused for agriculture, as coolant, in on site dust suppression and for drinking water. Tailings often toxic and left behind in mine sites or stored in large scale tailing dams can find eco-friendly use depending on the mineral and chemical composition of the tailings.

Battery driven mining equipments is often powerful enough to replace diesel driven options. Replacing Diesel Engine with Electric Engines wherever possible can significantly

reduce the amount of CO_2 produced in mining operation. (Table 1)

All these efforts lead toward the concept of green mining which entails a careful balance of measures and adopting new equipment and altering the supply chain to accommodate more sustainable process.

Table 1 : Green Mining

Technology	Old Method	Green Mining Method
Power Use and Emissions	Large amounts of grid power were necessary. Equip-ment used high-emission fuels like diesel and propane.	The mining site will have its own heat and power plant running on natural gas. Equipment will also run on natural gas.
Water Use/Waste Water Production	Huge amounts of freshwater had to be pumped to the site for use. This water would then be used and up to 850 gallons of waste water would be produced per minute which then had to be pumped miles away to evaporation ponds.	Almost the entire initial freshwater brought in to start the process can be recycled. More than 120 acres of evapo-ration ponds will be eliminated and fresh-water consumption will be reduced by about 90%.
Tailings	Mine tailings needed to be stored behind a tailings dam along with the wastewater.	Water will be removed and recycled from the tailings to create a paste. The paste will be layered and impact on the environment will be minimized.
Air Emissions	Harmful chemicals had been emitted into the atmosphere from previous methods.	The harmful chemicals are still produced, but now there are fuel gas treatment plants to minimize CO_2 and other chemical emissions.

The term illegal mining refers to cases where operators harvest resources, they have no legal right to exploit. There is usually an absence of land rights, mining licenses or exploration of mineral transportation permit. Official statistics indicates that there were more than 82,000 instances of illegal mining in 2010 alone, an annual rate of 30 criminal Act for every legitimate mining operation in the country. But this report as well argues that an even bigger problem in the failure of key regulatory mechanism to ensure that even legal mine operators comply with the law and respect human rights.

For an example, Bellary, a Remote district of Karnataka (Fig.3) got transformed into a barren land due to excessive mining, now devoid of agriculture and with shrinking ecosystem. Unscientific and illegal mining has even affected the rainfall pattern of Bellary and has rendered its land unfit for cultivation. (Ref. 4)

Fig. 3 : Illegal mining at Bellary devastated the area. Photo source – down to earth, March, 2011

The negative effect of illegal mining are as follows :

1. The formation of sick holes.
2. Contamination of soil and ground water.
3. Loss of bio-diversity.
4. Chemical leakage.

The M. B. Shah commission which was set up by the Central Government in November 2010 highlighted how high export prices are fuelling large scale illegal mining of the ores in several states of India. Karnataka for example lost around 16,000 crore due to illegal mining between 2006 and 2010. The commission recommends banning export of the worse until and “effective enforcement agency is in place to check illegal mining operation”. The commission report points out that a large number of mines in the state are working without the required approval under the forest conservation Act. (F.C.A.) of 1980. Since illegal mine operators do not confirm to the essential norms pertains to safety of the workers and proper mine closure, reclamation and rehabilitation which gives birth to large scale social dissatisfaction among local project affected people. Natural resources should not be “Frittered away”, by just one generation and need to be conserved, the commission report says. (Ref.5)

THE GOAL FOR SUSTAINBLE MINING & DEVELOPMENT :

To follow the process of sustainable mining is not a very easy task. Sustainable mining is chiefly based on the advancement of technology and to incorporate the new technology and latest scientific operational system successfully in the entire mining operations. If keeping pace with the technological advancement is one side of

the coin, the other side of the coin is closely monitoring all the parameters and day to day data of every operation so that in no way the pollution can go beyond the stipulated limit with an eye on the safety of the front line mining staff. The steps of sustainable mining and development are summarized be as follows:

A. To implement scientific mining

Prior to 1970's, haphazard and unscientific mining was widely prevalent in the Indian Coal industries. (Fig.4)

Fig. 4 : Pictures showing Unscientific Mining

The nationalization of the coal mines changed the situation in both CCL and TATA Steel the accent now is on scientific mining which is sought to be realized through a series of technical management mining practices in their coal mines. However, the steps of scientific mining are as follows :

1. Preparation of systematic mining plan and use of state of the art mining software in mine planning and implementation.
2. Formulation of EMP through the EIA process.
3. Adoption of wet drilling and controlled blasting techniques in the order to reduce vibration and dust.
4. Blast free mining using surface miners for producing coal with reduced air pollution and improved quality and conservation of coal.
5. In pit crushing and conveying of coal through conveyors belts for less dust and noise.
6. Using advance equipment in place of conventional cyclones and Vacuum belt filters for coal beneficiation and reducing ash content of coal.

An important aspect of scientific mining is related to mineral waste management. In the open caste mines provision are made for the removal and storage of top soil and sub soil separately so that these can be re-laid at the time of reclamation for developing the land uses of the reclaimed land surface. Here the external waste dumps are provided with toe walls, toe drain etc. In the order to reduce soil erosion scientific mining takes care of solid and liquid waste management which includes proper identification, segregation, collection and disposal of solid waste, safe disposal of hazardous waste into impervious concrete bins, disposal of tailings for reuse in brick kilns, use of washery rejects as fuel in power houses, collection of used pill by oil recovery system and its disposal through authorized recyclers.

B. Minimizing Environmental Impact

The next step towards sustainable mining is to minimize the environmental impact which takes three main forms.

a. Land disturbances that covers change of land used and land form, visual impact of an open pit or waste dump and subsistence of the ground surface due mining.
b. Destruction of habitat including flora, fauna, natural watersheds and drainage pattern and of aquifier causing lowering of water table.
c. Adverse chemical impact of improperly treated waste which cover air pollution due to dust and noxious fumes, water pollution due to surface run off from different areas of mines, waste dumps seepage from tailing, dam etc. effluents including acid mine drainage, associated with many past and present coal and metaliferrous mines, as also noise and ground vibration due to blasting. (Ref.6)

Mineral washes and contaminated process water and run off are the two major releases from mining and their management presents a great challenge to the mineral industry. In case of metaliferrous mining, high volume of wastes are produced because of low or very low concentration of metal in the ore. Further mines are the big contributes of carbon in the environment (Carbon Emission).

The environmental impact of iron ore mining in Chhattisgarh is massive. (Fig.5) The Bailadila (Dantewara) and Dallirajhra, the Shankhini and Dankini rivers are the most polluted rivers in India. Shankhini is the main river in Bailadila, due to excess mining the colour of the river water is converted to red water and there is a huge scarcity of drinking water in this region. (Ref.7)

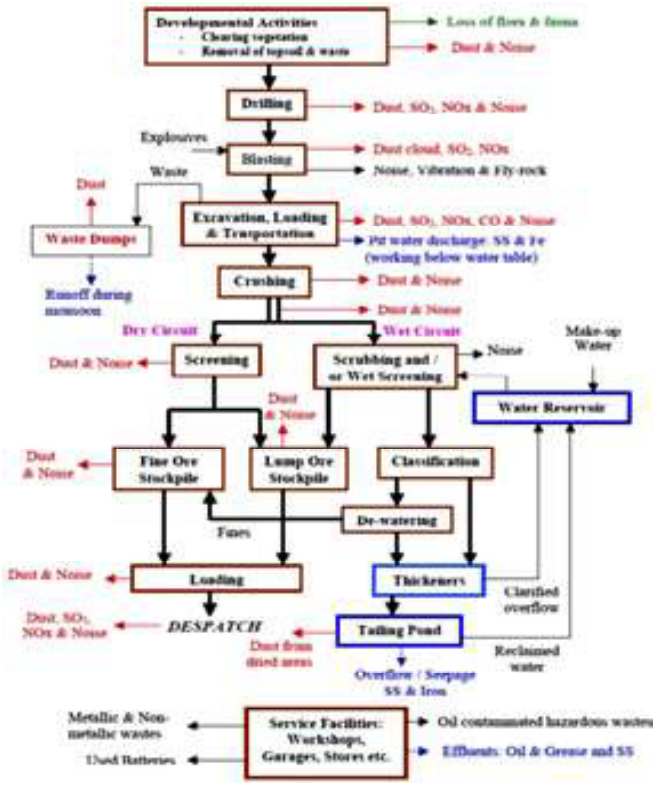


Fig. 5 : Environmental consequence of an iron ore mine

Methane in the second biggest contributor to global warming after CO_2, with a shorter atmospheric life time, but much stronger potency and warming potential. During mining fractured coal steams and surrounding strata emit methane into atmosphere.

The countries with the highest amount of methane emission from proposed coal mines are China (572 MT), Australia (233 MT), Russia (125 MT), India (45 MT), South Africa (34 MT), the US (28 MT), and Canada (17 MT).

Tate explained that coal mines leak methane during mining operation and long after a mine has been abandoned and said the only way to reduce those leaks are through mitigation technologies, recovery and utilization practices or not mining. India, like all coal producing countries, needs to plan for how to manage methane leaks from existing operations and abandoned mines.

Hence, in order to contribute to sustainable mining and development, a mine must minimize environmental impact throughout the mining life cycle from exploration, through construction and extraction to closure and reclamation. This is achieved through the adoption of effective environmental management which includes the following elements.

1) Environmental Impact Assessment (EIA) and preparation of Environment Management Plan (EMP) during mine planning.

2) Biodiversity management including mitigating the effects of flora and fauna and preventing pollution of rivers, streams and creeks.

3) Pollution control in respect of airborne contaminants, noise and vibration.

4) Management of hazardous substances including process reagents, oil and fuel.

5) Managing acid mine drainage.

6) Tailings management including recycling and reuse.

7) Management of water including that generated during mining operations, mineral handling and process.

According to Stewart and Petrie, generation of waste, both its quality and quantity is “a direct function of technology choice” and “improvements in environmental performance are realized primarily by changes of technology—not simply in hardware choice but also operating and management practices.”

C. Advancement of Technology

Keeping pace with advancement of technology and its successful application in mining operation not only can prevent and accident or hazard inside the mines but also can reduce to a great extent the negative effect of mining on local environment and make it sustainable.

In extraction and processing, mechanization and advances in equipment capacities automation and continuous movement machinery (e.g., conveyor belt), improvement in computer aided mine design and management, automated handling system and adoption of scheduled preventive maintenance of machinery as a standard operating practice have increased the efficiency in mining operation that have contributed to the reduction

of environmental damage. Very effective software programmes are being used with application in areas such as blasting operation and grinding processes in mining, the quality of explosives have been improved considerably that allows 'cast' or 'throw' blasting where the waste, material is thrown directly into storage areas allowing the machinery to extract less waste materials.

D. Mine Closure and Rehabilitation

The dangers of allowing no longer working mines to exists cannot only allowing wasted debris the opportunity to rot and decay on site, but it can lead to illegal or unregulated mining activity as well. Hence, at the end of mine cycle proper mine closure is required.

The final stages of the mining cycle, namely mine closure and associated reclamation and rehabilitation of lands earlier utilized for mineral extraction have perhaps the most important significance for sustainable development in the mineral sector.

Mine closure comes only after production and processing activity have permanently ceased leading to decommissioning of site infrastructure. The aim of the perfect mine closure process is to restore the surrounding environment to a state, resembling as closely as possible that which existed prior to the commencement of mining as measured by both chemical and biological parameters and to ensure that environmental restoration is adequate to allow the establishment of a diverse and functional eco-system in the area.

Environmentally, a mine closure plan must accompany the following to ensure sustainable development—

1) The Mine infrastructure (roads, buildings, spoil heaps, tailings, and waste rock areas etc.) is evaluated and those posing safety risk are removed from the site.
2) Hazardous substances are identified and disposed off in a controlled manner according to hazardous waste management regulations.
3) Post abandonment risks are minimized.
4) A healthy environment is made available for the future.
5) Adequate (surface and ground) water supplies, clean air and productive land are made available for future operations.
6) Progressive rehabilitation and revegetation of land takes place along with appropriate landscaping for any future land use activities planned for the area.
7) Opportunities for beneficial uses of land exists for future land owners and other users of land. Thus when mine closure is done properly and efficiently, it can be a mechanism for transferring capital extracted from mining to future generation paving the way for development on a long, long term basis.

The reclamation, rehabilitation and resto-ration work of a mined area involves retaining the mined outland to a useful form but it is not always a single phase work. It includes filling of the overburden into the quarry void up to the original ground level, spreading of top soil and plantation over the reclaimed land. It also involves the development of ponds as some areas which are unfilled. (Ref.5)

CONCLUSION

India is richly endured with many minerals. The minerals are basic and strategic materials for industrial and economic development.

During 2020-21 the mineral production in India from 32 States / Union Territories is shown below (Fig.6):

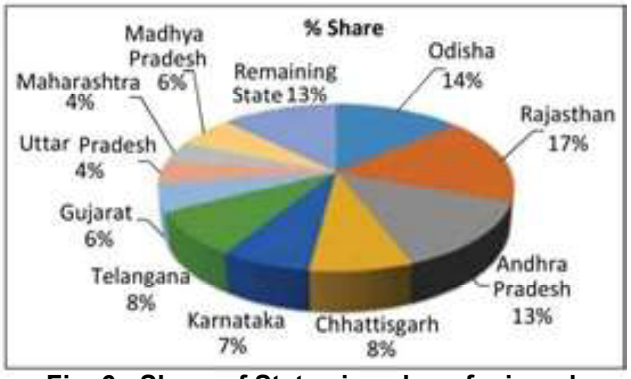


Fig. 6 : Share of States in value of mineral production 2020-21 (estimated) (Excluding Atomic & Full Minerals)
***Source* : Statutory Returns submitted to IBM**

which reveals that 87.40% of production was confined to 10 States, and Rajasthan is in leading position (*Source* : Annual Report 2020-21, Ministry of Mines, Government of India). (Ref.8)

The mining sector in India contributes approximately four percent to the GDP and is one of the largest employers in India, employing more than one million workers which is around 4% of the Indian workforce. India produces 89 minerals, out of which 4 are mineral fuels, 11 metallic, 52 non metallic and 22 minor minerals. The total value of mineral production during 2016-17 has been estimated by MoM at INR 2,57,882 crore. There are more than 3500 mining operation in the country most of which are on a very small scale and 300 of which are in the non fuel sector. The industries are dominated by Govt. corporation (PSU) which employ more than 90% of the industry work force.

Sustainable mining and development has emerged as an important concern for mankind following intensified damage to environment and socio cultural integrity that accompanied accelerated economic development in many reason of the world in post World war II years.

In operational terms the sustainable development in the mining sector employees a mix of scientific mining and technological improvement, improved environmental management, including pollution control, enhanced socio economic development of local areas and communities. Effective regulation by Govt. and good Governance as well as self regulation and ethical conduct on the part of mining enterprises play a crucial role in the achievement of sustainable mineral development. Sustainable mining is an all inclusive concept which also engulfs the concept of needs and limits on the environment to meet the present and future needs. It basically means economic and social development that endures over the long term. For the mining sector what it translates into is that mining should contribute to the well being of the present generation without compromising that of the future generation for a better quality of life. This is possible if mining enterprise are able to substitute in there project areas the damaged natural capital (mineral resources) with compensating investment in other form of assets such as physical infrastructure, human and social capital that will guarantee income for the affected people in mining project area beyond the life of the mine.

Unfortunately in India the main focus of governance in the mineral sector has been on regulation rather than on development aspects of mining. In fact the Key for creating a sustainable mining industry is moving from individual adoption to a large scale adoption by the entire mining industry which has to be supported by a robust regulatory and legislative mechanism. While legislative and regulatory reforms have to an extent led to many better practices the government and industry must design best practices to ensure an overall profitability and sustainability of the mining sector. With regards to this developing affordable technologies are imperative for India so that it can be easily adopted by small scale mining enterprises as well. (Ref.9)

REFERENCE

1. Sustainable Mining in India. Overview of Legal and Regulatory Frame Work, Technologies and Best Process Practices, Indian Chamber of Commerce Publication.

2. A Review of Sustainable Mining and Resource Management, Miranda, R., David, A. Dzombak, Carnegie Mellon University, Department of Civil and Environmental Engineering.

3. Can Mining be Sustainable? Samir Lahiri, 24.04.2017, down to earth.

4. The Horrors of Mining – Ritimo by Steffi Elizabeth Thomas.

5. Ministry Indifferent to Illegal Mining – by S. Juneja, 31.01.2012, down to earth.

6. Sustainable Development – Emerging issues in India's Minerals Sector. Sponsored by Planning Commission, Government of India, Institute of Studies in Industrial Development, May, 2012.

7. Impact of iron ore mining in Chhattisgarh by Bhumika Das – Recent Research in Science & Technology, 2014, 6(1), 27-29, ISSN: 2076-5061.

8. Annual Report – Ministry of Mines, Government of India, 2020-21.

9. ICMM Report, 2006 – Setting the standard to meet the challenges of sustainable development.

The Indian Mining & Engineering Journal, Vol. 61, No.08 August 2022, pp.32-45
Printed in India, @ IME Publications, ISSN 0019-5944

Dust in Opencast Coal Mines – Its Source, Prevention & Control (Part – I)

Anant Kumar Tiwari* G.K.Pradhan**

ABSTRACT

The destruction of the environment in mining areas has had an impact on public life in the form of air pollution, noise pollution, land degradation, forest degradation, water pollution & water table retreat, heat & humidity , among other things. The government is aware of these issues and has made steps to address several areas of harmful effects of Dust generated during every stages of mining, processing and transport of coal/ore. The mine management has to implement various methods of preventing dust generation, suppression to not to make them airborne, dust survey to ensure better workplace conditions by following the acts/rules/regulations & DGMS Circulars. There are sufficient provision in various legislation to address the issues concerning dust, despite which the issue of dust prevention and control is most important for saving human life.
All owner/agent/manager will be strictly adhere to the restriction, otherwise, there are Rules to taken against the defaulters. Every mining company is required to prepare & submit a Dust Management Plan to the concerned agencies in order to effectively implement the provisions of various laws related to prevention and control of Dust in mining operations.

INTRODUCTION

India is third largest Coal producing country in the world and about 95% Coal production by opencast mining. The conventional system of opencast mine is drilling-blasting, excavation, crushing, transporting of coal from coal face to end user points & overburden at dumping points (internal and/or external as available). The HEMM which comprises in those various processes are Shovel, Drill, Grader, Dozer, Dumper, and Dragline. Earlier, as it is mentioned that mining operations are always associated with fatal effect of land degradation, environmental disorders, noise and air pollution and it results to overall environmental corrosion. Blasting process which is also carried out, give rise to blast-induced ground vibrations, disturbance to water regimes., air-blast, fly rock, blasting fumes, dust cloud, noise, and damage to nearby structures. Crushing and drilling operations also cause a lot of dangerous environmental complaint and harmful results such as air and noise pollution.

An attempt has been made in this paper to highlight environmental problems associated with large opencast mines with special reference to dust.

**M.Tech(Mining) Student **Prof. of Mining Engineering & Dean Faculty of Engineering & Technology*
AKS University, Satna

DUST

It is a fine, dry power consisting of small microscopic particles of solid matter lying on the ground or on the surfaces or carried on the air like as Brownian motion in the environment. It can be made up of coal, rock/ overburden, bacteria, smoke, ash, salt crystal from the ocean, sand etc.

Statutory provisions dealing with coal mine dust

Coal Mines Regulation 2017 had made following stipulations for all mines to follow **–**

Permissible limit of respirable dust -

(a) 8 hours time-weighted average concentration of airborne respirable coal dust shall not be more than 2 milligrams /cubic meter of air if free respirable silica is less than 5% and
(b) If free respirable silica % is 5 or more than airborne dust shall not be more than 10/% of free respirable silica.
(c) Every month or whenever RIM requires air sample shall be taken for concentration of respirable dust & determine the concentration of respirable dust.
(d) Sample shall be taken immediately if commissioning of any plant, equipment or machinery or introduction of any new work practice or any alteration.

All result of measurement shall be systematically recorded within 14 days of date of collection of sample in bound paged register & countersigned & dated by colliery manager within 24 hours.

If any place exceed the dust concentration that the permissible limit than immediately steps shall be taken to minimize the emission & to notify the RIM.

The recommendations of 12th Conference on Safety in Mines held during 28-29th January 2020 (circulated as DGMS Technical Circular(MAMID)/08 dated 29.4.2020) had also deliberated on – 'Prevalence of pneumoconiosis/ silicosis amongst workers, present status of dust control measures and strategy for improvement.

4.1 Permissible respirable dust levels be brought down to 1.0 mg/m3 (In case percentage of free silica in mines is up to 5) or 5 divided by percentage of free silica in Dust, from the present level, in the line of prescribed limits of National Institute for Occupational Safety and Health (NIOSH), USA.

4.2 For early detection of Silicosis amongst Miners of Styone quarries, Medical examination should be conducted at least once in every year and Chest Radiography once in every two years.

4.3 All mining companies shall have the services of at least one Doctor qualified in OH and trained in ILO classification of chest radiographs. DGMS may facilitate necessary training if needed.

4.4 In order to establish a close employer-employee relationship, Mine owners should try to keep contractual workers on permanent basis as far as practicable, and not to change workforce frequently and otherwise.

4.5 State Government shall create facilities like Chest Radiography (X-ray machine 300 mA ore more), Spirometry, Audiometry, Blood Biochemistry etc. at Primary/Community Health Centres and also get their Doctors trained in OH and ILO Classification of Ch est Radiograph, if necessary with the funds available under District Mineral Fund(DMF).

4.6 There shall be at least one referral occupational health centre established in every state, for confirmation and tertiary care of Pneumoconiosis cases.

4.7 For getting further insight into various other occupational lung diseases due to dust, Diesel Particulate Matter, etc. appropriate scientific agencies may be engaged.

4.8 To create awareness amongst the workers about the dust related diseases, mine management shall conduct structured training and awareness programmes at regular intervals.

4.9 Every mine owner shall submit a quarterly return relating to measures taken to prevent generation of respirable dust at all workplaces in the mine.

DGMS (Tech.) (S&T) Circular No.01 Dhanbad, Dated 21st January 2010, covered the Respirable Dust Measurements and Control to Prevent Pneumoconiosis in Mines. This was in line with the an integrated effort which is being made by the Government of India to significantly reduce the prevalence of Pneumoconiosis/ Silicosis by 2015 and to totally eliminate Pneumoconiosis/ Silicosis at workplaces by 2030 in line with the International Labour Organisation (ILO) and the World Health Organisation's (WHO) Global Programme for the Elimination of Silicosis.

Dust generation being very high in drilling/boring, to ensure a total control on it DGMS had brought out Circulars. DGMS Circular of 10th March 2017: regarding Approval of dust suppression/prevention devices fitted in drilling and boring equipment used in metalliferous mines under regulatlion 124(6)(b)(ii) of Metalliferous Mines Regulations, 1961. In case of coal mines, 10th March 2017: Circular on Approval of dust suppression/prevention devices fitted in drilling and boring equipment used in coal mines under regulation 123(6)(b)(ii) of Coal Mines Regulations, 1957.

In June 2015,DGMS conducted one day brain storming technical session on "Respirable mine dust - assessment & management system in mines". Some of the salient observations are stated below –

"xxxx Sadly, it is also an acknowledged fact that not much has been done to mitigate the associated hazards of airborne respirable dust in mines on health, leading to National as well as State Human Rights Commissions, assuming greater role on the matter. The irony of the matter is that the existing statutory provisions in this regard can immensely contribute to reversing the trend if only followed more proactively by all stake holders.

xx He apprised the gathering of the recent recommendations made by Rajasthan State Human Rights Commission in this connection many of which were

with far reaching consequences, thereby clearly focussing on the urgency to address the matter. x x all other mining companies present on the occasion to immediately take appropriate actions for effective control of respirable dust in mines, specially to strengthening the sampling and analysis aspects which are commensurate to employment in the mines for arriving at representative understanding on the matter, rather than the cursory arrangements existing presently. He also cautioned that any leniency on the matter would not be appreciated either by the Government or by the society involved.

x x The technical session ended with an overwhelming consensus to immediately overhaul the current dust measurement and control regimes in place and to follow statutory stipulations in letter and spirit and to build a realistic and trust worthy data bank."

To create awareness about harmful effects of dust and on silicosis DGMS had conducted a one day Seminar in August 2019 at Hospete region where a large number of iron ore mines and stone quarries are in operation.

Safety Management Plan and Assessment and Ranking of Risk

DGMS has brought out an innovative system of Safety Management and CMR 2017 had also mentioned at CMR 104, the role of owner, agent and manager in prepariong Safety Management Plan. Even for metalliferous mines, in the revised MMR 1961, the same has been incorporated.mFor the first time in 2002, DGMS through DGMS(Tech.)(S&T) Circular No. 13 dated 31.12.2002 had issued a document entitled – 'Safety Management System – A Guidelines for Implementation'. This was followed by several deliberations with all stake holders and the Conference of Safety in Mines (IXth and Xth) brought out recommendations to adopt Risk Management as a tool for development of appropriate Health & Safety Management systems. To make it vibrant and updated, DGMS(Tech)(S&T) Circular No. 02 of 2011of 4th March 2011 and DHMS(Tech.)(S&T) Circular No. 05 of 2,04.2016 was issued. Again in 2019, DGMS Technical Circular No. 3 brought out guidelines for Implementation of Safety Management Plan at Mines.

For the dust, which has caused immense fatalities and is a global concern, the system of Risk Assessment for Risk Score due to Dust as a hazard is stated below –

Risk Score = Consequence x likelihood
Risk Score = Consequence x probability x Exposure
Scale of Consequence

- Several Dead 5
- One Dead 1 * Relate to Dust
- Significant chance of fatality 0.3
- One Permanent disability 0.1

Less Chance of fatality

- Many lost time injuries 0.01
- One lost time injury 0.001 * Relate to Dust
- Small injury 0.0001

Scale of Exposure

- Continuous 10 * Drilling and pe and post blast preparation by a driller
- Frequent Daily 05* Drilling & Blasting, Workmen in the Crushers/CHPs/Dumps etc
- Seldom (weekly) 01** For other workmen and supervisors attending blasting, loading maintenance in mine faces, haul roads, dumping sites etc.
- Unusual(monthly) 02
- Occasional(Yearly) 2.0
- Once in 5 years 1.5
- Once in 10 years 0.5
- Once in 100 years 0.02

Scale of Probability

- May well be expected 10 * Dust exposure is related.
- Quite possible 07 * Dust exposure.
- Unusual but possible 03
- Only remotely possible 02
- Conceivable but unlikely01
- Practically impossible 0.5
- Virtually impossible 0.1

Calculating Risk Score due to Dust –

(A) Risk Score for Dust = 1 x 1
(B) Risk Score = 1 x 10 x 10 = 100
or 1 x 7 x 5 = 35

MINE DUST

All operations involving mine development till opening up of benches, handling of top soil, over burden, storage of OB and or Coal/Ore involves generation of dust. When the soil, OB or ore is excavated with or without blasting

(excavation by rippers, rock breakers, surface miners, highwall miner, bucket wheel excavators etc) generate dust. The only difference is material excavated or fragmented by mechanical means generate finer dust. After material is loosened or fragmented when handled by excavators to load into the dumpers also generate dust. At the time of movement of dumpers on haul roads, at the point of unloading also dust is generated. In mines having Dragline method of mining the dust generated is at the time of bucket filling, hoisting and dumping. Blasting operations also generates huge volumes of dust. Amount of dust is dependent on the quantum of explosive used and location of the benches. The last source of dust generation is at the Coal Handling plant or Ore handling plant, crushing and screening plant and ore/coal storage space.
if efficient measures are not taken to suppress it.

CLASSIFICATION OF DUST

Dust generated in mines depends upon the chemical and physical composition of the material being mined, and its classification is influenced by the nature of harm created.

A. Fibrogenic Dust
a. Silica (quartz, crystobalite, tridymite, chert)
b. Silicates (asbestos, talc, mica, silimanite)
c. Metal fumes
d. Beryllium ores
e. Iron ores
f. Carborundum
g. Coal (bituminous, anthracite)

B. Carcinogenic Dusts
a. Asbestos
b. Radon daughters
c. Arsenic
d. Diesel particulate matter (a suspended carcinogen)
e. Silica (a suspended carcinogen)

C. Toxic aerosols (poisonous to body organs and tissues etc.)
a. Dusts of ores of beryllium, lead, uranium, radium, thorium, chromium, vanadium, manganese, arsenic, mercury, cadmium, antimony, selenium, nickel, tungsten, silver.
b. Mists and fumes of organic and other body-sensitising chemicals

D. Radioactive dusts
a. Ores of uranium, radium, thorium (injurious because of alpha and beta radiation)
b. Dusts with radon daughters attached (source of alpha radiation)

E. Blasting dusts (combustibles when air borne)
a. Metallic dusts (magnesium, aluminium, zinc, tin, iron)
b. Coal (bituminous, lignite)
c. Sulphide ores
d. Organic dusts

F. Nuisance dusts (little adverse effects on humans)
a. Gypsum
b. Kaolin
c. Limestone

Dust when airborne and inhaled is having impact on the particle clearing mechanism of lung leading to irreparable damage to the respiratory system and settles inside.

Physiological Effects of Dust
Human Respiratory System

When we inhale air through nose and mouth air alongwith other aerosols (dust, bacteria, and pollen) are also introduced into the body. Air when passes through the nasal passages, larger particles are cleared by hair and mucus. Thereafter air flows through the nasopharynyx region, where it is warmed. Subsequently air passes through the trachea (windpipe), the bronchi (the two short branches off the trachea), and the bronchioles (branches off the bronchi) and into the alveoli (the terminal lung sacks where oxygen is transmitted into the blood stream). Along the trachea, bronchi and bronchioles, particles of medium size are impacted on the mucous layer lining the openings. Particles larger than 10µm are caught in ciliary escalator and brought back up through the bronchial tree to the throat. This material is then coughed or swallowed. The smaller particles are deposited on the lung surface through setting, impaction, Brownian motion. For these types of dusts, body's defence mechanism consists of phagocytes (wandering scavenger cells) called alveolar microphages. These microphages engulf the particles and isolate them to lymph nodes for disposal. These scavenger cells are called the garbage collector of respiratory system as they ingest invading particles.

If the particles microphages ingest free silica particle, it explodes. The lung is left with destroyed microphages and

free silica particle. The particle is then ingested by another microphage which in turn is destroyed by explosion and this process goes on. Every human being has billions of microphages. The human body has evolved into an efficient organization designed to eliminate particles found in natural environment. However, when an individual inhales sufficient particles below 10µm, the microphages are overwhelmed. When enough microphages are destroyed, the residual biological material forms scar tissues. Initially the scars are small enough but consequently adjacent scars coalesce. As the scar tissue continue to increase, more lung tissue is rendered useless. Individual develops shortness of breath and his life expectancy is reduced. Figure 1, Explains the Human Respiratory System.

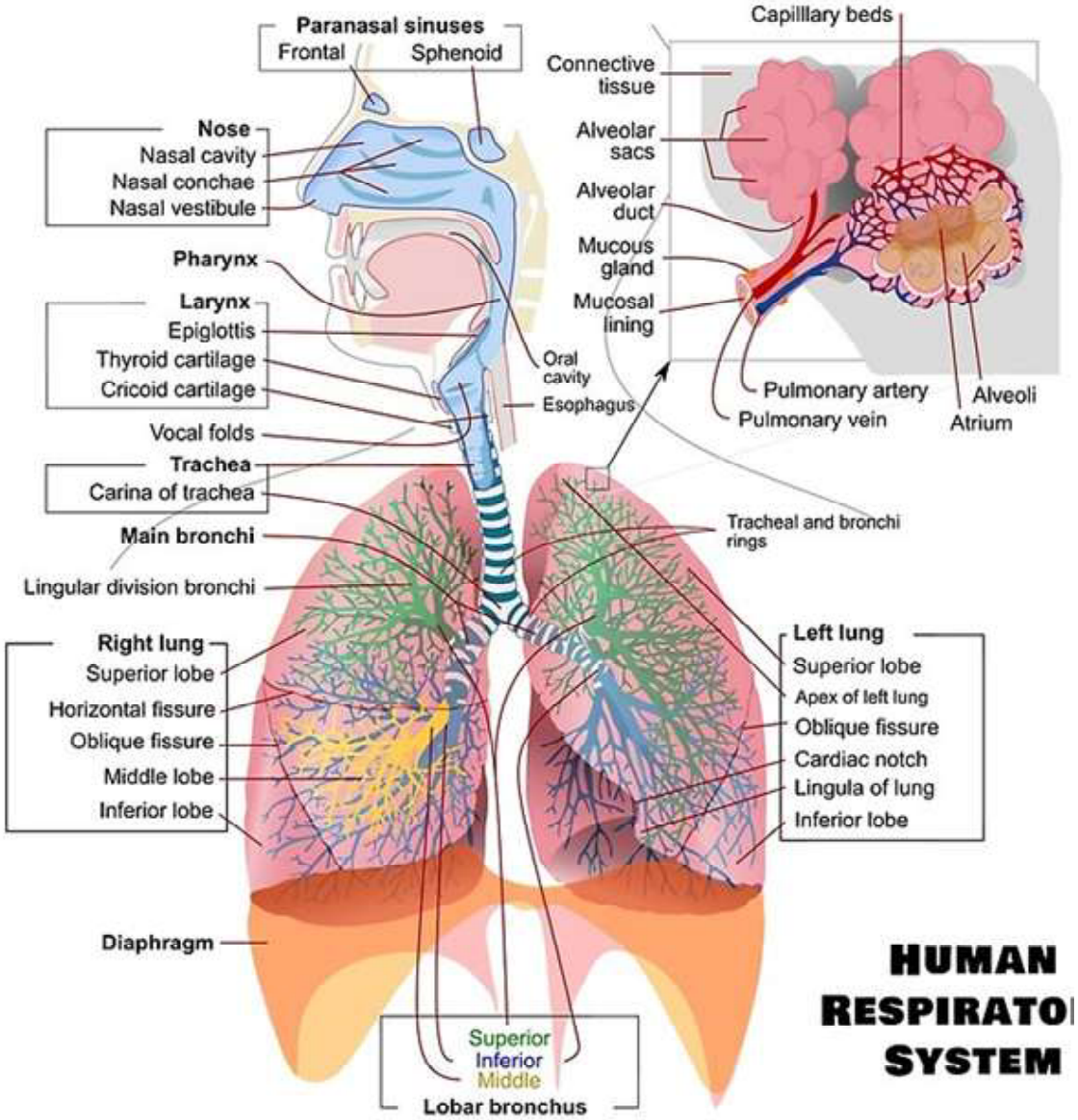


Figure 1 : Human Respiratory System
(Source : https://www.redbubble.com/i/art-board-print/Human-Respiratory-System-Diagram-by-allhistory/30345034.7Q6GI)

Pneumoconiosis

ILO Working Group in 1971, had defined, pneumoconiosis – 'as the accumulation of dusts in lungs and the resulting reaction of dusts of lung tissues to it. It is the most common lung dysfunction seen among miners. Pneumoconiosis is characterised by the formation of fibrous tissues in lungs due to dust deposition. Pathologically, pneumoconiosis is divided into two groups

- Collagenous
- Non-collagenous

Non-collagenous pneumoconiosis is caused by non-fibrogenic dusts. General features are

- Alveolar architecture remain in tact
- Least stromal reaction comprising primarily reticular fibres
- Reversibility of dust reaction

Collagenous pneumoconiosis

It is caused by fibrogenic dusts as altered tissue response to nonfibrogenic dust. It is categorised by:

- Permanent modification or destruction of alveolar architecture
- Collagenous stromal reaction from moderate to highest point
- Permanent scarring of lungs

However, difference between collagenous and no-collagenous pneumoconiosis is tough and constant exposure may cause conversion from non-collagenous to collagenous.

Depending upon specific casual material, different terminologies are associated with different types of pneumoconiosis. Such as -

- Silicosis (dusts of quartz, trydymite and cristobalite)
- Silicate pneumoconiosis (dusts of silicate mineral such as kaolin, talc, tremolite, actinolite and anthophylite)
- Coal Workers' pneumoconiosis (coal dust)
- Beryllium disease (dusts of beryllium compounds including ores)
- Siderosis (dusts of iron including ores) [8]

Factors Responsible for Pneumoconiosis
Health effects of dust chiefly depends upon

- Composition
- Concentration
- Size of particles
- Time of exposure

i). Composition
Chemical and mineralogical composition is an important factor in determining the degree of harmfulness of dust. Some mineral dusts are harmless where as some other mineral dusts are harmful e.g. free silica is more harmful than combined silica, asbestos is carcinogenic in nature. The surface energy of the particles and solubility is also very important in case of toxic dusts. Free silica content is accepted universally as the most dust reaching lung, not that of the air borne dust or the mineral or rock producing the dust that is important. Free silica content of dust can be determined through X-ray diffraction analysis, differential thermal analysis (DTA) and infra-red spectrograph.

ii) Concentration
Concentration of dust can be measured in 3 different ways:
a. Mass of the dust per unit volume of air. (mg/m3 or micrograms/m3)
b. No. of particles per unit volume. (ppcc)
c. Surface area of particles per unit volume.

Mass concentration in the respirable size range has been established as the criteria for the determination of pneumoconiosis occurrence. For silica dust, surface area concentration of the respirable fraction is needed to determine harmfulness, as the toxicity of silica dust is more closely associated with the surface area of particles, because surface area determines the solubility of the particle. Tyndalloscope is the only instrument through which particle surface area concentration can be measured.

iii). Time of Exposure
Dust exposure take time of occupational exposure to develop to critical level. In ten years time, Asbestosis reaches critical level whereas silicosis in years of exposure reaches critical stage. The period of exposure required to develop silicosis increases with decrease in concentration. Some diseases like coal worker's pneumoconiosis cease progressing when exposure to the dust is eliminated. Whereas silicosis is progressive in nature, once developed it progresses even if exposure to dust is terminated.

There is a certain extent to which human respiratory system can dispose inhaled dust. Larger size particles

deposited in the upper respiratory tract is removed through ciliary action. Where as in case of fine particles, microphages engulf them and remove them to lymph nodes, whereas fibrosis may develop. When the lymph nodes attain saturation fibrosis develops. Hence, it is obvious that incidence of occurrence of pneumoconiosis can be directly co-related to exposure time.

iv) Size of the Particles

Dust particles size refers to the equivalent diameter, which is defined as the diameter of the spherical particles of unit density having the same falling velocity as the particle in question. Particles lesser than 5µm diameter are most likely to penetrate to lungs and became deposited in alveoli. Maximum damage is caused by particles of 1µm size. It decreases for both higher and lower sizes. It happens because particles larger than 5µm are deposited in the upper respiratory tract, whereas particles of 1µm or lesser size reach the alveoli.

Investigations undertaken in Indian Mines in the recent years

Chaulya et el (2004) carried out an assessment of air quality around Lakhanpur area of Ib valley.TSP, PM10, SO2, NOx were monitored at 13 locations for a period of one year. 24 hour and annual average concentrations of TSP and PM10 exceeded NAAQS standards whereas SO2 and NOx remained within the limit. 31.94% of TSP was found to be within PM10. Green belts were prescribed as a mitigation measure.

Chinthala & Khare(2011) in their paper presented a comprehensive description of the dispersion mechanisms in the deep open pit coal mines considering the topographic, thermal and meteorological factors.

Kumari et al. (2011) carried out a study to determine quartz content in airborne respirable dust (ARD) using FTIR spectrometer. Personal dust samplers were used to collect airborne respirable dust at different locations of the mine using GLA-500 PVC membrane filters. Percentage of quartz was found to be less than 1% in almost all workings at Jharia coalfield. Maximum Exposure Limit (MEL) was equal to 3mg/m3 in most of the working places.

However in case of metal mines, quartz content was found to be more than 5% in many workings. It has been found that good ventilation and wet drilling controls the dust problem at some locations, whereas in some other locations rotations of workers are required.

Mukherjee et al. (2005) assessed respirable dust, free silica content and personal exposure of the miners to find the risk of coal worker's pneumoconiosis in 9 coal mines of eastern India during 1988-91. The percentage of free silica is found to be less than 5% in most cases except among quarry loader and drillers in opencast mines.

Mishra and Jha (2010) carried out dispersion modelling in an opencast coal mine and validated the results with the actual field data. The research was aimed for the validation of FDM model. They have assessed activity wise dust generation potential and studied distance vs dust concentration to determine impact zone of dust concentration. According to them the major polluters were haul road and coal transportation road. Dust emission from the mine was directly proportional to the length of the transportation road and to the speed of vehicle. Fugitive dust modelling used for dust dispersion modelling was 90% accurate in predicting dust concentration. They have found that dust particles are largely deposited within 100m. Concentration decreases with increase in distance away from source and within 300m to 500m after which it reaches background concentration. Also 80% of dust generated by the haul trucks is greater than 10µm.

Trivedi et al. (2008) examined different sources of dust generation and calculated dust emissions from different point, line and area sources in an opencast coal mine. Fugitive Dust Model was used by them for Air Quality Modelling. Dust produced by different mining activities doesn't add to ambient air quality beyond 500m. Modified Pasquill and Gifford formula was used to determine level emission rate. Predicted value of suspended particulate matter was found to be 68-92% of the observed value. An exponential fall in TSPM concentration with distance from source had been observed. Dust generation due to mining activity didn't contribute to ambient air beyond 500m. The main sources of dust emission were loading and unloading of coal, overburden and haul road.

Chaulya et al. (2002) carried out study for determination of emission rate for SPM to calculate emission rate for various opencast mining activities. For validation Fugitive Dust Modelling (FDM) and Point, Area and Line source model (PAL2) were used. Both models run separately for the same input data for each mine to get predicted

concentrations at three receptor locations. FDM was found to be more suitable for Indian mining conditions. It was observed hat coal handling plants, haul roads and transport roads were the major sources of dust emission. The average accuracy between observed and predicted values for SPM at certain locations for PAL2 and FDM model were found to be 60-71% and 68-80% respectively.

Free Silica

Mukherjee et el (2005) studied the role of free silica, personal exposures of miners in respirable dust and the associated risk of coal workers' pneumoconiosis in 9 underground coal mines of eastern India. Dhatrak and Nandi (2019), studied the silica dust exposure profile in relation to prevalence of silicosis among Indian sandstone mine workers. Their study indicates that silica exposure below the prescribed limit in India is likely to be harmful. The prescribed exposure limit (PEL) for crystalline silica in India of 0.15 mg/m3 is not adequately protective. Hence, there is an urgent need to reduce exposure to silica in these workplaces to prevent silicosis and to review the present standards as the government of India remains committed to the elimination of silicosis by 2030.

Prajapati, et el(2021) extensively studied to characterize respirable dust and crystalline silica generated during mining and processing of from limestone, iron, and bauxite mines in India. They collected total, 86 personal dust samples from limestone (n = 30), iron (n = 30), and bauxite (n = 26) mines using dust sampler. The concentration of crystalline silica was analyzed using FTIR spectroscopy. Geometric mean respirable dust concentrations observed were 0.92, 1.08, and 1.07 mg/m3 for limestone, iron, and bauxite mines respectively, similarly for crystalline silica concentration observations were 0.015, 0.012 and 0.008 mg/m3 respectively. Among the three studied ores, mean crystalline silica concentration was statistically significant ($p < 0.05$) using an analysis of variance test. Although the detected levels of exposure are within the Indian exposure limits, attention should be paid to lower crystalline silica levels to minimize the risk of silicosis.

Mishra & Das (2020) conducted an exhaustive study in Talcher Coalfields and reported as mine dust as one of the major cause of concern leading to air pollution. According to their investigation, 6.4% X-rays showed evidence of TB and having silica dust concentration of 0.11 to 0.16 mg/m3. The TB cases significantly increased from 2% to 6% to 12.7% as the work exposure increased from <10 years to 11–20 years to >20 years respectively. 8.5% of the TB cases were seen among the workers having more than 10 years of work exposure. The odds ratio (95% CI) for work exposure more than 10 years to less than 10 years was 4.53 (1.92–10.65). Such incidence can be reduced if silica particles from work environment can significantly be reduced, thereby reducing the number of TB cases. They have identified drilling as the main cause and adoption of wet drilling should be practiced and personal protective equipment should be regularly used.

Nandi, S. et el (2020) were of the opinion that Pulmonary Tuberculosis among Stone Miners of India is due to Silica Exposure.

Exposure time

Ganesan (2019) studied the impact of exposure to coal mine dust in miners for 10 years and 20 years. The observations of the study revealed that the exposure to coal mine dust for a period of 20 years predisposes the miners to Type 2 diabetes. The contributing factor for this predisposition was found to be oxidative stress which was indicated by the level of serum antioxidants and serum TBARS in the study groups.

Impact on Plants/vegetation

Katare et el (2015), reported the effect of different Mining Dust on the Vegetation of District Balaghat, M.P, According to them, the physical and chemical characteristics of a range of mining dust types effects on photosynthesis, respiration and transpiration. Plants growing on this atmosphere show a reduction in growth performance and yield. Visible injury symptoms and decreased in productivity on vegetation is well noticed. Most of the plant community structure is altered.

In his research paper Pichhode et. al. (2015), highlighted the effect of Copper Mining Dust on the Soil and Vegetation with special reference to M alanjkhand Copper mine of Hindustan Copp[er Ltd. in India, According to the results reported by them, the dust deposition occurred throughout the Malanjkhand, Balaghat on to a wide range of vegetation types and from a wide range of sources.A recent survey was undertaken of regional staff of environmental management group of Malanjkhand, Balaghat (M.P.) for observations of copper dust deposition onto sites of special scientific interest.

Dust generation sources & Dust Control Measures in Opencast Working

Ghose & Majee(1998) while studying the sources of particulates during various opencast operations , stated that coal processing alone produces 72% (Figure 2, & 3).

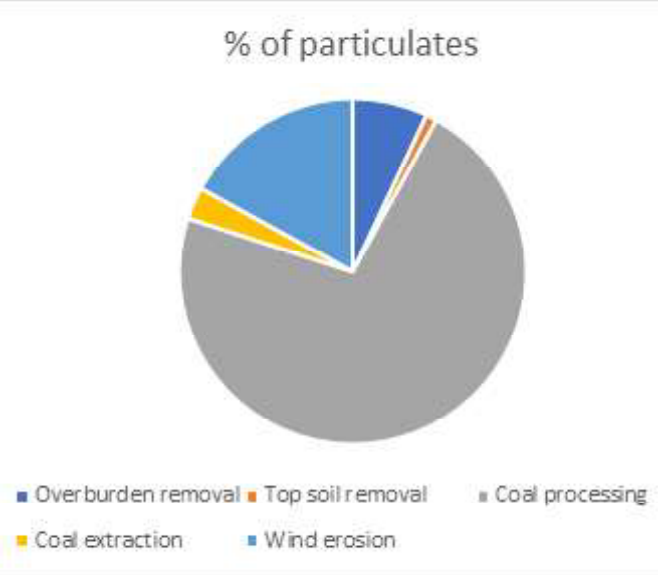


Figure 2 : Presents the operations and their contribution to the generation of the particulates (Ghose & Majee, 1998)

Later, Mandsal et el(2022) had done extensive research on dust control and suggested measures to control them. One of their study as reported by Mandal et el (2022) is presented at Figure 1.

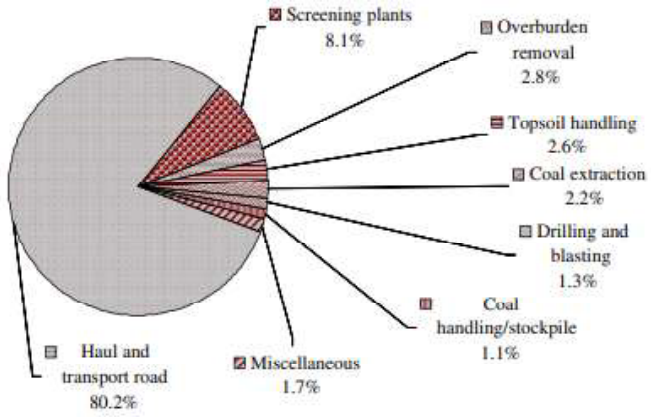


Figure 3 : Percent contributions to total dust emissions from a typical Indian opencast coal mine(After, Mandal et el, 2022)

Digital solutions
Modelling and ANN based model

Trivedi et el (2009) aided by dust dispersing modelling using fugitive dust model for Sasti Opencast mine of WCL, have predicted that mining dusts does not contribute to the ambient air quality in surrounding areas beyond 500 m in normal meteorological conditions.

Lal & Tripathy (2012), while working on three models dust generated in North Karanpura Opencast Coal Mine, did extensive field study and collected samples to predict the concentration of dust particles at various locations away from the source of pollution developed an ANN based model. They had developed three Models, using Multilayer Perception Network and learning is done by back–propagation algorithm. 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.

Assessment and modelling of dust concentration

Mishra (2010), undertaken the dust Dispersion Modeling in an Opencast Coal Mines of Mahanadi Coalfields Ltd. Tripathy et el (2015) had reported about their study related to Assessment and modelling of dust concentration of Lakhanpur Opencast Coal Mines of

MCL. According to their study, using DustTrak-II, dust analysed from drilling is the most polluting source in PM2.5, PM4 and PM10 whereas surface miner was the most polluting source in PM1.0. The data from personal dust exposure monitoring of workers using PDS (Personal Dust Sampler- APM500) suggest that, the dust exposure of worker was the maximum for explosive carrier at 29.41 mg/m3 which is much above the regulatory limit of 3 mg/m3 . In general, for most of the employees under study, personal respirable dust exposure was found to be beyond the permissible limit. The characterization of the collected dust samples suggest that the dust from coal transport road was having minimum quartz content i.e., 0.23%, whereas maximum quartz content was found at wet haul road of LOCP i.e., 0.49%. The dust dispersion modelling explained about the predicted dust concentration and suggest that, for 24 hour period for the year, the highest dust concentration for PM10 at all other places except at Lakhanpur, Mauliberena, Adhapara, Negipali, Kudopali and Baliput were found to be above NAAQS limit of 100 µg/m3 . The annual average of dust concentration, at most of the places at and around LOCP were found to be below NAAQS limit of 60 µg/m3 except at Tingismal, Khuntmahul, Karlajori, Khairkuni, Khaliapali, Banjipali.

Nagesha et el (2018) developed an empirical model to predict particulate matter using multiple regression analysis method and were used for determining the dust concentration of PM10 during drilling operation. The models were developed using the data of Mine-1 and the data collected from the second Mine-2 was used for validation. The results show that the developed models predict dust of PM10 at 70% reliable outputs, with an 30% of error. These models can be used for predicting the dust concentration level of PM10 in atmosphere at Coal mines.

IoT based real time solution

As reported by Niraj & Chaki (2018), the usage of IoT based real time solution has been developed to enhance the monitoring of dust hazards and optimize wastage of suppressant, water and increase the haul road life. The challenges are the connectivity of the sensors which will feed data to the server for real time data analytics. If the real time connectivity is ensured, it will enable improvements in the air quality and reduce operating costs of the mine. Soon, analyzing the dust levels using visual/video analytics will also provide the enhanced framework models for dust containment.

Particle size distribution

Ghose (2007), was of the opinion that more stringent air quality standards should be adopted for coal mining areas and due consideration should be given on particle size distribution of the air-borne dust while designing control equipment.

Other studies conducted in respect of Indian coal mines

Ghose(2007) studied the generation and Quantification of Hazardous Dusts from Coal Mining in the Indian Context; Ghose & Majee (2007), reported about the characteristics of Hazardous Airborne Dust around an Indian Surface Coal Mining Area; Kumari et el (2011), reported about the methods of determination of quartz and its abundance in respirable airborne dust in both coal and metal mines in India; Trivedi(2008) and his team studied the dust generation and its dispersion due to mining activities in Durgapur open cast coal project of W.C.L.

Kashi et el (2015) and (2019) studied the application of Synthesised Polyacrylamide (PAM) at Laboratory condition for reducing the dust generation of Haul Road by improving Water Holding Capacity(WHC). PAM solution shows better efficiency than water to reduce dust emission by enhancing moisture carrying capacity of haul road of opencast coal mining. This led to improvement in visibility and health safety of miners.

Tripathy and Dash (2019), undertook measurement of respirable dust concentration and assessment of health risk due to metals around Lingaraj opencast coal mine of Talcher, Odisha.

DUST CONTROL TECHNIQUES

After identifying the sources of dust, efforts are being made to prepare a location plan, extent of influence, quantify them and also analyse their chemical composition so as to develop a system of suppressing them. Dusts generated during mechanical processes are finer in size and have very harmful effect on the health of the workmen and supervisors associated with it.
Some of the commonly adopted techniques to control dust generation are -
(a) Wet drilling
(b) Wetting the blasting block
(c) Wetting the blasted muck after blasting. In many limestone mines special arrangement is made to spray water from the excavator before commencement of loading blasted material into dumpers.
(d) Spraying of water on haul roads, ramps, at a regular interval; but due to its high surface tension, it is not significantly potential as a wetting agent.
(e) Water spraying added with Surfactants to increase the wetting and capturing capacity by affecting surface tension of the liquid and its interfacial tension against dust.
(f) Adding Binding materials with water on haul road. Several researchers have reported that a reduction of 27% and 36% in respirable dust and total airborne dust concentrations after the addition of surfactant to water. Director General of Mines Safety has also issued circulars for ensuring environmental safety and hazard issues [Pandey, (2019)]. One such chemical, Dustron PC Coal has been developed by Syntron Industries, Ahmadabad in collaboration with CIMFR, Dhanbad. The product is non toxic, biodegradable, meets all the safety standards as per statutory requirement and has been proved to be very effective in controlling dust at haul road (Trivedi and Kumar, 2011). Dustron PC Coal is poured into the conventional water spraying container in recommended dilution and sprayed on the haul road surface in a conventional way. It improves water penetration, water retention, agglomeration of dust and reduces the water consumption of dust with improved dust control. Syntron Industries has conducted a number of studies for dust control with the help of Dustron PC used in mines haul road. The results of these studies conducted at various coal and metal mines vis-a-vis conventional water treatment with respect to various parameter on these haul roads are being summarised in the following six tables. These studies reveals the significant improvement in water conservation on mine haul roads, including:

1. Water requirement decreases by more than 50% and a commensurate reduction in diesel consumption for running of water tanker. Moisture of haul roads are increased three fold in comparison to normal watering.

2. Sieve test analysis of haul road dust with chemical and with water alone reveals that application of chemical improves agglomeration conditions as fines (size 0.5 mm or less) have been reduced after application of chemical by 80%
(g) Haul road construction and maintenance along with black topping.
(h) Dust extraction system in drills, surface miners, crushing plant etc helps in dust reduction.
(i) In long term – Green belt development helps in dust control.
(j) Crushers at the CHP fitted with high efficiency bag filters, water sprinkling system effectively check fugitive emissions from crushing operations, conveyor system, haulage roads, transfer points, etc.

Crusher houses and CHP areas in several coal mines are equipped with dry fog dust suppression system. Fixed type dust suppression system installed at all conveyor networks & various mineral transfer points could reduce dispersal to a great extent. Conventional coal stock yards are replaced with concrete silos for dust controls. Mobile water sprinklers (pressurized water tankers) are used in mine haul roads and approach roads. Further, new water sprinklers have been procured to increase the capacity of the water sprinkling on the haul roads. Coal from mining to washery is being sent through pipe conveyor to reduce the fugitive emission. Water Mist Canon is being used in coal stacking area (Figure 4).

Figure 4 : Dust control system in Haul Roads, CHPs, Coal storage etc. of West Bokaro Coal Mines of Tata Steel.) (Source : https://www.tatasteel.com/media/12939/ec-compliance-report_wbd-tsl_fy21h1.pdf)

However, all these techniques are ineffective as they cannot completely remove the dust (i.e., the source) from road surface. For effective control measures, dust has to be collected from road surface and converted into solid form, which may be used as domestic fuel. Thus, the overall objective of the present study includes characterization of road dust for further use as domestic fuel to meet the twin problems of minimization of huge amount of dust pollution in mining areas and its utilization in useful manner.

Future outlook

Coal produced by opencast mining will continue to dominate in Indian energy scenario. The thrust on enhancing coal production on the other hand is all set for a change to ensure better and safer work place. In a write up brought up by Ministry of Coal ''Technology Roadmap for Coal Sector' (2021) for Dust suppression the roadmap is –

(a) Deployment of Mist spray canon for dust suppression in TOP 75 opencast mines.

(b) Fog canons are to be introduced in different mines which are deployed at coal stock yards and Railway siding which effectively suppress air borne dust.

(c) Truck mounted fog canons should be introduced in all mines of coal India for dust suppression in haul road.

(d) Wheel washing of trucks entering & Leaving mines.

(e) Deployment of mechanical road sweepers.

(f) Black topping of road transport roads &

(g) Plantation along road transport roads to minimize air pollution.

(h) Improvising on the foam technology, Lu, Xin-xiao *et el (2015) have introduced jet cavitation techniques and their field application indicated that the reliable and simple foaming system adopting the new adding method makes a marked dust suppression effect.*

CONCLUSION

Dust continues to be an area of concern for all globally. It is more dominant in small quarries in un-organised sector where its source, measurement, control etc are in a low key. However, regulators and local villagers are now quite concern with this aspect to ensure reduction and control. In this context the most critical area in and around a mine has been ore/coal transport by road, and efforts need to be made to have mechanized loading. In case of most large coal mines, silo loading of coal into wagons have been adopted. In some iron ore and limestone mines, use of pipe conveyors and other dust free systems are creating reduction in dust generation. Use of surface miners in coal benches is another laudable effort to reduce the fugitive dust emission. Most coal companies of CIL have gone for largescale use of surface miners.

In the second part of this paper case study of one of the large coal mines will be presented.

SELECTED REFERENCES

1. Bidari, M & Swamy, K.V. (2022) Risk Assessment, Xafety Management Plan and Accident Prevention in Mines – A DGMS Approach, Procc. Of National Mining Conclave 2022, Bengaluru, Organised by Mines Safety Association Karnataka, pp. 69-89.

2. Chinthala, S. and Khare, M. (2011), Particle Dispersion Within a Deep Open Cast Coal Mine, Air Quality - Models and Applications, DOI: 10.5772/16326.

3. DGMS : Technical Circulars

4. Dhatrak, S and Nandi, S.(2019), Assessment of silica dust exposure profile in relation to prevalence of silicosis among Indian sandstone mine workers: Need for review of standards, American Journal of Industrial Medicine, https://doi.org/10.1002/ajim.23077.

5. Ganesan, S. et el (2019) Exposure To Coal Mine Dust Predisposes Mine Workers to Oxidative Stress and Diabetes Mellitus, Research Journal of Pharmacy and Technology, Vol. 12,Issue 9, pp. 4107-4110. doi: 10.5958/0974-360X.2019.00708.X.

6. Ghose M.K. (2007), Generation and Quantification of Hazardous Dusts from Coal Mining in the Indian Context, Environ Monit. Assess, 130, 35–45.

7. Ghose M.K. and Majee S.R. (2007), Characteristics of Hazardous Airborne Dust around an Indian Surface Coal Mining Area, Environmental Monitoring and Assessment, 130, 17-25.

8. Kashi, V.K. et el(…), Reducing the Dust Generation of Haul Road by Improving Water Holding Capacity with the Application of Synthesised Polyacrylamide at Laboratory Condition, Nature Environment and Pollution Technology, An International Quarterly Scientific Journal, Vol. 19, No. 1, pp.413-419.

9. Kashi, V.K. et el (2019), Surface Coal Mine Haul Road Dust Suppression Using Hydrolysed Amylopectin grafted Polyacrylamide, Procc of ICOMS, NCL-Singrauli, pp. 68-71.

10. Katare, J. et el (2015), Effect of Different Mining Dust on the Vegetation of District Balaghat, M.P - A Critical

Review, International Journal of Science and Research (IJSR), Volume 4 Issue 8, August 2015, pp. 603-607.

11. Kissell, Fred N. (2003) IC 9465 : Handbook for Dust Control in Mining, U.S.Department of Health and Human Services, pp. 132.

12. Kumari S., Kumar R., Mishra K.K., Pandey J.K., Udayabhanu G.N. and Bandopadhyaya A.K. (2011), Determination of quartz and its abundance in respirable airborne dust in both coal and metal mines in India, Procedia Engineering, 26, 1810 – 1819.

13. Lal, B & Tripathy, S.S.(2021), Atmospheric Pollution Research, Atmospheric Pollution Research Prediction , Volume 3, Issue 2, April 2012, Pages 211-218, ShankarTripathyhttps://doi.org/10.5094/APR.2012.023.

14. Lu, Xin-xiao, et el (2015), A new adding method of foaming agent used for foam dust suppression in underground coal mines, Journal of Central South University volume 22, pages3116–3122 (2015)

15. Mishra P.C. and Jha S. (2010), Dust Dispersion Modeling In Opencast Coal Mines and Control of Dispersion in Mahanadi Coalfields of Orissa. Paper presented in International Conference on Environment, Energy and Development (from Stockholm to Copenhagen and beyond) December 10 - 12, 2010, Sambalpur University, Published in The Bioscan, Vol. 2; 479-500; 2010.

16. Mishra, N and Das, N (2020), Coal Mining and Local Environment: A Study in Talcher Coalfield of India, Air, Soil and Water Research, 10(1): (2020). https://doi.org/10.1177/1178622117728913.

17. Mukherjee A.K., Bhattacharya S.K. and Saiyed H.N. (2005), Assessment of respirable dust and its free silica contents in different Indian coalmines, Industrial Health, 43, 277–284.Operation manual of DustTrak II. www.tsi.com/.../8530-8531-8532-DustTrak_II-6001893-web.pdf. Last accessed22nd April 2014.

18. Mukherjee, A.K. et el (2005), Assessment of Respirable Dust and its Free Silica, Industrial Health 2005, 43, pp. 277–284.

19. Nagesha, K.V. et el (2018) Development of empirical model to predict particulate matter, Procc. of AIP Conference, Volume 1992, Issue 1.

20. Nandi, S. et e; (020) Pulmonary Tuberculosis among Stone Miners of India vis-à-vis Silica Exposure, Indian J Occup Environ Med. 2020 May-Aug; 24(2): 102–105.

21. Niraj & Chaki, S. (2018) In Opinions-Managing mine dust pollution in near real time leveraging IoT and Analytics, By Analytics India Magazine, (https://analyticsindiamag.com/managing-mine-dust-pollution-in-near-real-time-leveraging-iot-and-analytics/).

22. Pandey, J.K. (2019), Dust control practices in the Indian mining industry, in Naj Aziz and Bob Kininmonth (eds.), Proceedings of the 2012 Coal Operators' Conference, Mining Engineering, University of Wollongong, 18-20 February 2019, pp. 185-192. https://ro.uow.edu.au/coal/406.

23. Pandey, J K, Sen, Raja, Mondal, P C, Srivastava, S K and Palroy, P, 2008. Determination of air borne respirable dust concentration and free silica content at x seam bench of 6/10 OCP, Mudidih Colliery, BCCL, CIMFR Dhanbad Study report No. SI/MS/42/2007-2008.

24. Pichhode , M. et. al. (2015) Effect of Copper Mining Dust on the Soil and Vegetation in India, A Critical , Journal of Modern Sciences and Engineering Technology (IJMSET), Volume 2, Issue 2, 2015, pp.73-76.

25. Prajapati, S.S. et el (2021) Respirable dust and crystalline silica exposure among different mining sectors in India, Archives of Environmental and Occupational Health 2021: 1-7, DOI: 10.1080/19338244.2021.1919857.

26. Trivedi, S M and Kumar, Ajay, 2011. Dust suppression of mine haul road: few case studies, in, Proceedings of All India Seminar on Advances in Mine Production and Safety, 26-27 Aug., CIMFR,, Dhanbad, pp 239-246.

27. Tripathy, D.P. et el (2015), Assessment and modelling of dust concentration in an opencast coal mine in India, Global NEST Journal, Vol 17, No X, pp XX-XX, 2015, p. 10.

28. Trivedi R., Chakraborthy M.K. and Tewary B.K. (2009), Dust deposition using fugitive dust model at an opencast coal project of western coalfields limited, India, Journal of Scientific and Industrial Research, 68, 71-78.

29. Trivedi R. and Chakraborty M.K. (2008), Dust generation and its dispersion due to mining activities in Durgapur open cast coal project of W.C.L-A Case Study, The Indian Mining & Engineering Journal, February, pp. 24 – 31 46.

30. Trivedi R., Chakraborty M.K. and Tewary B.K. (2009), Dust Dispersion Modeling using fugitive dust model at an opencast coal project of Western Coalfields Limited, India, Journal of Scientific & Industrial Research, 68, 71–78

31. Tripathy, D.P. and Dash. T.R. (2019), Measurement of respirable dust concentration and assessment of health risk due to metals around an opencast coal mine of Talcher, Odisha, Geofizika Vol. 36 No. 1 (2019) , DOI: https://doi.org/10.15233/gfz.2019.36.2.

32. Zhao, Xiaoliang et el (2021), A research on dust suppression mechanism and application technology in mining and loading process of burnt rock open pit coal mines, Journal of the Air & Waste Management Association, Volume 71, 2021 - Issue 12, pp. 1568-1584.