

भारत कोकिंग कोल लिमिटेड

एक मिनी रत्न कम्पनी
(भारत कम्पनी कोल इंडिया का एक उपक्रम)
कोयला भवन, कोयला नगर
धनबाद-826005
सी आईएन : U10101JH1972GO1000918

महाप्रबंधक का कार्यालय

पश्चिमी झरिया क्षेत्र

पो. मुनीडीह, जिला: धनबाद (झारखण्ड) 828129

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Bharat Coking Coal Limited

A Mini Ratna Company

(A Subsidiary of Coal India Limited: A Maharatna Company)

Regd. Off. : Koyla Bhawan, Koyla Nagar

Dhanbad - 826005

CIN : U10101JH1972GO1000918

OFFICE OF THE GENERAL MANAGER WESTERN JHARIA AREA

PO: MOONIDIH, DISTT: DHANBAD (JHARKHAND) - 828129

PHONE NO 0326 2273483, FAX NO: 0326 2273445, e-mail gmwj.bcccl@coalindia.in

Ref: - BCCL/WJA/ENV/2021/112

Date:- 30/11/2021

To,
The Director,
Ministry of Environment & Forest and Climate Change
Regional Office (ECZ), Bunglow No. A-2,
Shyamali Colony, Ranchi – 834002.

Sub: - Submission of six-monthly reports on compliance of Environment Clearance for the period from April'2021 to Sept'2021 in respect Cluster-XI group of mines of BCCL.

Ref: EC Order No. – J-11015/77/2011-IA.II (M) Dated: - 26.08.2013.

Dear Sir,

Please find enclosed herewith the six-monthly reports on compliance of Environment Clearances for the period from April'2021 to Sept'2021 in respect of Cluster XI group of mines of BCCL. We hope you will find in order.

Thanking you,

Encl: - As Above

Yours faithfully,

General Manager

W.J.Area, BCCL

CC to:-

1. The Director, 1A Monitoring Cell, Paryavaran Bhawan, CGO Complex, New Delhi – 110003.
2. The Member Secretary, Jharkhand State Pollution Control Board, TA – Division Building, Dhruwa– Ranchi – 834004.
3. HoD (Env.), BCCL, Koyla Bhawan Dhanbad.
4. GM, W.J. Area.
5. Nodal Officer (Env.), WJ Area.

"Copy for uploading online on "parivesh portal" of MoEF&CC and send by e-mail"

**ENVIRONMENTAL CLEARANCE COMPLIANCE OF CLUSTER-XI (GRANTED
VIDE EC No. J-11015/77/2011-IA.IIM Dated 26.08.2013)**

(From April'21 - Sept'21)

Sl. No.	A. Specific Conditions by MOEF:	Compliance
i.	No mining shall be undertaken in/under the forestland until prior forestry clearance has been obtained under the provisions of FC Act 1980.	No mining will be undertaken in/under the forestland until prior forestry clearance has been obtained under the provisions of FC Act 1980. However an application for forest clearance has been submitted online for Moonidih mine with reference number FP/JH/MIN/9699/2015 in Feb'2019, it is presently under process.
ii.	You will need to seek and obtain approval under the FC Act for diversion of the entire forest land located within the mining lease within a period of two years from 1.2.2013 i.e. date of issue of FC Division's guidelines vide no. 11-362/2012-FC, failing which the mining lease area will be reduced to the non-forest area plus the forest area for which you have been able to obtain the FC at the end of this time period. In the case of reduction in mine lease area, you will need to get a revised mining plan approved from the Competent Authority for reduced area and enter into a new mining lease as per reduced lease area. The EC will be construed to be available for the mining lease area as per the revised mining lease deed.	Amendment in EC is granted for 1982.90 Ha. Leasehold area of Moonidih UG mine on 26th July 2019 for Cluster XI group of mines.
iii.	The maximum production in the cluster shall not exceed beyond that for which environmental clearance has been granted for the cluster XI.	It is being complied. The production from the cluster is within the limit for which environmental clearance has been granted. Moonidih washery is operating within the permissible limit of 1.6 MTPA. Enclosed as ANNEXURE I.
iv.	The open cast quarries of the abandoned mines should be backfilled to the ground level and restored with native species.	Complied
v.	All coal from smaller UG mines should be transported by high capacity and mechanically covered trucks/ tippers.	Various mechanically covered trucks Manufacturers for the transportation of Coal and OB in India have been contacted and things are under process. At present coal transportation has been done by trucks with tarpaulin cover. Covering of truck has been made mandatory in the transportation contract.
vi.	Green belts shall be developed on both sides of the roads.	Complied.

		Plantation work on 12 Ha OB dump has been completed with the help of Forest Department (Approx.30000 saplings have been planted) Approximately 1500 flower saplings have been planted on Gopalichuck dump slope.
vii.	Action plan for quenching of fires and rehabilitation along with the details of master plan be submitted to the MoEF for monitoring purpose.	Complied. Jharia Master Plan is already uploaded on BCCL website and under implementation.
viii.	Presently coal to Moonidih washery from other mines of the cluster is taking place through NH. An alternate route for coal transportation may be explored.	Coal from P.B. Area is direct feed coal and hence washing is not required. Presently coal (wet enough due to sprinkling at loading and unloading point) from Moonidih mine transported to Moonidih washery through conveyor belt and coal dispatched from Moonidih washery through rail transport.  (Coal transport from Moonidih Mine to Washery through Conveyor belt)  (Coal transport in tarpaulin covered Truck)
ix.	For understanding the composition of emissions from coal mine fires, BCCL may	Agreed.
x.	Initiate action as proposed in the visit report of the EAC to Dhanbad.	Action as proposed in the visit report of EAC has been initiated.
xi.	The approved mining plan be submitted to the MoEF.	Mining Plan of Gopalichuk OC and Kendwadiah OC is submitted and Feasibility report of other mines is also submitted. Revised Mining plan along with Mine closure plan of Moonidih colliery of Cluster XI was approved by the 348th Board empowered sub-committee meeting of BCCL held on 29.01.2019.

xii.	The measure to identify in the Environmental Plan for Cluster- XI groups of mine and the conditions given in this environmental clearance letter shall be dovetailed to the implementation of the Jharia Action Plan.	Environmental plan for Custer XI group of mines and the condition given on the environment clearance has been dovetailed. As per Table 1 of Jharia Action Plan Pootkee XV Seam & Moonidih XVIIT seam fire status – Extinguished. Kendwadih XIII, XIV seam & kachhi Balihari XV seam fire status – Dormant.
xiii.	The proponent shall prepare time -series maps of the Jharia Coalfields through NRSC to monitor and prevent fire problems in the Jharia Coalfields by Isothermal mapping /imaging and monitoring temperatures of the coal seams (whether they are close to spontaneous ignition temperatures) and based on which, areas with potential fire problems shall be identified. Measures to prevent ingress of air (Ventilation) in such areas, to prevent restart fresh/spread fires in other areas including in mines of cluster II shall be undertaken. Expertise available internationally could also be utilized for control of fire in Jharia Coalfields and for their reclamation and to further minimize time for fire and subsidence control. Isothermal mapping using thermal imaging has been got done by NRSC. Measures would be taken to prevent ingress of air (ventilation) in such areas, which may re-start fresh fires.	It has been complied. NRSC was engaged for preparation of time series maps to monitor and prevent fire problems of Jharia Coalfield by Isothermal mapping/imaging and monitoring temperatures of the coal seams and NRSC has submitted their final report in January 2018 in which the area of fire has been reduced from 9.00 Km ² to 3.28 km ² . NRSC report is enclosed as ANNEXURE II.
xiv.	The embankment constructed along the river boundary shall be of suitable dimensions and critical patches shall be strengthened by stone pitching on the river front side and stabilized with plantation so as to withstand the peak water flow and prevent mine inundation.	Not applicable. BCCI submission for Non Applicability enclosed in ANNEXURE III.
xv.	No mining shall be undertaken where underground fires continue. Measure shall be taken to prevent/check such fire including in old OB dump areas where the fire could start due to presence of coal/shale with sufficient carbon content.	It is being complied
xvi.	Mining shall be carried out as per statuette from the streams/nalas flowing within the lease and maintaining a safe distance from the Nalas flowing along the lease boundary. A safety barrier of a minimum 60m width shall be maintained along the nalas/water bodies.	Complied as per statute.

xvii.	Thick green belt shall be developed along undisturbed areas, mine boundary and in mine reclamation. A total area of 254.67 ha shall be reclaimed and afforested.	Plantation work on 12 Ha OB dump has been completed with the help of Forest Department (Approx.30000 saplings have been planted) Approximately 1500 flower saplings have been planted on Gopalichuck dump slope. 400 bamboo saplings planted along the boundary of Gopalichuck OC mine. 300 sapling are planted at various location at Moonidih mine.
xviii	Details of transportation, CSR, R&R and implementation of environmental action plan for the clusters-XI should be brought out in a booklet form within a year and regularly updated.	Complied. Enclosed as Annexure IV
xix.	Specific mitigative measures identified for the Jharia Coalfields in the Environmental Action Plan prepared for Dhanbad as a critically polluted area and relevant for Cluster XI shall be implemented.	It is being complied in the name of Dhanbad Action Plan. It has been prepared in consultation with Jharkhand Pollution Control Board for entire BCCL and not on cluster basis. It is being implemented comprehensively for all the mines of BCCL. Online PM10 Analyzer has been installed at Moonidih to Check the Ambient air quality continuously. Some of the salient actions of this cluster are as under: Enclosed as Annexure V
xx.	The locations of monitoring stations in the Jharia Coalfields should be finalized in consultation with the Jharkhand State Pollution Control Board. The Committee stated that smoke/dust emission vary from source to source (fuel wood, coal, fly ash from TPPs, silica from natural dust, etc.) and a Source Apportionment Study should be got carried out for the entire Jharia Coalfields. Mineralogical composition study should be undertaken on the composition of the suspended particulate matter (PM₁₀ and PM_{2.5}) in Jharia Coalfields and also quantified. These studies would help ascertain source and extent of the air pollution, based on which appropriate mitigative measures could be taken.	It is being complied. Establishment of ambient environment quality monitoring stations has been finalized with the consultation of Jharkhand State Pollution Control Board. Draft Final Report of Source Apportionment Study has been submitted by NEERI, Nagpur and under examination at BCCL for final comments. Progress report of Source Apportionment study is Enclosed as Annexure VI
xxi.	The proponent will continue the existing Road-Rail transport network system in view of the implementation of the Master Plan (for 10 years) and another 5 years, gestation period after the completion of Master Plan for consolidation of the backfilled dug out fire areas and unstable areas is required. All mitigation measures (like covered trucks, green belting on either sides of the roads, enhanced water sprinkling, strengthening and maintaining the roads etc.) shall be adopted up	Action has been taken for conveyor-cum-rail transport system. Meanwhile transportation is being done by covering vehicle with tarpaulin cover. Coal from P.B. Area is direct feed coal and hence washing is not required. Presently coal (wet enough due to sprinkling at loading and unloading point) from Moonidih mine transported to Moonidih washery through conveyor belt. Enclosed as Annexure VII

	to 15 years (Phase-I) with the existing road-rail transport system. In phase-II, BCCL shall implement conveyor-cum-rail transport to avoid movement of trucks within the cluster for coal transportation in Phase-II which shall start after 15 years. Transportation of coal shall be by Rail and Conveyor belt, minimizing the existing road transport system in all the mines of the cluster and shall continue after 15 years. Loading of coal by pay loaders shall be discontinued. Adequate number of suitably designed off-take points shall be provided.	 (Coal transportation through conveyor belt)  (Coal transportation from tarpaulin covered Truck)  (Water Sprinkling from Mobile Tanker)
xxii.	16944 nos of PAFs should be rehabilitated at cost of Rs 53776.60 Lakhs as per the approved Jharia Action Plan.	Implementation of master plan has already been started through Jharia Rehabilitation and Development Authority (JRDA), Dhanbad.
xxiii	Regular monitoring of subsidence movement on the surface over and around the working area and impact on natural drainage pattern, water bodies, vegetation, structure, roads, and surroundings shall be continued till movement ceases completely. In case of observation of any high rate of subsidence movement, appropriate effective corrective measures shall be taken to avoid loss of life and material. Cracks shall be effectively plugged with ballast and clayey soil/suitable material.	It is being complied and will be implemented as the case may be. Regular subsidence monitoring is done at underground mines. Enclosed as ANNEXURE - VIII
xxiv	Coal Extraction shall also be optimized in areas where agricultural production is continuing. Some pillars shall be left below the agricultural land. No depillaring & coal extraction should be carried out below habitation, H.T. Lines & beneath road, water bodies.	It is being complied. Being implemented as per statute.
xxv.	Subsidence shall be monitored closely and if subsidence is found exceeding the permitted limits, then the landowners shall be adequately compensated with mutual agreement with the landowners.	It is being complied. Enclosed as ANNEXURE - VIII

xxvi.	3-tier plantation should be developed 2 km stretch of road from the mine using native species.	It is being complied. Plantation is being done on roadside in non-coal bearing areas and colonies.
xxvii.	Water sprinkling system shall be provided to check fugitive emissions from loading operations, conveyor system, haulage roads, transfer points, etc. Major approach roads shall be black topped and properly maintained.	It is being complied. Mobile water tankers are used for spraying water. Sprinkler arrangement provided in respect of Moonidih washery and Moonidih mine. Water sprinkler are provided at Moonidih Underground at transfer and coal cutting points to reduce coal dust. At Moonidih washery some new sprinkler arrangement near loading point and washery gate to VIP office is provided for dust suppression. Enclosed as Annexure VII  (Water Sprinkling from Mobile Tanker)
xxviii	A progressive afforestation plan shall be prepared and implemented over the mine lease area acquired and shall include areas under green belt development, areas along roads, infrastructure, along ML boundary and township etc., by planting native species in consultation with the local DFO/Agriculture Department.	It is being complied. 400 saplings planted around mine boundary. 600 around weigh bridge and area office boundary. 20 Ha site is given to forest department for plantation work in FY 2020-21. 200 saplings are planted at XV seam mine boundary, shaft shrinking and 500 at Dhobni Plantation Site of Moonidih mine in FY 2020-21. 600 Sapling distributed to local public and employees in FY 2020-21 by WJA. - Plantation work on 12 Ha OB dump has been completed with the help of Forest Department (Approx.30000 saplings have been planted). 1500 Flowering saplings planted on slope of OB Dump Enclosed as Annexure IX
xxix.	Acid Water Treatment Plant, volume of water to be treated and disposal of brine should be provided.	Presently there is no acid water mines in Cluster-XI.
xxx.	Mine discharge water outside the ML shall be monitored, particularly for TDS and treated to conform to prescribed levels before discharge into the natural environment.	It is being complied. Being monitored. Moonidih washery is operating under closed water circuit system. Pilot scale Mine Water Treatment Plant is installed at P.B. Area to convert mine water into drinking water. 1 No Pressure Filter is installed near P.B. Project and 2 nos. of pressure filters are installed at Moonidih mine to supply clean water.

xxxii.	The Company shall put up artificial groundwater recharge measures for augmentation of groundwater resource, in case water table shows a declining trend. The project authorities shall meet water requirement of nearby village(s) in case the village wells go dry due to dewatering of mine.	It is being complied. Mine water is being used for the industrial as well as domestic non drinking purpose. Mine water is also utilized for the community and irrigation purposes. Artificial Rainwater Harvesting Structure is constructed and fully functional near Area office of WJ Area. Enclosed as Annexure X  (Artificial Rain water Harvesting Structure)
xxxiii.	Besides carrying out regular periodic health checkup of their workers, 10% of the workers identified from workforce engaged in active mining operations shall be subjected to health checkup for occupational diseases and hearing impairment, if any, through an agency such as NIOH, Ahmadabad within a period of one year and the results reported to this Ministry and to DGMS.	It is being complied. Draft report submitted by NIOH has been scrutinized by Medical department, BCCL. NIOH have been requested to arrange a final closure presentation at BCCL and to submit the final report as well. NIOH also done an Awareness workshop on occupational disease. Enclosed as Annexure XI
xxxiii i.	The mining in the existing mines would be phased out after expiry of the current mining lease and after reclamation of mined over area. The operating mines may be analyzed and monitored for compliance of conditions, having bearing with movement of wild life until such time they are closed/phased out.	Complied
xxxiv.	Sufficient coal pillars shall be left unextracted around the air shaft (within the subsidence influence area) to protect from any damage from subsidence, if any.	Complied in respect of all mines of Cluster XI.
xxxv.	High root density tree species shall be selected and planted over areas likely to be affected by subsidence.	Plantation in BCCL is being done on 3-tier basis, in which both, Monocotyledonae (Monocots) such as grasses, bamboo etc and Dicotyledonae (Dicots) such as sheesham, mango etc are being planted for developing an extensive root system. The Monocots having fibrous root system. The Monocots having fibrous root system helps in developing roots density at the topsoil level while, Diocots having the tap root system have a distributed root density topsoil, subsoil and regolith layer of soil. These two root system together forms the high root density system. Enclosed as Annexure XII
xxxvi.	Depression due to subsidence resulting in water accumulating within the low lying areas shall be filled up or drained out by cutting drains.	Complied

xxxvi i.	Solid barriers shall be left below the roads falling within the blocks to avoid any damage to the roads.	Being Complied.
xxxvi ii.	The CSR Action Plan shall consist of need-based CSR Action Plan, CSR Auditing and monitoring mechanism etc. The proponent will spend 5 % of the retained earnings of the previous year subject to a minimum of Rs. 5/- per ton of coal production which should be adjusted as per the annual inflation The progress made thereon shall be uploaded on the company annually on the company website. Monitoring of the impacts of activities under CSR shall be carried out periodically.	Complied. CSR work is handled at Headquarter level and every area is assigned work. CSR work carried out from April'20 till Sept'21 is enclosed as <u>Annexure –IV</u>
xxxix .	Third party evaluation shall be got carried out regularly for the proper implementation of activities undertaken in the project area under CSR. Issue raised in the Public Hearing shall also be integrated with activities being taken up under CSR. The details of CSR undertaken along with budgetary provisions for the village-wise various activities and expenditure thereon shall be uploaded on the company website every year. The company must give priority to capacity building both within the company and to the local youth, who are motivated to carry out the work in future. The gap/space available between the entire mine area should be suitably planted with native species. Plantation should also be made in vacant area and along the road side so as to reduce dust pollution.	It is being complied.
xl.	Central recreation park with herbal garden should be developed for use of all inhabitants.	Sneh-Smriti Upvan is constructed at P.B. Area Office consisting of flowering, fruit, medicinal and ornamental saplings.
xli.	The mine water should be treated properly before supply to the villager.	It is being complied. An action plan for the utilization and treatment of surplus Mine Water has been prepared by Environment, Civil and CSR department conjointly. In this regard, 26 Mines have been identified for the implementation of scheme in the Phase-I. A pilot scale mine water treatment plant in collaboration with CSIR, CIMFR is installed at P.B. Area office to convert mine water into drinking water. 2 number of pressure filter (1500 gph each capacity) are installed for treating mine water. Two number of pressure

		filters are also installed in Moonidih mine for mine water treatment.
xlii	Mine discharge water shall be treated to meet standards prescribed standards before discharge into natural water courses/agriculture. The quality of the water discharged shall be monitored at the outlet points and proper records maintained thereof and uploaded regularly on the company website.	Complied. Mine discharge water is being allowed to settle down in the mine sumps before passing through sedimentation tank. The monitoring of water quality parameters is being carried out by CMPDIL. Enclosed as Annexure XIII
xliii	The void shall be converted into a water reservoir of a maximum depth of 15-20 m and shall be gently sloped and the upper benches of the reservoir shall be stabilized with plantation and the periphery of the reservoir fenced. The abandoned pits and voids should be backfilled with OB and reclaimed with plantation and or may be used for pisciculture.	As working in P.B. Area does not approached combined seam therefore water reservoir cannot be formed. In due course we will be able to comply this point in future.
xliv	Regular monitoring of groundwater level and quality of the study area shall be carried out by establishing a network of existing wells and construction of new piezometers. The monitoring for quantity shall be done four times a year in pre-monsoon (May), monsoon (August), post-monsoon (November) and winter (January) seasons and for quality including Arsenic and Fluoride during the month of May. Data thus collected shall be submitted to the Ministry of Environment & Forest and to the Central Pollution Control Board/SPCB quarterly within one month of monitoring. Rainwater harvesting measures shall be undertaken in case monitoring of water table indicates a declining trend.	Complied. CMPDI RI-II has prepared a report for Location and design of Piezometers. Groundwater monitoring data has been enclosed as Annexure XIV
xlvi	ETP shall also be provided for workshop, and CHP, if any. Effluents shall be treated to confirm to prescribe standards in case discharge into the natural water course.	There is no CHP under of Cluster XI. Effluents from mine is treated before discharge. ETP is provided at compressor house. Effluent treated is not discharged into the natural water course rather sent to washery for further usage.
xlvi	For monitoring land use pattern and for post mining land use, a time series of land use maps, based on satellite imagery (on a scale of 1: 5000) of the core zone and buffer zone, from the start of the project until end of mine life shall be prepared once in 3 years (for any one particular season which is consistent in the time series), and the report submitted to MoEF and its Regional office at Ranchi.	Complied. Presently a time series map of vegetation cover in the Jharia Coal Field is being carried out through CMPDI, Ranchi using satellite imagery. Further CMPDI has been requested to prepare “Time series of land use maps based on satellite imagery of the core zone and buffer zone.

xlvi.	A Final Mine Closure Plan along with details of Corpus Fund shall be submitted to the Ministry of Environment & Forests five year before mine closure for approval. Habitat Restoration Plan of the mine area shall be carried out using a mix of native species found in the original ecosystem, which were conserved in-situ and ex-situ in an identified area within the lease for reintroduction in the mine during mine reclamation and at the post mining stage for habitat restoration. the mining plan and post- mining plan, closure plan should be prepared and submitted to the Ministry;	It shall be complied. It will be complied when mine life will reach its final phase.
xlvi.	A separate management structure for implementing environment policy and socio-economic issues and the capacity building required in this regard.	Agreed
xli.	The raw coal, washed coal and coal wastes (rejects) shall be stacked properly at earmarked	Agreed. Being Complied.
1	Site(s) within stockyards fitted with wind breakers/shields. Adequate measures shall be taken to ensure that the stored minerals do not catch fire.	Complied. Coal is directly feed to Moonidih washery by conveyor belt by proper sprinkling at discharge point from Moonidih Colliery. Coal is stocked in silos of Moonidih Washery in which ample amount of water is sprinkled on regular basis.
li.	Hoppers of the coal crushing unit and washery unit shall be fitted with high efficiency bag filters and mist spray water sprinkling system shall be installed and operated effectively at all times of operation to check fugitive emissions from crushing operations, transfer points of closed belt conveyor systems and from transportation roads.	Being Complied. Some more water sprinkler have been added nearby Hopper of Coal Crushing unit and loading points for water spraying and also mobile water tanker are used for spraying and also mobile water tanker are used for spraying water spraying water in transportation road.
li.	All approach roads shall be black topped and internal roads shall be concreted. The roads shall be regularly cleaned with mechanical sweepers.	Compliance under process.. Presently cleaning of roads done manually.

lii.	Green belt of 3 ha shall be developed all along the periphery of the site, along the areas such as the washery unit, crushing unit, and stockyard. A 3-tier avenue plantation would be developed along vacant areas, near washery, storage yards, loading points and transfer points and along internal roads and main approach roads and on the road upto the railway siding and at the siding. The road between the coal washery and the main -road shall be black topped and thick 3-tier vegetation between the washery and villages/habitations shall be developed. In addition, a 10m thick green avenue plantation in the transportation route from washery to Majhri Railway Siding (of WCL) shall be provided in consultation with and approval of WCL under CSR.	Under Compliance. There is no Majhri Railway siding (of WCL). Plantation work has been done along mine boundaries, overburden dump, weighbridge and along roads.
liii.	Trucks engaged for mineral transportation outside the washery up to the railway siding shall be optimally loaded. The trucks shall be properly maintained and emissions shall be below notified limits. Facilities for parking of trucks carrying raw coal from the linked coalmines shall be created within the Unit.	Complied. Certificate of Vehicle Fitness (Form 38) under Motor Vehicle Rules 1989 issued by DTO, Dhanbad.
liv.	Records of quantum of coal (in TPD) and ash content of raw coal being washed, clean coal and coal rejects produced from every batch of washing shall be maintained and details thereof uploaded on the company website.	Records of Coal fines/Slurry are Maintained and are regularly updated in the Website.
lv.	The washery unit shall be a zero-discharge facility and no wastewater shall be discharged from the washery into the drains/natural watercourses. Recycled water shall be used for development and maintenance of green belt and in the Plant Operations.	There is a Zero discharge from the washery and the water are recycled for the plant operations and for the development of the Green belts, inside the Washery premises.
lvi.	Coal fines shall be recovered from the coal slurry, washery discharge and used in power generation and records of quantum of coal fines collected and used shall be properly maintained.	Stock of slurry is maintained, Records of Coal Fines are Maintained.
lvii.	No additional groundwater shall be used for the Plant Operations. Any additional water requirement envisaged shall be obtained by recycle/reuse to the maximum extent and from rainwater harvesting measures.	Complied.
lviii.	Heavy metal content in raw coal, and washed coal shall be analyzed once in a year and records maintained thereof.	Agreed. Coal Sample has been sent to IIT(ISM), Dhanbad for analysis, Result awaited.

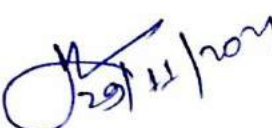
lix	Corporate Environment Responsibility:	Enclosed as Annexure-XV
a	The Company shall have a well laid down Environment Policy approved by the Board of Directors.	Agreed
b	The Environment Policy shall prescribe for standard operating process/procedures to bring into focus any infringements/deviation/violation of the environmental or forest norms/conditions.	Agreed
c	The hierarchical system or Administrative Order of the company to deal with environmental issues and for ensuring compliance with the environmental clearance conditions shall be furnished.	Agreed
d	To have proper checks and balances, the company shall have a well laid down system of reporting of non-compliances/violations of environmental norms to the Board of Directors of the company and/or shareholders or stakeholders at large.	Agreed
Sl.No	B. General Conditions by MOEF:	Compliance
i.	No change in mining technology and scope of working shall be made without prior approval of the Ministry of Environment and Forests.	Complied
ii.	No change in the calendar plan of production for quantum of mineral coal shall be made.	Being Followed.
iii.	Four ambient air quality monitoring stations shall be established in the core zone as well as in the buffer zone for PM₁₀, PM_{2.5}, SO₂ and NO_x monitoring.	The fixing up of locations of monitoring stations in the Jharia Coalfields has been taken up with the Jharkhand State Pollution Control Board. Enclosed as Annexure XVI

		The work of monitoring of ambient environment has been done through CMPDI, Regional Institute Dhanbad having laboratory recognized under EPA Rules.
iv.	Data on ambient air quality (PM₁₀, PM_{2.5}, SO₂ and NO_x) and heavy metals such as Hg, As, Ni, Cd, Cr and other monitoring data shall be regularly submitted to the Ministry including its Regional Office at Ranchi and to the State Pollution Control Board and the Central Pollution Control Board once in six months. Random verification of samples through analysis from independent laboratories recognized under the EPA rules, 1986 shall be furnished as part of compliance report.	Complied. Monitoring for the same is done by CMPDI having own laboratory recognized under EPA Rules. Monitoring data is Enclosed as Annexure XVI
v.	Adequate measures shall be taken for control of noise levels below 85 dBA in the work environment. Workers engaged in blasting and drilling operations, operation of HEMM, etc. shall be provided with ear plugs/muffs.	Being Complied.
vi.	Industrial wastewater (workshop and wastewater from the mine) shall be properly collected, treated so as to conform to the standards prescribed under GSR 422 (E) dated 19th May 1993 and 31st December 1993 or as amended from time to time before discharge. Oil and grease trap shall be installed before discharge of workshop effluents.	CMPDI Dhanbad is carrying out monitoring of environment quality work. There is arrangement for treatment of effluent discharge to prescribed standards.
vii.	Vehicular emissions shall be kept under control and regularly monitored. Vehicles used for transporting the mineral shall be covered with tarpaulins and optimally loaded.	Complied. Vehicles used for transportation are covered with tarpaulin covers.
viii.	Monitoring of environmental quality parameters shall be carried out through establishment of adequate number and type of pollution monitoring and analysis equipment in consultation with the State Pollution Control Board and data got analyzed through a laboratory recognized under EPA Rules, Monitoring of environmental quality parameters shall be carried out through establishment of adequate number and type of pollution monitoring and analysis equipment in consultation with the State Pollution Control Board and data got analyzed through a laboratory recognized under EPA Rules, 1986.	Presently, CMPDI Dhanbad is carrying out regular monitoring of environmental quality work.
	Personnel working in dusty areas shall wear protective respiratory devices and they shall also be provided with adequate training and	Complied. Vocational training Centers under

ix.	information on safety and health aspects.	Separate Human Resource Development Dept. is Conducting regular training program on these issues. Due to COVID-19 pandemics VTC under separate HRD deptt. is NOT conducting regular training programme on these issues till date. VTC training details is enclosed as Annexure XVII
x.	Occupational health surveillance Programme of the workers shall be undertaken periodically to observe any contractions due to exposure to dust and to take corrective measures, if needed and records maintained thereof. The quality of environment due to outsourcing and the health and safety issues of the outsourced manpower should be addressed by the company while outsourcing.	IME (Initial Medical Examination) & PME (Periodic Medical Examination) of the workers is undertaken in initial phase and periodic wise respectively. The records are maintained properly. Details of IME and PME Enclosed as Annexure XVII
xi.	A separate environmental management cell with suitable qualified personnel shall be set up under the control of a Senior Executive, who will report directly to the Head of the company.	A full-fledged Environment Department, headed by a HOD (Environment) along with a suitable qualified multidisciplinary team of executives which includes Environment, Mining, Excavation, Civil, Survey, Electrical & mechanical, Forestry disciplines executives and technicians (4 nos.) has been established in Headquarters. They are also trained in ecological restoration, sustainable development, rainwater harvesting methods etc. At the project level, on Executive in each area has also been nominated as Project Nodal Officer (Environment) and is also entrusted with the responsibility of compliance and observance of the environmental Acts/ Laws including environment protection measures. The activities are monitored on regular basis at Area and at Headquarters levels. GM (Environment) at head quarter level, co-ordinates with all the Areas and reports to the Director (Technical) and in turn he reports to the CMD of the company. The team is multidisciplinary and very much motivated under the guidance of company's Director (Technical) and CMD. Further capacity building at both corporate and operating level is being done.
xii.	The funds earmarked for environmental protection measures shall be kept in separate account and shall not be diverted for other purpose. Year-wise expenditure shall be reported to this Ministry and its Regional Office at Ranchi.	It is being complied. Agreed to report the same.

xiii.	The Project authorities shall advertise at least in two local newspapers widely circulated around the project, one of which shall be in the vernacular language of the locality concerned within seven days of the clearance letter informing that the project has been accorded environmental clearance and a copy of the clearance letter is available with the State Pollution control Board and may also be seen at the website of the ministry of Environment & Forests at http://envfor.nic.in .	Complied.
xiv.	A copy of the environmental clearance letter shall be marked to concern Panchayat/Zila Parishad, Municipal Corporation or Urban local body and local NGO, if any, from whom any suggestion/representation has been received while processing the proposal. A copy of the clearance letter shall also be displayed on company's website.	Complied.
xv.	A copy of the environmental clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The EC letter shall also be displayed at the Regional Office, District Industry Sector and Collector's Office/Tehsildar's Office for 30 days.	Complied.
xvi.	The clearance letter shall be uploaded on the company's website. The compliance status of the stipulated environmental clearance conditions shall also be uploaded by the project authorities on their website and updated at least once every six months so as to bring the same in public domain. The monitoring data of environmental quality parameter (air, water, noise and soil) and critical pollutant. Such as PM₁₀, PM_{2.5}, SO₂ and NO_x (ambient) and critical sectoral parameters shall also be displayed at the entrance of the project premises and mine office and in corporate office and on company's website.	Complied.
xvii.	The project proponent shall submit six monthly compliance reports on status of compliance of the stipulated environmental clearance conditions (both in hard copy and in e-mail) to the respective Regional Office of the Ministry, respective Zonal Office (s) of CPCB and the SPCB.	Complied. Last Environmental Compliance for the period of Oct'2021 to March'2021 Ref No. BCCL/WJA/ENV/2021/28(A) dated 29.05.2021

xviii.	The Regional Office of this Ministry located at Ranchi shall monitor compliance of the stipulated conditions. The Project authorities shall extend full cooperation to the office(s) of the Regional Office by furnishing the requisite data/information/monitoring reports.	Complied.
xix.	The Environmental statement for each financial year ending 31 March in Form -V is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be uploaded on the company's website along with the status of compliance of EC conditions and shall be sent to the respective Regional Offices of the MoEF&CC by e-mail.	Complied. Environment statement is sent to The Member Secretary, JSPCB, Ranchi. Moonidih Mine Environmental Statement for April'2020 – March'2021 Ref. No. MND/PO/Env/28/2021/677 dated : 05/08/2021 Moonidih Washery Environmental Statement for April'2020 – March'2021 Ref. No. BCCL/MND/MCW/PO/ENV/2021/E-995 dated 13.09.2020


 Additional General Manager
 P.B.Area
 Additional General Manager
 POOTKEE BALIHARI AREA
 B.C.C.L. DHANBAD


 Project Officer
 Moonidih Washery
 PROJECT OFFICER
 MOONIDIH COAL WASHERY


 Project Officer
 Moonidih Colliery
 PROJECT OFFICER/AGENT
 MOONIDIH COLLIERY
 B C.C. LTD.

ANNEXURE – I

EC grant for Cluster XI is 6.474 MTPA (Peak Production). The production from Cluster-XI is only 0.41 MT for the period of April'2021 to Sept'2021, which is well within the limits.

Production from April'2021 to Sept'2021 (Tonne)	
Colliery	Production (Tonne)
Moonidih Colliery	3,19,571
Other Mines	90,660
Total Production from Cluster is	4,10,231 Tonne = .41 MT

ANNEXURE-II

As per specific condition no xiii. The proponent shall prepare time -series maps of the Jharia Coalfields through NRSA to monitor and prevent fire problems in the Jharia Coalfields by Isothermal mapping /imaging and monitoring temperatures of the coal seams.

DELINEATION OF SURFACE COAL FIRE AND LAND SUBSIDENCE IN THE JHARIA COALFIELD, DHANBAD, JHARKHAND FROM REMOTE SENSING DATA

**GEOSCIENCES GROUP
REMOTE SENSING APPLICATIONS AREA
NATIONAL REMOTE SENSING CENTRE
INDIAN SPACE RESEARCH ORGANISATION
DEPT. OF SPACE, GOVT. OF INDIA
HYDERABAD-500 037**



JANUARY, 2018

**DELINEATION OF SURFACE COAL FIRE AND
LAND SUBSIDENCE IN THE JHARIA COALFIELD,
DHANBAD, JHARKHAND FROM REMOTE
SENSING DATA**

Report for

**BHARAT COKING COAL LIMITED (BCCL)
(A SUBSIDIARY OF COAL INDIA LTD.)
ENVIRONMENT DEPARTMENT, KOYLA BHAWAN
KOYLA NAGAR, DHANBAD – 826 005, JHARKHAND**

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REMOTE SENSING APPLICATIONS AREA
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HYDERABAD-500 037**

JANUARY, 2018



1. **Dr. K VINOD KUMAR**, Group Head, Geosciences Group
Project formulation and coordination
2. **Dr. Tapas R. Martha**, Scientist ‘SF’
Field survey and report preparation
3. **Shri Priyom Roy**, Scientist ‘SD’
Image processing, interpretation, field survey, maps and report preparation

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CONTENTS

ACKNOWLEDGEMENTS	i
EXECUTIVE SUMMARY	ii
LIST OF FIGURES AND TABLES	iii
CHAPTER – I INTRODUCTION	1
1.1 BACKGROUND	2
1.2 OBJECTIVES	2
1.3 STUDY AREA	3
CHAPTER – II GENERAL DESCRIPTION OF THE STUDY AREA	4
2.1 LOCATION AND ACCESSIBILITY	4
2.2 PHYSIOGRAPHY, DRAINAGE AND CLIMATE	4
2.3 GENERAL GEOLOGY	4
CHAPTER – III DATA REQUIREMENTS	7
3.1 REMOTE SENSING DATA	7
3.2 ANCILLARY DATA	7
CHAPTER – IV REMOTE SENSING DATA ANALYSIS	8
4.1 METHODOLOGY	8
4.1.1 PROCESSING OF LANDSAT 8 DATA	8
4.1.2 THRESHOLDING OF RADIANT TEMPERATURE IMAGE	9
4.2 METHODOLOGY FOR SUBSIDENCE DETECTION	12
4.2.1 PROCESSING OF ALOS-PALSAR-2 DATA	12
CHAPTER – V FIELDWORK	17
CHAPTER – VI POST FIELD WORK ANALYSIS	19
CHAPTER – VII DISCUSSIONS AND CONCLUSIONS	20
7.1 DISCUSSION	20
7.2 CONCLUSIONS	22
CHAPTER – VIII LIMITATIONS	24
REFERENCES	26
Annexure – I	27
Annexure - II	29
Annexure - III	31
Annexure - IV	34

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EXECUTIVE SUMMARY

Coal fire is a serious problem in Jharia coal field, where high ranking coals are gradually burnt due to these fires. The combined effect of surface and sub-surface fires and mining related subsidence has endangered the environmental stability of Jharia coal field. Coupled with the ecological changes instigated by open cast mining, the landscape in and around Jharia have changed drastically over the years. In the present study, delineation of coal fire and mining related land subsidence have been addressed. Thermal band of Landsat-8 (100m resolution) have been used to demarcate the coal mine fire areas from non fire areas. For this study, Landsat-8 data of May, 2017 have been used. The band 10 (10.60-11.19 μm) of Landsat-8 data is used to derive the relative radiant temperature. Further ALOS-PALSAR 2, L band microwave data has been used to delineate zone of probable land subsidence (using differential interferometry) due to mining. The study reflects that, compared to 2012, the eastern flanks (Lodna and Tisra) show a larger fire area. The western flank (Nadkhurkee and Shatabdi) and the northern flank (Katras and Gaslitand) show isolated fire pockets in active mines as well as OB dumps. Among all the colliery areas, Kusunda and Lodna area is most affected by coal mine fire. The current fire area mapped is 3.28 sq.km. Apart from this, five distinctive areas of land subsidence have been identified using interferometric method. These are primarily caused by older or active underground mining. The Moonidih Project is most affected by subsidence. The coal mine fire and subsidence areas are further verified on the ground. The final coal mine fire and subsidence map of Jharia coal field is prepared by using remote sensing data analysis with field validation.

LIST OF FIGURES AND TABLES

- Figure 1 : Study area map of Jharia Coalfield, Jharkhand
- Figure 2 : Geological map of Jharia coal field, Dhanbad, Jharkhand (published by CMPDIL)
- Figure 3 : False colour composite image of Jharia Coalfield (VNIR 3N,2,1) , with subset blocks (in red) to obtain temperature values (from radiant temperature image) within the Barakar formation across the Jharia coalfield.
- Figure 4 : Maximum temperature plotted against mean temperature for various locations; cluster separation observed around 39 °C (marked with arrow)
- Figure 5 : Coal mine fire map (May, 2017) of Jharia coal field, Dhanbad. The fire areas shown in this map have been verified in the field as per field points in figure 13.
- Figure 6 : DInSAR acquisition scheme
- Figure 7 : Work flow diagram for generating land subsidence map using DInSAR technique
- Figure 8 : ALOS-PALSAR - 2 Master-Slave pairs for short and long temporal base line processing
- Figure 9 : Fringe patterns generated from short baseline processing (e.g. Master: Oct, 16, Slave: Feb, 17)
- Figure 10 : Fringe patterns generated from long baseline processing (e.g. Master: Oct, 15, Slave: Feb, 17)
- Figure 11 : Subsidence map of Jharia coal field, Dhanbad
- Figure 12 : Total fire area statistics
- Figure 13 : Field data points for coal fire verification
- Figure 14 : Field data points for subsidence verification

Field Photographs

- Figure 15 : Fume cracks in Lodna-Tisra Area. (point 39 in figure 13 and table 4)
- Figure 16 : Burnt area near OB dump in Lodna area (point 41 in figure 13 and table 4).

- Figure 17 : Coalfries in active seams in Kusunda (point 23 in figure 13 and table 4)
- Figure 18 : Sagged area due to subsidence, south of Block II OCP. (point 1 in figure 14 and table 5).
- Figure 19 : Fire in OB dumps in Kusunda area. (point 24 in figure 13 and table 4).
- Figure 20 : Fume cracks in the Bhulanbarari area.

List of Tables

- Table 1 : Generalised stratigraphy of JCF
- Table 2 : List of satellite data used in the present study
- Table 3 : Threshold temperature for fire area estimation of individual mines.
- Table 4 : Coal Fire observations during fieldwork (see figure 13 for reference)
- Table 5 : Coal Fire observations during fieldwork (see figure 14 for reference)
- Table 6 : Colliery wise break-up of change in fire area from 2012 to 2017

CHAPTER I

INTRODUCTION

Coal fire is a perennial problem in Jharia coal field (JCF) covering 447 sq. km. area in the Dhanbad district of Jharkhand state. Subsurface and surface coal fires are a serious problem in many coal-producing countries. The severity and extent of mine fires in some of the Indian coalfields, particularly Jharia and Raniganj coalfields, are quite alarming. Combustion can occur either within coal or in coal dumps on the surface. Considerable economic loss and environmental problem arises due to the coal fire. Coal fire burns valuable coal and also creates difficulties in mining by increasing the cost of production or making existing operations difficult. Noxious gases like sulphur dioxide, nitrogen oxide, carbon monoxide, carbon dioxides, which are the result of coal burning processes, often affect the immediate surroundings of an active coal fire area (Gangopadhyay, 2003). These greenhouse gases not only affect local atmosphere but also play a crucial role in the damages, found associated with coal fire such as land surface subsidence and surface cracking. Coal fires are caused by oxidation of coal but the reaction involved in oxidation of coal is not understood till date. Broadly, the potential for spontaneous combustion lies in its ability to react with oxygen at ambient temperature. This occurs through the reaction of oxygen at the surface of the coal resulting in an exothermic reaction. As a consequence, the temperature of coal rises and if temperature reaches the threshold temperature, ranging between 80⁰ to 120⁰C, a steady reaction starts, which produces carbon dioxide. Temperature keeps on increasing once CO₂ started to form and at 2300⁰C, the exothermic reaction becomes rapid. It is known that high grade coals (high carbon content) are more fire prone, though the reason behind this is not well understood. Another important parameter, which controls fire, is the size of the particles. Larger the effective area of coal (fire particles), more rapidly the reaction proceeds. Cracks, fissures play a role like positive catalysts to coal oxidation by slowly supplying oxygen / air through their conduits.

Coal mining in Jharia Coal Field (JCF) started way back in 1895. History of fire in Jharia Coal Field date back to 1916 when the first incidence of fire was reported from XIV seam of Bhowrah colliery. JCF was nationalised in 1972 and over the decades, the fire has spread or been contained but never extinguished. The combination of underground fire and subsidence have affected vast areas of JCF.

1.1 Background

Remote sensing technique in thermal band offers a cost-effective and time-saving technology for mapping various geoenvironmental / hazardous features such as coal fires, forest fires, oil well fires, volcanic eruptions etc. NRSC has carried out coal fire mapping projects in the past; conducting an airborne campaign in 1989 and using Landsat-5 TM data in 1995 (Bhattacharya *et. al.*, 1995), over Jharia coalfield, Jharkhand and using Landsat-5 TM data for 2001 over Raniganj coalfield, West Bengal. Further, projects were executed in 2006 and 2012 in which coal fires of the JCF were mapped using Landsat-7 ETM+ and ASTER data, respectively. Additionally, a R&D study was taken up in 2013 to delineate subsidence areas using differential interferometric (DInSAR) technique. In view of the past experiences, based on the letter (Ref. no. NRSC/16/76) from Director (Tech.), Operations, BCCL addressed to Director, NRSC on 01 February 2016. a project was formulated to take up Coal fire and Land Subsidence study of the Jharia Coal Field using space-borne remote sensing technique. The formal Memorandum of Understanding between BCCL and NRSC was signed on 23rd of Dec, 2016.

1.2 Objectives

The following objectives are formulated on the basis of the above mentioned background:

- I. To map Coal fire in the study area based on pixel integrated relative radiant temperature derived from latest available Landsat-8 data of 2016-17 time period.
- II. To compare the change in the coal fire distribution in the Jharia coalfield within the period of 2012 and 2016-17.
- III. To delineate probable subsidence areas in the region using differential interferometry method.

1.3 Study Area

Jharia Coalfield is located in the Dhanbad district of Jharkhand state (Figure 1) and it is named after the main coal mining town of Jharia. It is situated in the Damodar River valley and is about 250 km NW of Kolkata. The coalfield is contained roughly within latitudes $23^{\circ} 42' N$ and $23^{\circ} 50' N$ and longitudes $86^{\circ} 09' E$ and $86^{\circ} 30' E$.

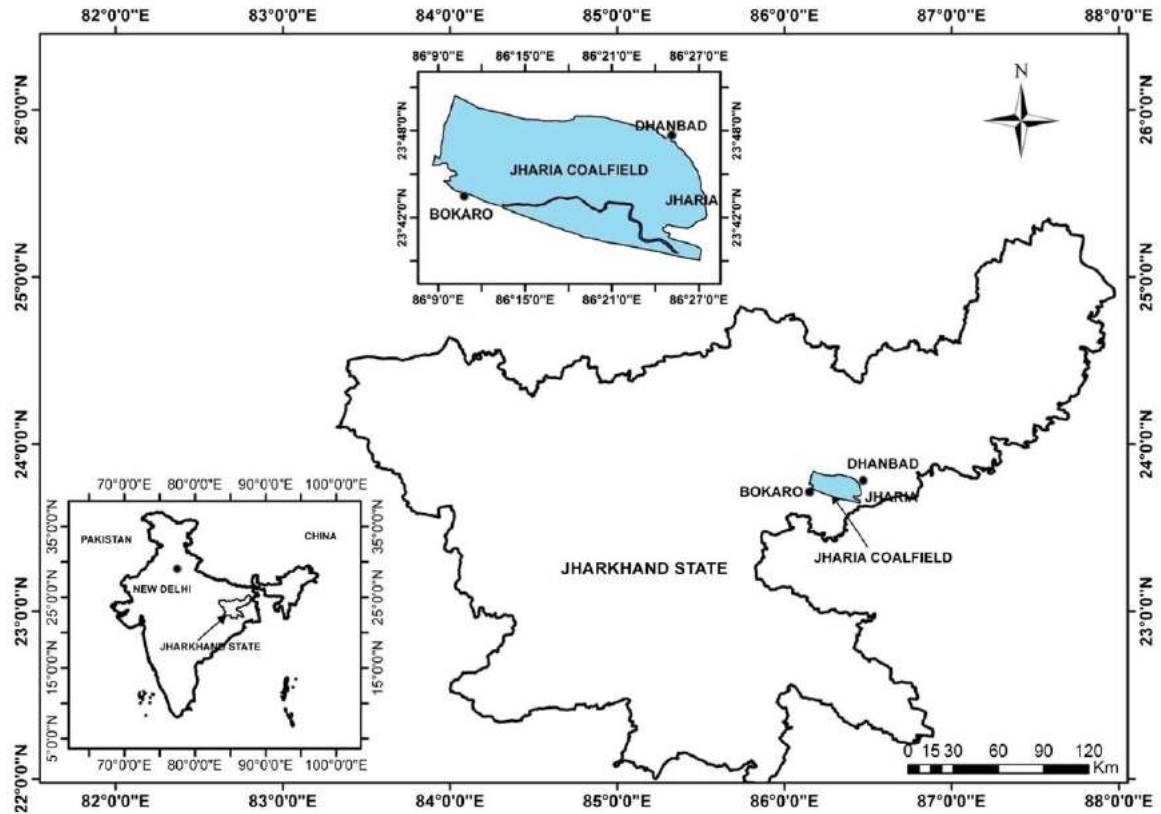


Figure 1: Study area map of Jharia Coalfield, Jharkhand

CHAPTER II

GENERAL DESCRIPTION OF THE STUDY AREA

2.1 Location and Accessibility

Jharia is an old mining town in the Dhanbad district of Jharkhand. This town is famous for its surrounding mines producing high grade coal and supplying mainly to the neighbouring industrial areas. Jharia is approximately 6 km in south western direction from Dhanbad town and connected by metal road. Dhanbad is well connected to Kolkata by road and rail.

2.2 Physiography, Drainage and Climate

Jharia coalfield is characterised by undulatory topography with very low rolling slope towards the eastern part of the area. The average height of the area is around 200 meters above the mean sea level. Damodar is the major river in the study area. The other tributaries to the Damodar River in this area are Jamuniya Nadi, Khudia Nadi, Khatri Nadi, Jarian Nala, Kari Jora and Domohani Nadi. Damodar River flows from west to east in this area. The minimum temperature is $<10^{\circ}$ C in the month of December – January and maximum temperature is $>50^{\circ}$ C in the month of May – June.

2.3 General Geology

Gondwana Super Groups of rocks of Up. Carboniferous to Lr. Cretaceous age (i.e. from 320 MY to 98 MY) are exposed here. Gondwana Super Group rocks unconformably overlie Archaean rocks. In Gondwana Rocks, Raniganj and Barakar Formations of Permian age have more potential as far as the coal production is concerned. Barakar Formation is exposed in north and north eastern part of the basin (Figure 2). Most of the coal mines are confined to the Barakar Formation in JCF. Barakars consists of coarse, medium grey and white sandstones, shales and coal seams. Raniganj consists of grey and greenish soft feldspathic sandstones, shales and coal seams. Faults are prevalent in this portion of basins (Figure 2). NW trending faults are conspicuous north to Jharia. Many lamprophyre and dolerite dykes are also exposed in this area in a criss-cross manner. The Raniganj Formation though coal bearing, has suffered much deformation due to faulting, thus causing difficulty for

mining in the area. The generalised stratigraphy of JCF is mentioned below (after Saraf, et al., 1995).

FORMATION	LITHOLOGY	MAXIMUM THICKNESS
Supra Panchet	Red and Grey sandstones and shales	300m
Panchet	Micaceous Yellow and Grey sandstones, Red and Greenish shales	600m
Raniganj	Grey and Greenish soft feldspathic sandstones, shales and coal seams	1050m
Ironstone Shales	Dark carbonaceous shales with ironstone bands	360m
Barakar	Coarse and medium Grey and white sandstones, shales and coal seams	630m
Talchir Boulder Bed	Coarse sandstones above and Greenish shales below	300m

Table 1: Generalised stratigraphy of JCF.

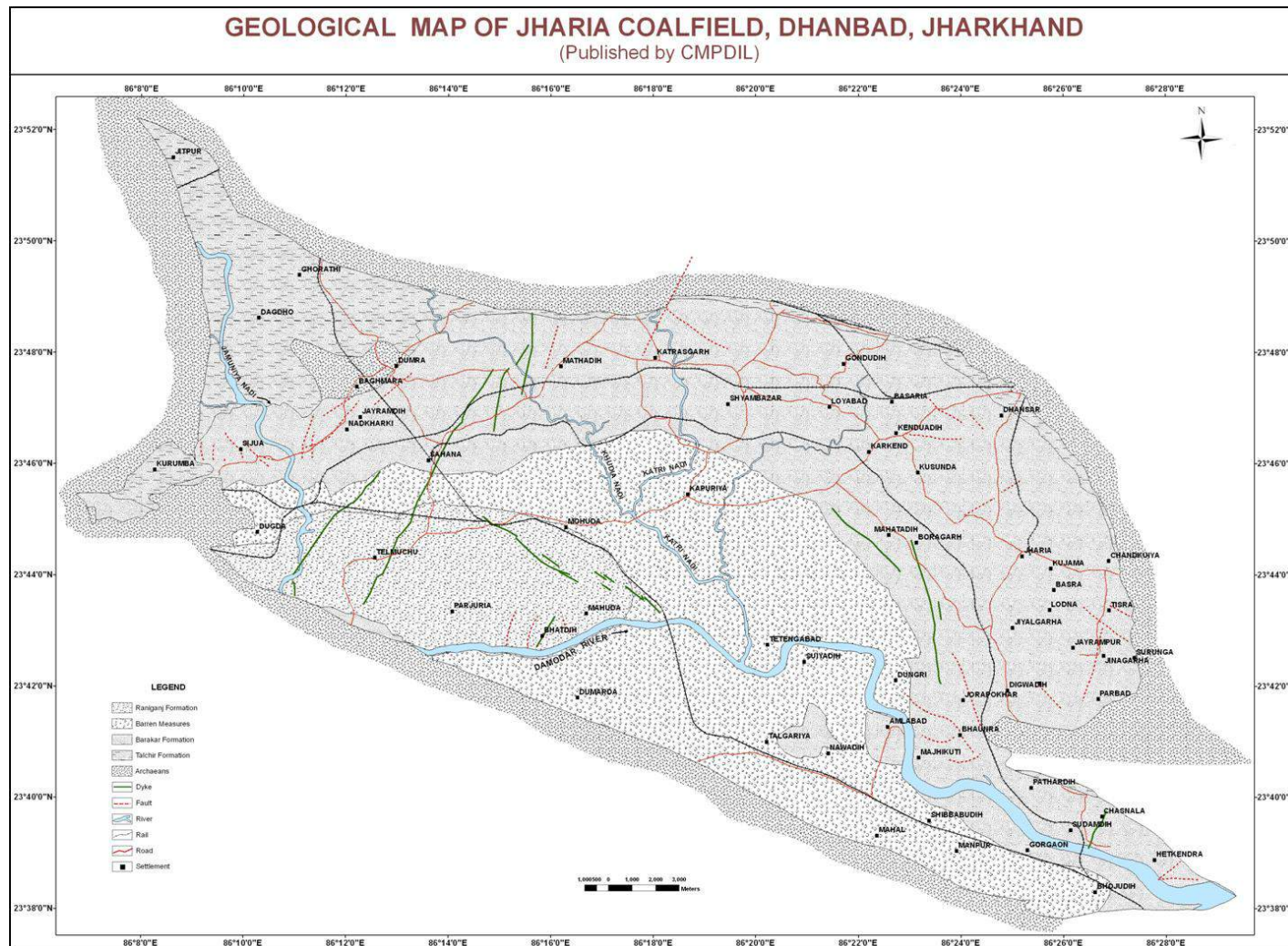


Figure 2 : Geological map of Jharia coal field, Dhanbad, Jharkhand (published by CMPDIL)

CHAPTER III

DATA REQUIREMENTS

3.1 Remote Sensing Data

The most recent available thermal satellite data was used in conjunction with the fieldwork for mapping coal fire in JCF. A coal fire map generated from the same, would serve as a reference for the fieldwork, as the observations can be verified in the field. For this purpose, a coal fire map was created from LANDSAT 8 TIRS data of 14-May 2017 .

Further, the coal fire map of 2012 prepared by NRSC (NRSC, 2012) from ASTER data was used as a reference to identify the changes that has occurred in the extent and disposition of the fires from 2012 to 2017.

For the land subsidence study, L-band microwave data from ALOS-PALSAR satellite (JAXA) were used. Five scenes of "Fine mode" SLC data were taken from PALSAR-2 archives over a period from October, 2014 to February, 2017. This was done to identify long term terrain changes and differentiate the same from short term changes due to mining excavations and overburden dumping.

Table 2: List of satellite data used in the present study.

Sl. No	Satellite	Sensor	Time	Date	Data source
1	LANDSAT-8	TIRS	Daytime	14 May 2017	USGS, USA
2	ALOS-PALSAR-2 (Fine mode)	PALSAR-2	-	4 October. 2014	JAXA, Japan
3				3 October, 2015	
4				20 February. 2016	
5				01 October, 2016	
6				18 February. 2017	

3.2 Ancillary data

1. Geological map of Jharia coal field.
2. Mine surface plans as provided by BCCL.

CHAPTER IV

REMOTE SENSING DATA ANALYSIS

4.1 Methodology

4.1.1 Processing of Landsat 8 Data

With the launch of the LANDSAT-8 mission in February, 2013; thermal space borne data is available from its thermal infrared sensor (TIRS). This has enabled monitoring of the earth with a spatial resolution of 100 m in the thermal domain with a repeat cycle of 16 days. The LANDSAT-8 has two channels (Band 10 and Band 11) in the thermal infrared region (Table 1) which ranges from 10.4 micrometer to 12.5 micrometer. In present study, band 10 of TIRS sensor (acquired on 14 May, 2017) has been used coal fire mapping (Gangopadhyay et al. 2012). The spectral domain of the band is known for its maximum transmittance (Chatterjee et al. 2007; Martha et al. 2010). The data are freely accessible through USGS portal (Landsat 8 download source: <http://landsatlook.usgs.gov>).

Landsat-8 data are available in GeoTiff format and the data are converted to top of the atmosphere spectral radiance using the radiance rescaling factors provided in the metadata file, using equation 1.

$$L_{\lambda} = M_L Q_{cal} + A_L \dots\dots\dots (1)$$

Where:

L_{λ} = Spectral radiance (Watts/ (m² * srad * μm)).

M_L = Band-specific multiplicative rescaling factor from the metadata.

A_L = Band-specific additive rescaling factor from the metadata.

Q_{cal} = Quantized and calibrated standard product pixel values (DN).

Once the spectral radiance (L_{λ}) for ASTER Band 13 and Landsat-8 band 10 data is generated, it is possible to calculate radiant (brightness) temperature directly using equation 2. Planck's radiation function (Planck, 1914) forms the basis of radiant temperature derivation from spectral radiances and the theory is discussed in detail in existing literatures (Gupta, 2003).

$$T_R = K_2 / \ln ((K_1 / L_{\lambda}) + 1) \dots\dots\dots (2)$$

T_R = Radiant (brightness) temperature,

K_1 = Calibration constant (1260.56 K),

K_2 = Calibration constant (666.09 watts/ (m² *ster*µm)),

L_λ = Spectral radiance

4.1.2 Thresholding of radiant temperature image

Once the Landsat-8 data are converted to radiant temperature image, the next step was to segregate fire pixels from the background, which requires the estimation of the cut-off temperature (Roy et al. 2015). This has been attempted by the statistical analysis of sensor derived radiant temperature to delineate clusters (in the scatter-plot) indicative for fire and non-fire pixels. Mean and maximum radiant temperatures are derived from randomly sampled uniform sized pixel blocks distributed in entire spatial extent of Barakar formation (Figure 3) known for fire bearing coal seams. The pixel block sizes are chosen to adequately represent the overall areal extent of the coalfield and homogeneously encompass all the mining blocks (27x27 pixels for Landsat-8, Figure 3). The maximum temperature value recorded in each representative area, derived from each of the datasets, is plotted against the mean temperature. The maximum temperature represents that of fire (wherever present), whereas the mean temperature represents the average background temperature, for normalization. The fire and background populations show considerable variance, separating coal fire and background radiant temperatures. The cut-off temperature derived is the maximum temperature of the background cluster, above which all temperatures represent coal fires. In the case of the Landsat-8 data used in this study, the cut-off temperature was determined around 39°C (Figure 4). Based on this cut-offs, regional coal fire map was prepared (Figure 5).

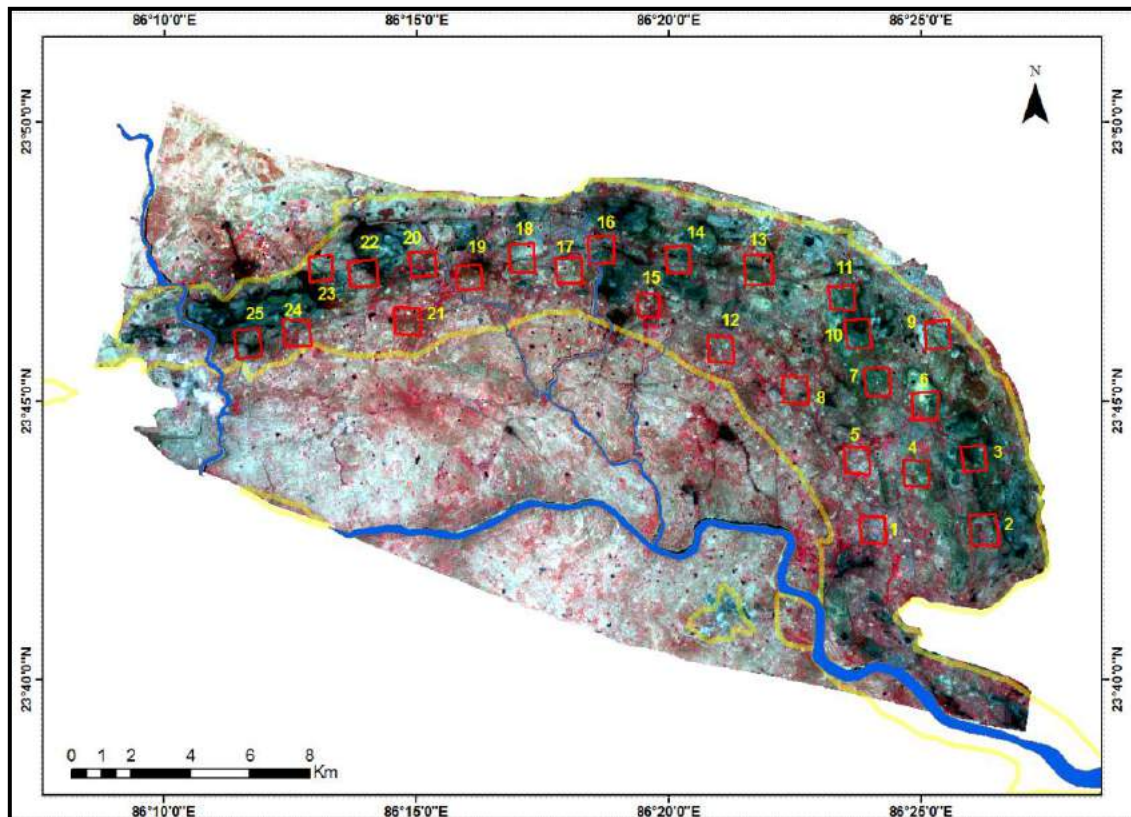


Figure 3. False colour composite image of Jharia Coalfield, with subset blocks (in red boxes) to obtain temperature values (from radiant temperature image) within the Barakar formation across the Jharia coalfield.

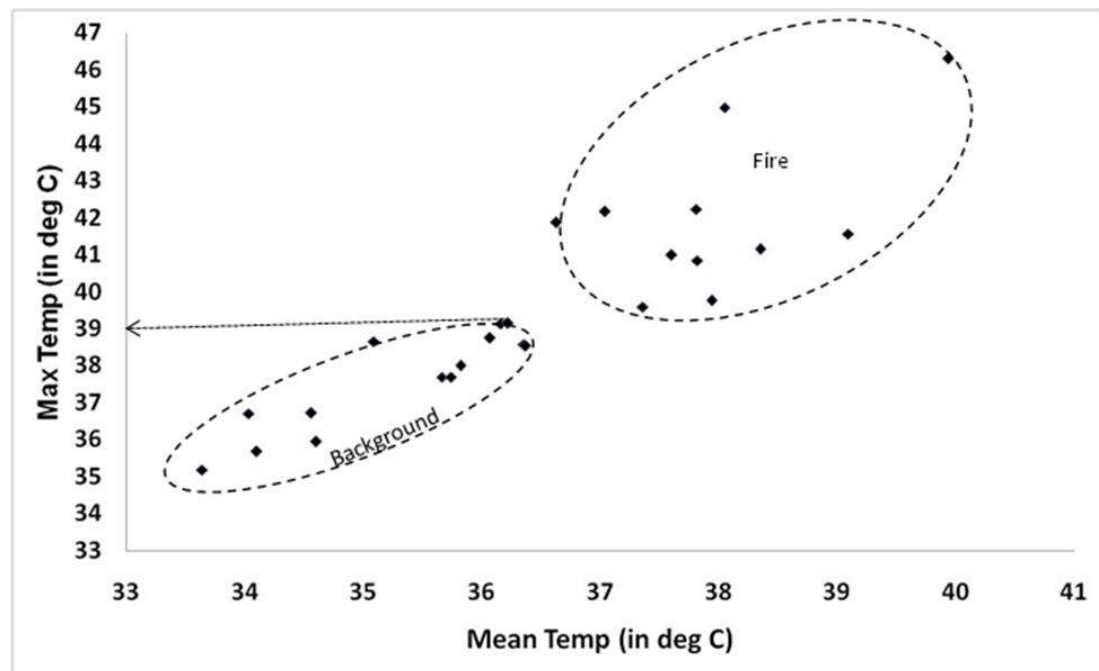


Figure 4. Maximum temperature plotted against mean temperature for various locations; cluster separation observed around 39 °C (marked with arrow)

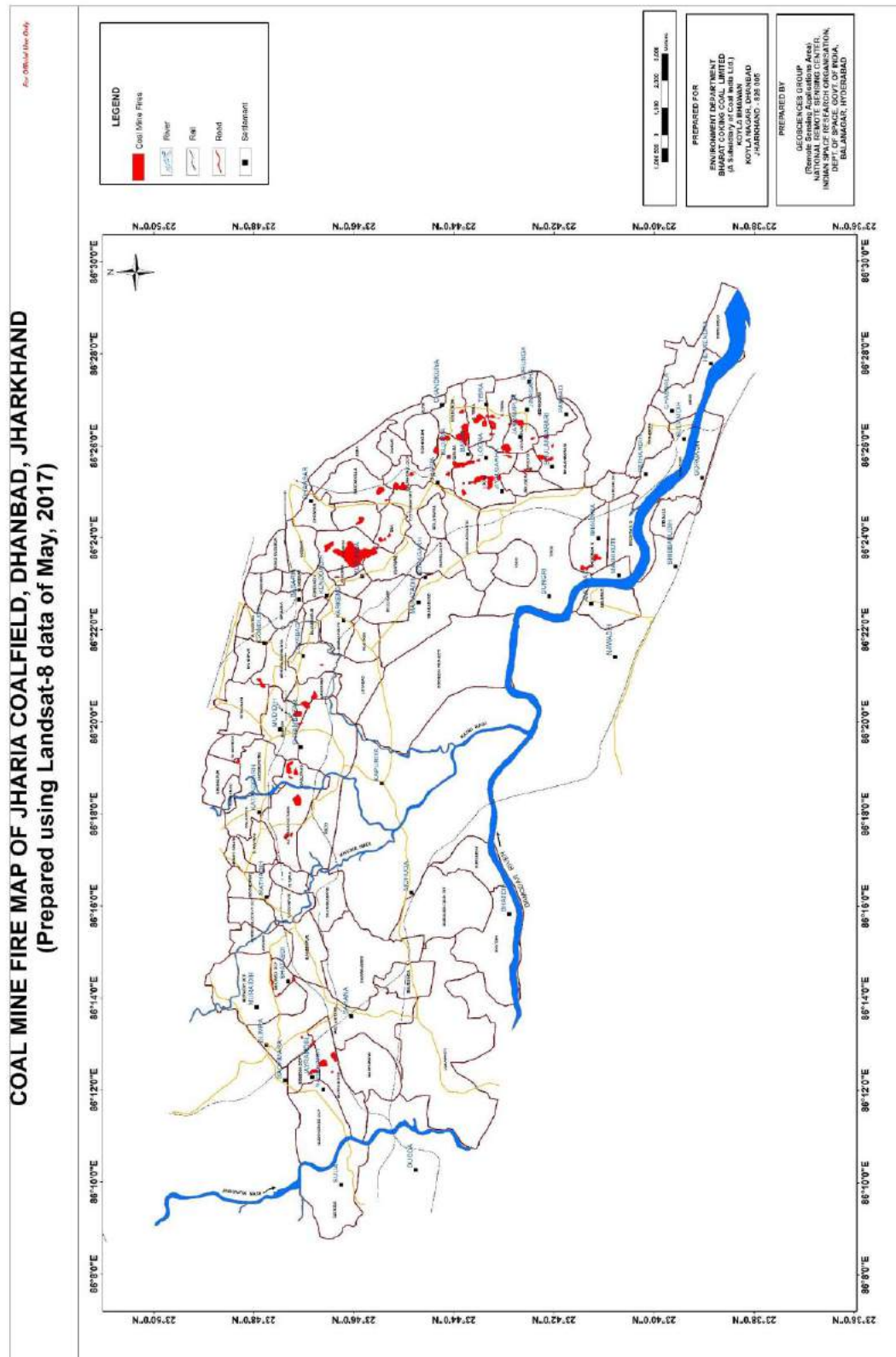


Figure 5: Coal mine fire map (May, 2017) of Jharia coal field, Dhanbad. The fire areas shown in this map have been verified in the field as per field points in figure 13.

4.2 Methodology For Subsidence Detection

4.2.1 Processing of ALOS-PALSAR 2 Data

Differential Interferometric SAR (DInSAR) techniques consist of combination of two SAR images of the same area acquired from slightly different positions (Figure 6).

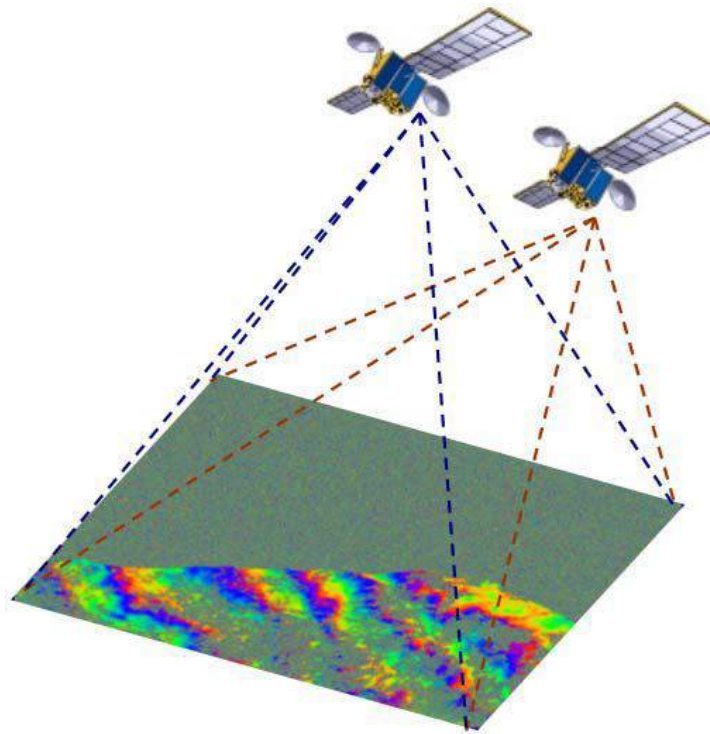


Figure 6. DInSAR acquisition scheme.

The result of this combination provides a new image, known as 'interferogram', whose phase component is formed by the following term:

$$\Delta\Phi_{Int} = \Phi_{Topo} + \Phi_{Mov} + \Phi_{Atm} + \Phi_{Noise} \quad (3)$$

where, Φ_{Topo} denotes the topographic component, Φ_{Mov} denotes the terrain deformation/ displacement component, Φ_{Atm} is the noise component and Φ_{Noise} is the thermal noise.

Topography, atmospheric effects and thermal noise needs to be removed or optimized to obtain precise measurements of terrain movement. When working with classical DInSAR interferograms (combination of two SAR images) the main problem is the presence of atmospheric artefacts, since there is no way to cancel them without a priori information. On the other hand, the term related with topography can be cancelled out using and external Digital Elevation Model (DEM) and the orbital ephemeris from the SAR acquisitions, considering no height errors on the DEM.

$$\Delta\Phi_{dif} = \Phi_{ErrorTopo} + \Phi_{Mov} + \Phi_{Atm} + \Phi_{Noise} \quad (ii)$$

Since the coal mine area is very dynamic in terms of its surfacial changes (open cast mine, abandoned mine, fire affected waste/reclaimed land, over burden dumps) over time, it is proposed to utilize an advanced DInSAR technique. It is a recent remarkable improvements in SAR differential interferometry that has led to an innovative approach based on the use of a large dataset of SAR images over the same area to overcome the intrinsic limitations of conventional DInSAR in terms of temporal and geometrical decorrelation as well as atmospheric disturbances (Ferretti et al 2001; Hooper et al 2004; Kampes, 2006; Lanari et al 2004; Mora et al 2003; Werner et al 2003).

Broad work flow diagram for generating land subsidence map using satellite based DInSAR technique is shown in Figure 7.

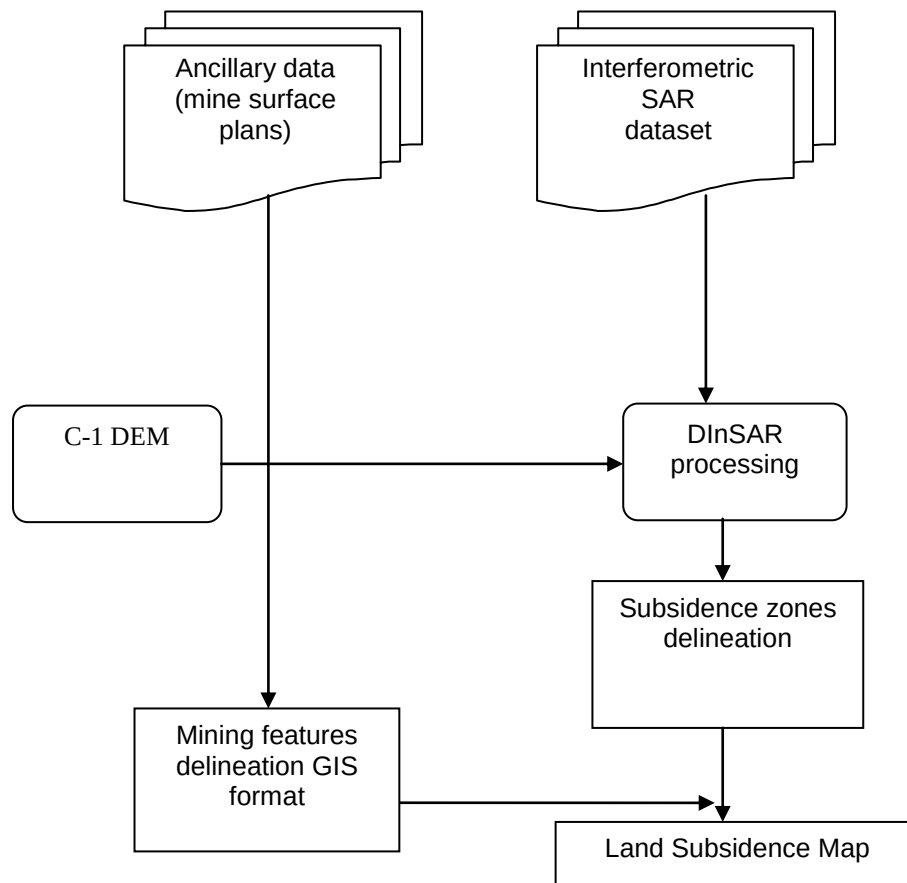


Figure 7. Work flow diagram for generating land subsidence map using DInSAR technique.

In the present study, 5 sets of ALOS-PALSAR L-band microwave data (as mentioned in table 1) were procured. The datasets were paired into master-slave pairs as per short and long temporal baselines. The short temporal baselines include master slave pairs of time difference of six months or less, whereas long temporal baselines include data pairs of time difference of one year or more. This has been illustrated in figure 8.

		SLAVE IMAGE				
		October, 2014	October, 2015	February, 2016	October, 2016	February, 2017
MASTER IMAGE	October, 2014					
	October, 2015					
	February, 2016					
	October, 2016					
	February, 2017					
		Short Temporal Baseline Pair (less than 1 year)				
		Long Temporal Baseline Pair (more than 1 year)				

Figure 8. ALOS-PALSAR - 2 Master-Slave pairs for short and long temporal baseline processing

The interferometric fringes generating from short baseline pairs will generally indicate terrain changes due to mining activity happening over a short period of time. This will include mining excavations and creation of new OB dumps adjacent to the mining area. Any incidences of slow land subsidence will not be demarcated in the results (figure 9).

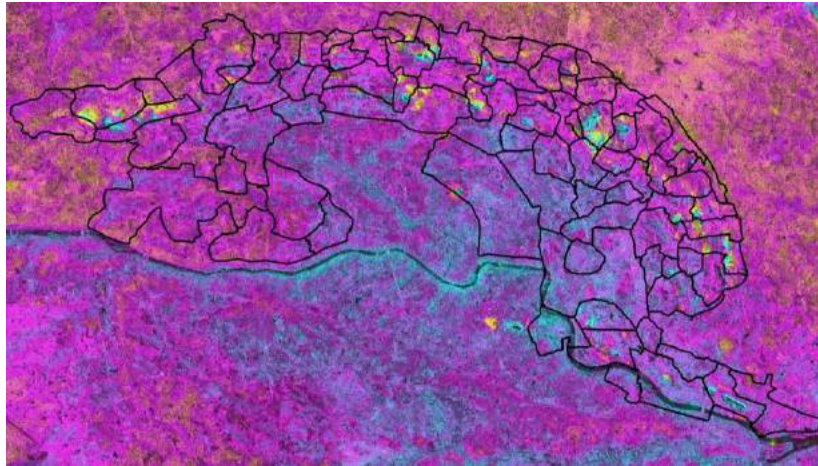


Figure 9. Fringe patterns generated from short baseline processing (e.g. Master: Oct, 16, Slave: Feb, 17).

On the other hand, master-slave pairs of long temporal baseline (one year or more, as shown in figure 8) will incorporate terrain changes due to mining activities as well, as long term ground subsidence from underground mining where ever present (figure 10).

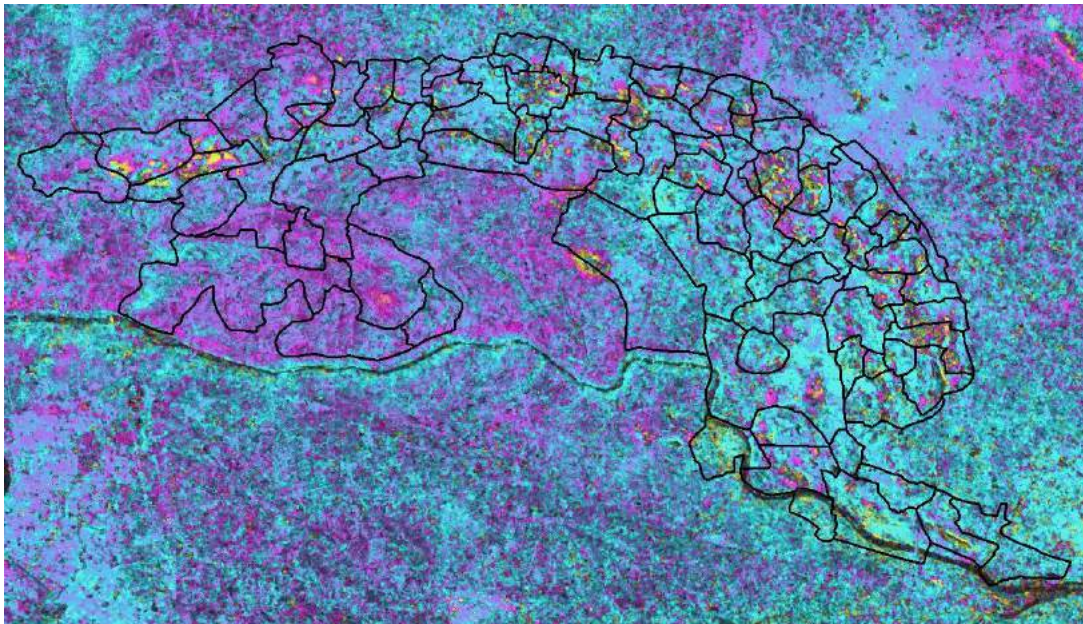


Figure 10. Fringe patterns generated from long baseline processing (e.g. Master: Oct, 15, Slave: Feb, 17).

The results from the long and short baseline processing can be compared and zone where fringes have been developed due to terrain changes due to mining excavation and dumping, can be systematically identified and demarcated. The remaining fringes from the long temporal baseline processing will then indicated towards zones where subsidence has taken place due to underground mining. Using this, a terrain change

map of the Jharia Coalfield was generated demarcating terrain changes due to mining activities and subsidence areas (Figure 11).

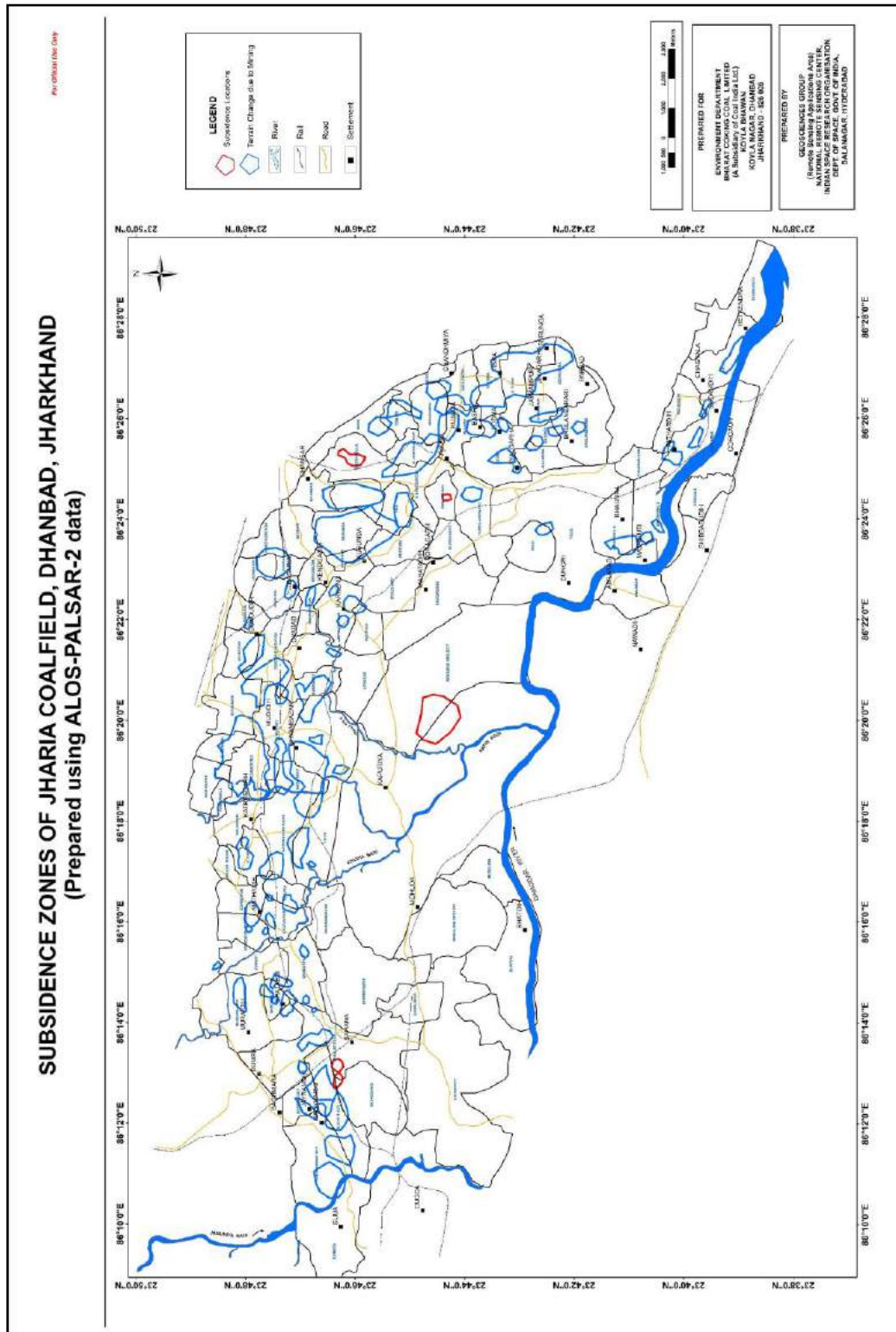


Figure 11: Subsidence map of Jharia coal field, Dhanbad.

CHAPTER V

FIELD WORK

A field work for verification of the coal fire locations and the subsidence zones as identified by the satellite data were taken up in December, 2017. A total of 53 coal fire points and 37 land subsidence locations were identified from the satellite data analysis. The locations of these points along with geographic coordinates were given to BCCL prior to the December, 2017 field work for their feedback on the status of these points. Out of the 53 coal fire locations identified, 52 points were confirmed to be fire bearing as per the present masterplan of the Jharia coalfield created by BCCL. Both the coal fire and the subsidence locations were further independently verified by NRSC during the fieldwork in December, 2017. The locations and the observations are coal fire and subsidence are provided in annexure 1 and annexure 2 of this report respectively.

The salient overview of the field observations are as follows:

Coal-fire observations:

1. The coal fires as observed identified by the Landsat-8 data are mostly accurately delineated. Fires have been identified in the western, northern and eastern flank of the coalfield with considerable accuracy in the spatial locations.
2. In the eastern flank, the main fire affected mines are Kusunda, Lodna and Tisra. Active fires area present in the mines and fumes can be seen from the OB dumps. The Bhowra and Bhulanbarari mines also show presence of fire, however, the extent of the fire area appears to be underestimated in the data. Similarly, the extent of fires in Lodna and Tisra appears to have been overestimated in the data. The largest extent of fire in the single mine block is that in Kusunda.
3. In the northern flank, the main fire bearing mines are Katras, Gaslitand and Mudidih, However, it is seen that in these areas, the fires appears in pockets and are not pervasively present. The spatial extent of the fires on the ground and as estimated in the data can be correlated.

4. In the western flank, the Block II OCP is the primary fire affected region. However, it is seen that the Shatabdi OCP also bears fire pockets along semi-vertical mine walls, This is not identified in the data.

Subsidence location observations:

1. Subsidence locations as identified by the data area difficult to verify in the field, unless there are tell-tale signatures like large cracks or fissures on the ground or damage to anthropogenic constructions like vertical cracks on building cracks etc.
2. Out of the 37 identified subsidence locations from the microwave data, it is seen that 32 are due to terrain changes resulting from mining activities like ongoing excavations or formation of new mining dump. These decrease or increase in elevations has resulted in forming of interferometric fringes in the data thus creating false positives.
3. Five areas were firmly established as subsidence zones. Out of these, the main area where subsidence is occurring in a pervasive scale, is that in the Moonidih Underground Project. The Moonidih Project is an underground long wall mine where excavations are going on for over decades. This may have resulted in pervasive subsidence in the region. The signatures of subsidence such as ground cracks are observed in the area.
4. Two adjacent locations are observed south of the Block II OCP and in Phularitand mining block. This may be resulted due to older underground mining in the area. Signatures such as sagging of ground is seen.
5. Another minor subsidence region was identified around the Simlabahal underground mining project. This is again due to active underground mining in the area. A similar region was also observed in the northern part of the Bastacolla mines where active underground mining is ongoing.

In lieu of the observations in field on the fire and subsidence locations, few post field work correction in the coal fire and subsidence maps was necessitated and has been discussed in the next chapter.

CHAPTER VI

POST FIELDWORK ANALYSIS

As observed in the fieldwork, there were certain mine areas where the presence of fire was not detected by the satellite data. For example in Shatabdi and Bhulanbarari mine areas, the fire appears in small pockets on mine faces and was possibly not detected by the threshold temperature calculated for the entire mine area. On the other hand, in the Bhowra, Lodna and Tisra mine areas, the spatial extent of fire appears to have been overestimated by the regional threshold temperature use to separate the fire and the background areas.

Therefore, mine specific threshold temperature analysis was carried out for Shatabdi, Bhulanbarari, Bhowra, Lodna and Tisra mine areas to correctly depict the fire areas on the ground. The threshold temperature selected from each of these mine areas are given in Table 3.

Table 3: Threshold temperature for fire area estimation of individual mines.

Name of the Mine Block	Threshold Temperature (in °C)
Bhowra	38.5
Tisra (north and south)	North : 41; South : 40.5
Lodna	41
Bhulanbarari	38.5
Shatabdi	38

Using the threshold temperatures as mentioned in the table 3, the previously undetected fire areas in the Shatabdi and Bhulanbarari mines were detected. Further the spatial extent of the fire areas in Bhowra, Lodna and Tisra mines were changed to adequately represent the actual extent of the fire on the ground. These were incorporated in the coalfire map shown in figure 5.

DISCUSSIONS AND CONCLUSIONS

CHAPTER VII

7.1 Discussions

7.1.1 Coal fire analysis

The present study is aimed to provide the status of coal fire in the Jharia coal field for the period of 2017. Landsat-8 data of May, 2012 was used to prepare the coal mine fire map (Figure 5) for the year 2017. The data have 100 m spatial resolution in the thermal bands and is as on study date, the best thermal satellite data available. The Coal fire maps of 2017 when compared to map of 2012 (NRSC, 2014) depicts the dynamics of coal fire. Coal fire is difficult to mitigate because of its dynamic nature. But the understanding the trend in the shift of coal fire zones and over all distribution of coal fire will help in environmental and risk management related to coal mining activities.

The coal mine fire map for the year 2017 (Figure 5 illustrates the overall fire distribution in the area). The maps reveal that the coal fires are distributed across the Jharia coal field in pockets associated with major open cast mining activities. All most all the coal mine fires are restricted to the Barakar Formation where coal seams are exposed. In the eastern flank of the arcuate shaped mining extent, the collieries in Lodna and Tisra (North and South) is the highest fire affected mining blocks and Bhowra, Bhulanbarari, Kujama and Jharia are also affected by multiple smaller fire pockets. The fire in the areas is mostly manifested by high temperature fume cracks with occasional presence of active flames especially the the Lodna-Tisra area. Further, towards the north east, in Ena and Kusunda active fires are more prevalent and the area is extensively affected. The highest radiant temperatures (in order of ~50°C) are recorded by the satellite sensors in these areas. In the north, a large number of moderate to small fire pockets are seen in the areas around Shyambazar (Figure 5 & 6). These are related to the mining areas of Katras, Gaslitand, Mudidih and Kankanee. Mining activity, over the last few of years has exposed new, isolated and discontinuous fires in these regions.

In the western flank, three distinguishable fire affected zones are seen. Toward the western end of the mining area, the Benedih and Block II OCP are affected by smaller fires from isolated coal seams. These again are surfacially manifested in the

form of fume cracks with smoke emanating from them. The Shatabdi OCP are also affected but fire is manifested in the along vertical mining wall sections.

Comparison of the 2017 coal fire map with that of 2012 (NRSC, 2014) indicated the dynamism in the spatial extent and distribution of the coal fires. The changes are highlighted as follows:

- i. In reference to the map generated in 2012, the 2017 map shows that the emergence/re-emergence of fires in the eastern flank, namely Kujama, Tisra, Lodna and Jharia etc. The entire zone has been affected by multiple fire occurrences. The spatial disposition of fires in Bastacolla, Jharia and Bhulanbarari appear to have a minor increase.
- ii. The areal extent of major fire zone around Kusunda/Kenduadih and Ena appears to remain the same, though here again the spatial location of the anomalies has changed. This is probably due to the mitigation and active mining in this region.
- iii. The fire zones in Benedih/Block II OCP and Shatabdi OCP have also changed/diminished in areal extent with presence of isolated smaller anomalies. There has been a considerable reduction in fire areas in and around the Shatabdi OCP.
- iv. The spatial disposition of fire areas around Katras, Gaslitand and Mudidih show minor change. In 2012, a number of small fire pockets were seen, however presently those fire pockets have given away to a few fire zones of moderate disposition.
- v. It needs to be noted that the 2012 study was carried out using ASTER data whereas the present study is carried out using Landsat-8 data. Therefore, the difference of sensor sensitivities will have a influence on the way the fires are sensed on the ground. Difference of sensor sensitivities will influence the number of fires identified as well as the areal extent of the fires in the data.

In summary, there is a change in the areal disposition of the fires from 2012 to 2017. Observations suggest the emergence/re-emergence of new areas in the eastern flanks in areas around Lodna and Tisra. Concurrently, there is a decrease in extent of fire areas Shatabdi, Nadkhurkee area in the western flank from 2012 to 2017. A quantitative comparison of the 2012 and 2017 data was carried out. As compared

2012, when the total fire affected extent of about 2.18 km²; in 2017 total fire affected extent is about 3.28 km². The colliery wise break-up of change in fire area from 2012 to 2017 is given in Annexure III.

7.1.2 Subsidence analysis

An attempt to identify subsidence zones in the Jharia Coalfield was also carried out using ALOS-PALSAR-2 L band microwave data using differential interferometric technique. 5 scenes of PALSAR-2 data spanning over a period of 2014 to 2017 were used to delineate the subsidence if any in the region and separately identify them from the terrain changes due to mining. Verification of the subsidence zones as seen from data is difficult as it requires visible signatures of subsidence in the form of cracks on the ground and damage to anthropogenic structures. In this study, data analysis and consequent field verification resulted in identification of 5 prominent subsidence areas. Of these, the major area where considerable ground subsidence is occurring is the Moonidih UG project. Long term underground mining has resulted in continuous subsidence in the area. Apart from this, the other four areas are south of Block II OCP, Simlabahal and Bastacolla. No quantitative estimates of the subsidence has been carried out in the study.

7.2 Conclusions

The following conclusions can be made:

1. As of the date of study in the year 2017 and in comparison with the previous study done in 2012, there has been a change in areal extent and disposition of the fire affected areas.
2. Compared to 2012, the eastern flanks (Lodna, Tisra areas) show considerable increase in fire disposition and the western flank (Shatabdi and Block II area) show diminished fire presence.
3. The major new fire areas are observed in the northern flank in the areas around Lodna and Tisra etc. These areas were not mapped as fire in the 2012 study.
4. The mines in Kenduadih and Lodna remain to be the worst affected with maximum presence of active fires.
5. There is an increase in areal extent of the fire (Figure 12) from 2012 to 2017.

Note: Estimations of fire extent (in terms of sq.km.) both in 2012 and in the present 2017 study are pixel based. They do not represent the actual ground area under fire. These estimations are made for comparative purpose only, to indicate the increase or decrease of areal disposition of fire. Hence, they should not be quoted as fire area on the ground.

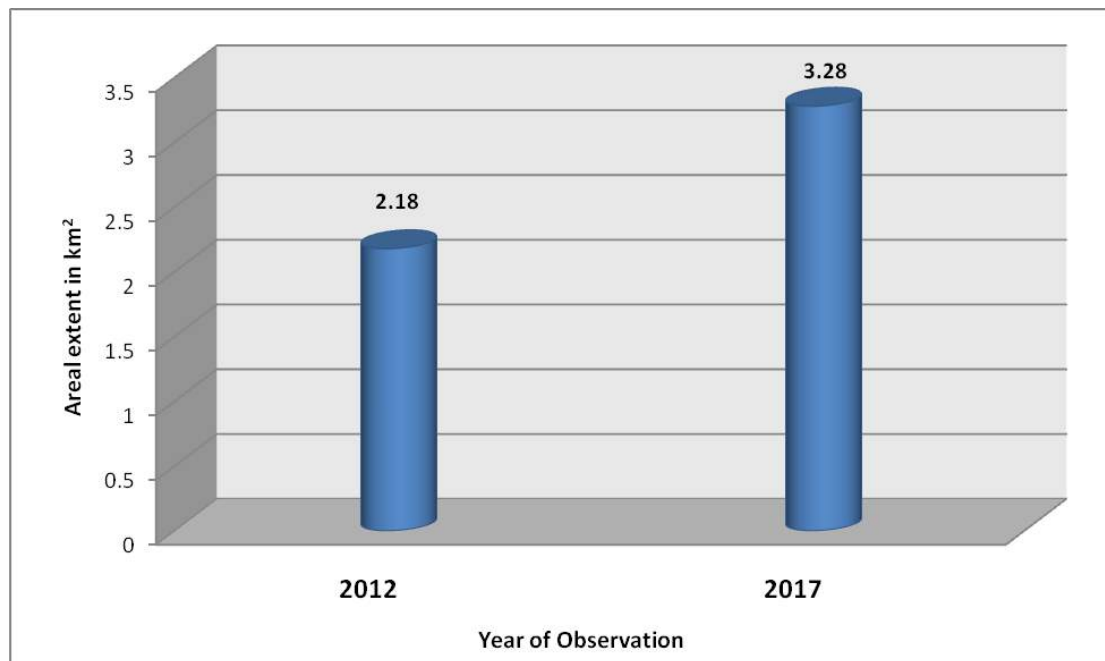


Figure 12: Total fire area statistics

CHAPTER VIII

LIMITATIONS

Delineation and mapping of coal fire from thermal data of remote sensing platforms carries with it some inherent limitations which needs to be understood in order to decipher the results obtained from it. This will assist in deducing the correct information and remove any ambiguity associated with the results. The key limitations of the data and the results obtained are as follows:

- 1) An anomalous pixel from LANDSAT data represents an area of 30m x 30m (resampled from spatial resolution of 100m) on the ground whose temperature is considerably higher than its surroundings. This can be attributed to two circumstances, namely the area has a very high intensity fire located within a smaller pocket or there are a number of low intensity fires spread across it. In both the mentioned cases the actual areal extent of the fire on the surface differs, but appears as a single anomalous pixel in the data. Hence, representation of fire affected ground area by means of pixel area is ambiguous and hence should be considered with caution.
- 2) There are locations as observed during the fieldwork, where coal seams are affected by active fires along vertical/semi-vertical sections of open cast mines (see cover page). In such cases, the actual areal expression of the fire affected area as seen by the sensor changes considerably and the representation from the same is not accurate.
- 3) As discussed in section 4.2.1, thresholding the data to separate the fires from the non fire areas, is a statistical technique. However, this method is dependent on how the temperature of non-fire background area is distinctive from the fire temperature.
- 4) The background temperatures vary with the time of the day when the data is collected, topography, and season of the year when the data is acquired. Night-time data has lower background temperature as compared to day-time. Similarly a data collected in October-November will have a considerably lower background temperature than that collected in May-June due to seasonal temperature variations. Hence, identification of the background temperature range becomes essential in

estimation of threshold temperature and the same varies depending upon the discussed controlling factors.

5) Generally, a constant threshold temperature is estimated over the entire study area, and the same is applied to delineate the fire areas from those of non-fire. However, it is seen that the application of such global thresholding may mask fires which are in turn seen in the field and that the threshold temperature value may vary locally. In the current scenario, it is seen that the fire locations as verified in the fieldwork at Bhulanbarari and Shatabdi were not identified in the data on application of a global threshold of 39°C. However, a subset of the data within the Bulanbarari area only, is analyzed with a lower threshold of 38.5°C, the fire pixels are manifested in the data. Hence, the appropriateness of a singular thresholding temperature value may need to be relooked upon. Future studies can be carried out using colliery wise statistical local thresholding to create a composite coal fire map.

6) Due to the mitigation measures taking place in various mines, it is seen that in a number of places the fire affected seam is excavated and dumped as overburden. However, these overburden dumps retain the excavated burning coals and thus are seen to have active fires occasionally. There lies a possibility that the same will be identified as anomalous pixels and hence, although the fire is not a part of any active coal seam, it will be included as a fire affected area in the final map.

7) Verification of the subsidence zones as detected from the interferometric technique is sometimes difficult due to lack in observable signatures of subsidence such as cracks on the ground and damage to anthropogenic structures.

Therefore, in quantitative estimation of fire affected areas and areas denoted as subsidence, the above mentioned limitations need to be taken into account diligently, as it is inevitable that the area estimate will not define the actual fire/subsidence affected area on the ground. However, the areal extent estimated from the data can be "like to like" compared to earlier estimates of similar studies to understand the change and dynamism of the fire in terms of area affected and spatial disposition.

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Annexure –I

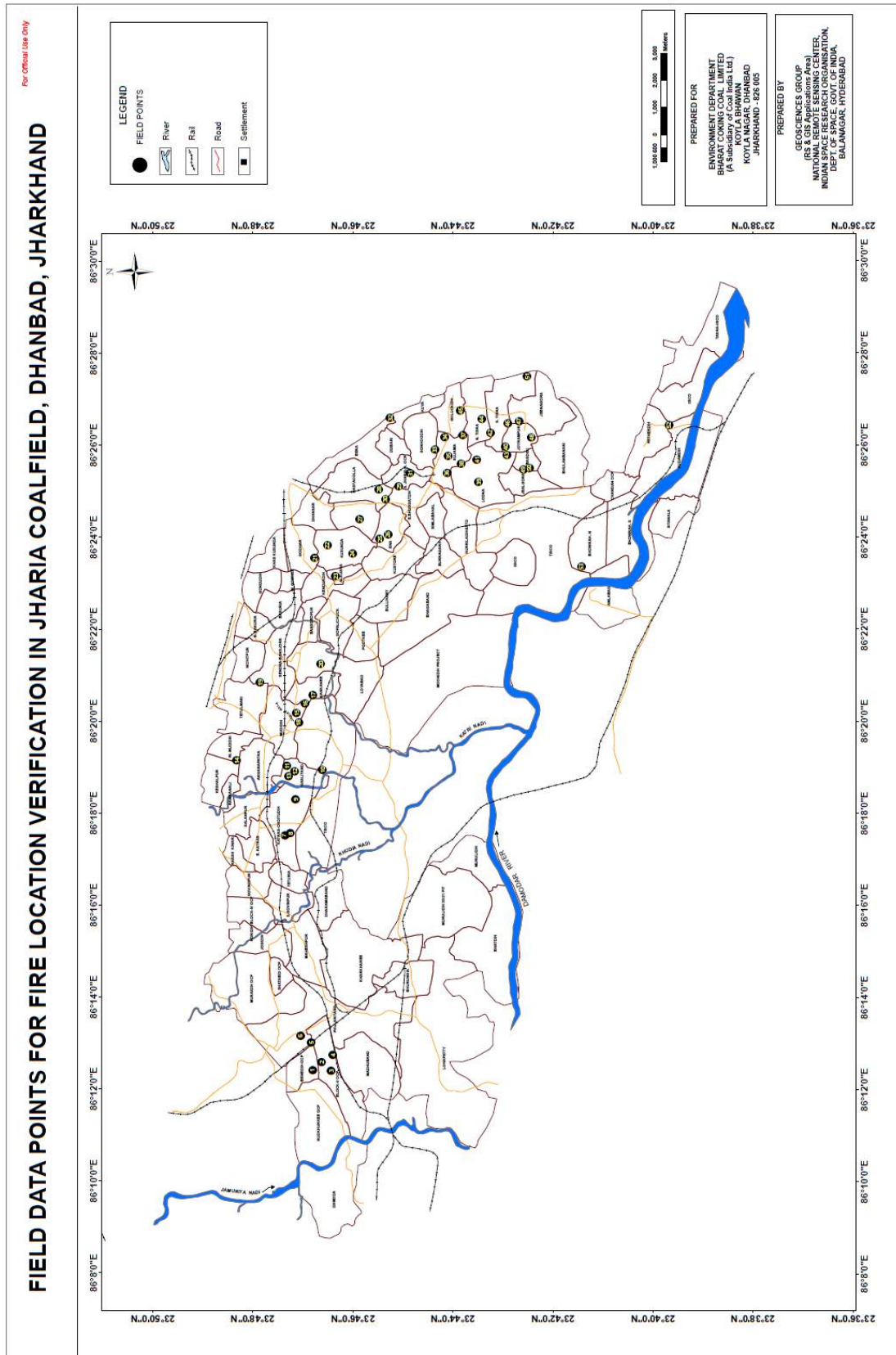


Figure 13. Field data points for coal fire verification

Table – 4: Coal Fire observations during fieldwork (see figure 13 for reference)

SL No.	Point of Observations		Comments		
	Latitude	Longitude	Type of Mining Activity	Presence of Coal Fire	Mine name and Any other Comments
1	23.7801	86.2068	OB Dump	Fire	ABOCP
2	23.7771	86.2097	Active Mine	Fire	ABOCP
3	23.7739	86.2066	Active Mine	Fire	ABOCP
4	23.7733	86.2124	OB Dump	Fire	ABOCP
5	23.7806	86.2168	No Working	Fire	ABOCP
6	23.7841	86.2192	No Working	Fire	Phularitand
7	23.7893	86.2919	No Working	Fire	Katras Chatudih
8	23.7875	86.2926	No Working	Fire	Katras Chatudih
9	23.7857	86.3049	Working	Fire	Gaslitand
10	23.7768	86.3157	Outside Jharia Mines		Tata
11	23.7887	86.3170	OB Dump	Fire	Gaslitand
12	23.7862	86.3151	OB Dump	Fire	Gaslitand
13	23.7880	86.3133	OB Dump	Fire	Gaslitand
14	23.8054	86.3191	Working	Fire	AKWMC
15	23.7855	86.3363	OB Dump	Fire	Mudidih
16	23.7826	86.3397	Working	Fire	Kankanee
17	23.7800	86.3427	Working	Fire	Kankanee
18	23.7848	86.3327	OB Dump	Fire	Mudidih
19	23.7977	86.3473	OB Dump	Fire	Sendra Bansjora
20	23.7775	86.3540	OB Dump	Fire	Loyabad
21	23.7793	86.3924	No Working	No fire	Kusunda (Domestic coal burning)
22	23.7753	86.3970	Working	Fire	Kusunda
23	23.7724	86.3858	Working	Fire	Kusunda
24	23.7669	86.3940	OB Dump	Fire	Kusunda
25	23.7578	86.3993	OB Dump	Fire	Ena
26	23.7550	86.4009	OB Dump	Fire	Ena
27	23.7645	86.4065	Working	Fire	ADIC
28	23.7580	86.4172	Old Quarry	Fire	ROCP
29	23.7515	86.4184	OB Dump	Fire	ROCP
30	23.7559	86.4137	OB Dump	Fire	ROCP
31	23.7476	86.4232	Working	Fire	ROCP
32	23.7543	86.4431	Outside Jharia Mines		Unknown site (Out side of Kuya)
33	23.7394	86.4317	Active Mine	Fire	Ghanoodih
34	23.7360	86.4362	OB dump	Fire	Goluckdih
35	23.7349	86.4293	OB Dump	Fire	Kujama
36	23.7354	86.4232	No Working	Fire	Kujama
37	23.7301	86.4369	Working	Fire	NT-ST
38	23.7305	86.4265	OB dump	Fire	Kujama
39	23.7249	86.4200	No Working	Fire	Lodna
40	23.7159	86.4327	Working	Fire	Joyrampur
41	23.7254	86.4280	No Working	No fire	Lodna
42	23.7209	86.4376	Working	Fire	NT-ST
43	23.7154	86.4296	Working	Fire	Lodna
44	23.7238	86.4427	Working	Fire	NT-ST
45	23.7309	86.4457	OB dump	Fire	NT-ST
46	23.7151	86.4412	Active Mine	Yes	NT-ST
47	23.7114	86.4419	OB Dump	Fire	NT-ST
48	23.7073	86.4360	Active Mine	Fire	Joyrampur
49	23.7097	86.4243	Working	Fire	Bagdigi/Joyrampur
50	23.7079	86.4249	Active Mine	Fire	Bagdigi/Joyrampur
51	23.7086	86.4582	Outside Jharia Mines		Unknown site (Out side of NT-ST)
52	23.6614	86.4404	Outside Jharia Mines		Chasnala
53	23.6906	86.3892	OB dump	Fire	Bhowrah (North)

Annexure –II

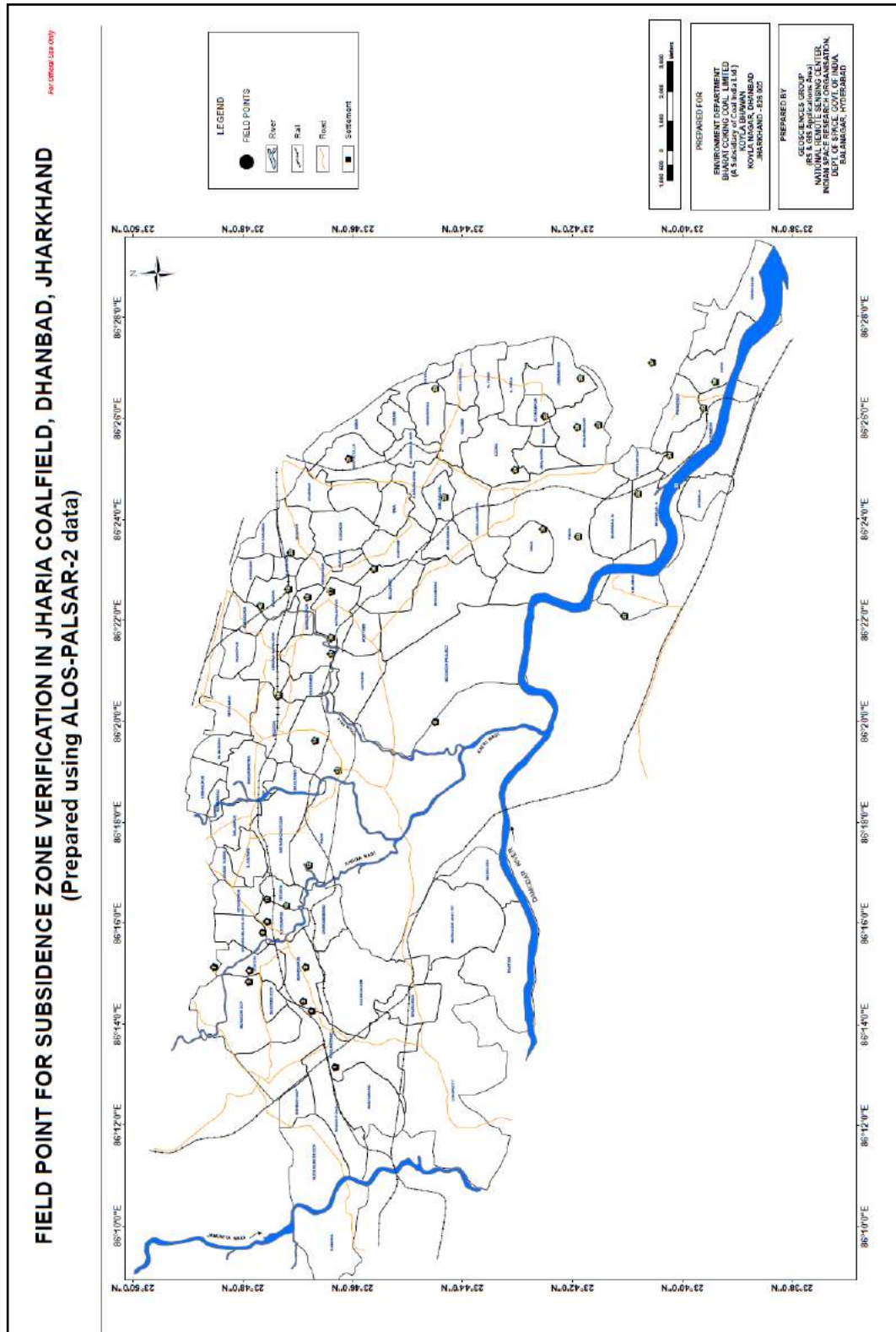


Figure 14. Field data points for subsidence verification

Table – 5: Coal Fire observations during fieldwork (see figure 14 for reference)

Sr. no.	Point of Observations		Comments	
	Latitude	Longitude	Mine name and Any other Comments	Signs of Subsidence (crack on building/ground crack etc.)
0	23.7416	86.3338	Moonidih UG Project	Sagged area, Building damage
1	23.7722	86.2192	South of Block II (2 areas)	Cracks on the ground
2	23.7817	86.2409		Terrain Change due to mining
3	23.7811	86.2521		Terrain Change due to mining
4	23.7792	86.2376		Terrain Change due to mining
5	23.7983	86.2473		Terrain Change due to mining
6	23.7981	86.2510		Terrain Change due to mining
7	23.8088	86.2521		Terrain Change due to mining
8	23.7941	86.2636		Terrain Change due to mining
9	23.7926	86.2671		Terrain Change due to mining
10	23.7868	86.2724		Terrain Change due to mining
11	23.7928	86.2746		Terrain Change due to mining
12	23.7800	86.2857		Terrain Change due to mining
13	23.7713	86.3171		Terrain Change due to mining
14	23.7783	86.3270		Terrain Change due to mining
15	23.7893	86.3419		Terrain Change due to mining
16	23.7734	86.3556		Terrain Change due to mining
17	23.7734	86.3762		Terrain Change due to mining
18	23.7804	86.3742		Terrain Change due to mining
19	23.7865	86.3769		Terrain Change due to mining
20	23.7855	86.3890		Terrain Change due to mining
21	23.7679	86.4199	Bastacolla	Sagged areas
22	23.7390	86.4071	Simlabahal UG	Sagged areas
23	23.7417	86.4431		Terrain Change due to mining
24	23.7176	86.4163		Terrain Change due to mining
25	23.7085	86.4339		Terrain Change due to mining
26	23.6986	86.4304		Terrain Change due to mining
27	23.6923	86.4312		Terrain Change due to mining
28	23.6977	86.4466		Terrain Change due to mining
29	23.7092	86.3967		Terrain Change due to mining
30	23.6985	86.3942		Terrain Change due to mining
31	23.6845	86.3681		Terrain Change due to mining
32	23.6804	86.4083		Terrain Change due to mining
33	23.6685	86.4110		Terrain Change due to mining
34	23.6706	86.4211		Terrain Change due to mining
35	23.6603	86.4366		Terrain Change due to mining
36	23.6568	86.4454		Terrain Change due to mining
37	23.6760	86.4516		Terrain Change due to mining
38	23.7603	86.3836		Terrain Change due to mining
39	23.7734	86.3609		Terrain Change due to mining
40	23.7948	86.3715		Terrain Change due to mining

Annexure –III

SL. NO.	COLLIERY AREA NAME	FIRE AREA 2012 (SQ. KM.)	FIRE AREA 2017 (SQ. KM.)	AREA CHANGE (SQ. KM.)	Increase/Decrease
1	DAMODA	0.0000	0.0000	0.000	NO FIRE
2	TISCO (west)	0.0000	0.0000	0.000	NO FIRE
3	IISCO	0.0000	0.0000	0.000	NO FIRE
4	TISCO (north)	0.0885	0.0153	-0.073	DECREASE
5	NUDKHURKEE OCP	0.0000	0.0000	0.000	NO FIRE
6	BENEDIH OCP	0.0530	0.0453	-0.008	DECREASE
7	BLOCK-II OCP	0.0530	0.1353	0.082	INCREASE
8	MURAIH OCP	0.1478	0.0022	-0.146	DECREASE
9	SHATABDI OCP	0.0378	0.0361	-0.002	DECREASE
10	TETURIA	0.0000	0.0000	0.000	NO FIRE
11	S.GOVINDPUR	0.0000	0.0000	0.000	NO FIRE
12	KORIDIH BLOCK-IV OCP	0.0000	0.0000	0.000	NO FIRE
13	JOGIDIH	0.0000	0.0000	0.000	NO FIRE
14	DHARAMABAND	0.0000	0.0000	0.000	NO FIRE
15	MAHESHPUR	0.0000	0.0000	0.000	NO FIRE
16	PHULARITAND	0.0133	0.0205	0.007	INCREASE
17	MADHUBAND	0.0000	0.0000	0.000	NO FIRE
18	AKASH KINARI	0.0000	0.0000	0.000	NO FIRE
19	GOVINDPUR	0.0000	0.0000	0.000	NO FIRE
20	E. KATRAS	0.0133	0.0000	-0.013	DECREASE
21	KATRAS-CHOITUDIH	0.1021	0.1368	0.035	INCREASE
22	KESHALPUR	0.0000	0.0013	0.001	INCREASE
23	RAMKANALI	0.0000	0.0000	0.000	NO FIRE
24	NICHITPUR	0.0000	0.0000	0.000	NO FIRE
25	E. BASURIA	0.0000	0.0000	0.000	NO FIRE
26	KHAS KUSUNDA	0.0000	0.0000	0.000	NO FIRE
27	GONDUDIH	0.0000	0.0000	0.000	NO FIRE
28	W. GODHAR	0.0012	0.0000	-0.001	DECREASE
29	BASURIA	0.0000	0.0000	0.000	NO FIRE
30	TETULMARI	0.0223	0.0220	0.000	DECREASE
31	DHANSAR	0.0000	0.0000	0.000	NO FIRE
32	GODHAR	0.1073	0.0000	-0.107	DECREASE
33	INDUSTRY	0.0119	0.0513	0.039	INCREASE
34	KUSUNDA	0.4243	0.7398	0.315	INCREASE
35	SENDRA-BANSJORA	0.0796	0.0275	-0.052	DECREASE
36	BASTACOLLA	0.0663	0.0810	0.015	INCREASE
37	BERA	0.0000	0.0000	0.000	NO FIRE
38	KUYA	0.0000	0.0000	0.000	NO FIRE
39	GOLUCKDIH	0.0301	0.1122	0.082	INCREASE
40	KUJAMA	0.0398	0.2404	0.201	INCREASE

41	S. JHARIA-R. OCP	0.0244	0.1118	0.087	INCREASE
42	DOBARI	0.0000	0.0000	0.000	NO FIRE
43	GONHOODIH	0.0398	0.0322	-0.008	DECREASE
44	SIMLABAHAL	0.0000	0.0000	0.000	NO FIRE
45	HURRILADIH&STD	0.0000	0.0000	0.000	NO FIRE
46	ENA	0.0918	0.0432	-0.049	DECREASE
47	BURRAGARH	0.0000	0.0000	0.000	NO FIRE
48	N. TISRA	0.0098	0.1802	0.170	INCREASE
49	LODNA	0.0000	0.3527	0.353	INCREASE
50	S. TISRA	0.0000	0.1015	0.102	INCREASE
51	BARAREE	0.1037	0.1074	0.004	INCREASE
52	AMLABAD	0.0000	0.0000	0.000	NO FIRE
53	PATHERDIH	0.0000	0.0000	0.000	NO FIRE
54	SUDAMDIH	0.0000	0.0000	0.000	NO FIRE
55	SITANALA	0.0000	0.0000	0.000	NO FIRE
56	MURULIDIH 20/21 PIT	0.0000	0.0000	0.000	NO FIRE
57	MURULIDIH	0.0000	0.0000	0.000	NO FIRE
58	BHATDIH	0.0000	0.0000	0.000	NO FIRE
59	LOHAPATTY	0.0000	0.0000	0.000	NO FIRE
60	IISCO	0.0000	0.0000	0.000	NO FIRE
61	TASRA-IISCO	0.0000	0.0000	0.000	NO FIRE
62	KENDUADIH	0.0610	0.0000	-0.061	DECREASE
63	BULLIHARY	0.0000	0.0000	0.000	NO FIRE
64	GOPALICHUCK	0.0000	0.0000	0.000	NO FIRE
65	POOTKEE	0.0000	0.0000	0.000	NO FIRE
66	BHURUNGIA	0.0000	0.0000	0.000	NO FIRE
67	KHARKHAREE	0.0000	0.0000	0.000	NO FIRE
68	GASLITAND	0.1194	0.1215	0.002	INCREASE
69	KANKANEE	0.0530	0.0525	-0.001	DECREASE
70	MUDIDIH	0.1141	0.1104	-0.004	DECREASE
71	W. MUDIDIH	0.0171	0.0000	-0.017	DECREASE
72	LOYABAD	0.0133	0.0063	-0.007	DECREASE
73	BHAGABAND	0.0000	0.0000	0.000	NO FIRE
74	MOONIDIH PROJECT	0.0000	0.0000	0.000	NO FIRE
75	E.BHUGGATDIH	0.0022	0.0214	0.019	INCREASE
76	ALKUSHA	0.0326	0.0294	-0.003	DECREASE
77	KUSTORE	0.0524	0.0463	-0.006	DECREASE
78	ANGARAPATRA	0.1331	0.0149	-0.118	DECREASE
79	SALANPUR	0.0000	0.0000	0.000	NO FIRE
80	BHOWRAH. N	0.0133	0.0980	0.085	INCREASE
81	BHOWRAH. S	0.0000	0.0000	0.000	NO FIRE
82	BAGDIGI	0.0000	0.0209	0.021	INCREASE
83	JEALGORA	0.0000	0.0067	0.007	INCREASE
84	JEENAGORA	0.0000	0.0470	0.047	NO FIRE

85	JOYRAMPUR	0.0099	0.1042	0.094	INCREASE
86	CHANDAN OCP	0.0000	0.0000	0.000	NO FIRE
87	BANSDEOPUR	0.0000	0.0000	0.000	NO FIRE
	TOTAL AREA	2.18	3.28	1.10	INCREASE

Table 6: Colliery wise break-up of change in fire area from 2012 to 2017

Note:

- 1) "**NO FIRE**" implicates that the fire has not been identified satellite data (*either absent or below sensor resolution*)
- 2) "**INCREASE**" implies, increase in fire area OR emergence of fire areas not identified in 2012 study.
- 3) "**DECREASE**" implies, decrease in fire area OR fire areas of 2012, which are not identified in present study (*either absent or below sensor resolution*).
- 4) Estimations of fire extent (in terms of sq.km.) both 2012 and in present 2017 study are pixel based. They do not represent the actual ground area under fire. These estimations are made for comparative purpose only, to indicate the increase or decrease of areal disposition of fire. Hence, they should not be quoted as fire area on the ground.

Annexure –IV



Figure 15: Fume cracks in Lodna-Tisra Area. (point 39 in figure 13 and table 4)



Figure 16: Burnt area near OB dump in Lodna area (point 41 in figure 13 and table 4)



Figure 17: Coalfries in active seams in Kusunda (point 23 in figure 13 and table 4)



Figure 18: Sagged area due to subsidence, south of Block II OCP. (point 1 in figure 14 and table 5)



Figure 19: Fire in OB dumps in Kusunda area. (point 24 in figure 13 and table 4)



Figure 20: Fume cracks in the Bhulanbarari area.

भारत कोकिंग कोल लिमिटेड

एक मिनी रत्न कम्पनी
(महारात्न कम्पनी कोल इंडिया का एक उपक्रम)
पंजीकृत कार्यालय कोयला भवन, कोयला नगर
धनबाद-826005
सी.आइ.एन. : U10101JH1972GO1000918

महाप्रबंधक का कार्यालय**पश्चिमी झरिया क्षेत्र**

पो. मुनीडीह, जिला: धनबाद (झारखण्ड) - 828129

फोन नं. 0326 2273483; फेक्स: 0326 2273445 ई-मेल: grwj.bcd@coalindia.in

**Bharat Coking Coal Limited***A Mini Ratna Company**(A Subsidiary of Coal India Limited: A Maharatna Company)*

Regd. Off. : Koyla Bhawan, Koyla Nagar

Dhanbad - 826005

CIN : U10101JH1972GO1000918

**OFFICE OF THE GENERAL MANAGER
WESTERN JHARIA AREA**

PO: MOONIDIH, DISTT: DHANBAD (JHARKHAND) - 828129

PHONE NO: 0326 2273483, FAX NO: 0326 2273445. e-mail : gmwj.bcd@coalindia.in

EC Cluster-XI Specific Condition no. (xiv) by MoEF –

The embankment constructed along the river boundary shall be of suitable dimension and critical patches shall be strengthened by stone pitching on the river front side and stabilized with plantation so as to withstand the peak water flow and prevent mine inundation.

BCCL Submission –

Moonidih Mine of Bharat coking coal limited is an underground mine. The current underground working are situated at a depth of more than 500 m from surface. The mine working have been designed in such a way that there is no effect of subsidence on the surface.

Damodar River is situated in the south edge of the mine leasehold boundary of Moonidih mine. The underground working of Moonidih mine are situated at a horizontal distance of more than 500 m from the river. There is no opencast mine within the leasehold of Moonidih mine. So there is no danger of inundation of the mine from Damodar River hence this condition is presently not applicable.


13/01/21
AGM
W.J.Area


13-1-2021
GM
W.J.Area

CSR, R&R and Transportation Plan of Cluster XI

As per EC Condition (Specific Condition No XVIII)

Details of transportation, CSR, R&R and implementation of environmental action plan for each of the 17 clusters should be brought out in a booklet form



Bharat Coking Coal Limited
(A Mini Ratna Company)
P.B Area
Dhanbad

UNDERSTANDING THE SCOPE OF CSR INTERVENTION
(BASELINE STUDY REPORT)



FOR
BHARAT COKING COAL LTD. (BCCL)
DHANBAD

BY-
NATIONAL CORPORATE SOCIAL RESPONSIBILITY HUB
TISS, MUMBAI

25th NOVEMBER 2013

CIL'S POLICY FOR CORPORATE SOCIAL RESPONSIBILITY (CSR)

Introduction

Mining of coal has profound impact on the people living in and around the areas where the mines are established. The obvious impact of the introduction of any production activity in such areas change the traditional lifestyle of the original inhabitants and indigenous communities and also change the socio-economic profile of the Area. Hence, the primary beneficiaries of CSR for the company are:

- Land oustees
- PAPs and
- Those staying within the radius of 25 Kms of the Project.

Poor and needy section of the society living in different parts of India are the second beneficiaries. In the aforesaid backdrop, policy on Corporate Social Responsibility of CIL has been framed after incorporating the features of the Companies Act 2013 and as per notification issued by Ministry of Corporate Affairs, Govt. of India on 27.02.2014 as well as DPEs guidelines and broadly covers the following: -

- a) Welfare measures for the community at large, so as to ensure the poorer section of the Society derived the maximum benefits.
- b) Contribution to the society at large by way of social and cultural development, imparting education, training and social awareness especially with regard to the economically backward class for their development and generation of income to avoid any liability of employment.
- c) Protection and safeguard of environment and maintaining ecological balance.

Objectives

The main objective of CSR policy is to lay down guidelines for the coal companies to make CSR a key business process for sustainable development for the society. It aims at supplementing the role of the Govt. in enhancing welfare measures of the society based on the immediate and long term social and environmental consequences of their activities. CIL will act as a good Corporate Citizen, subscribing to the principles of Global Compact for implementation.

Areas Covered under CSR

- The poor and needy Section of the Society living in different parts of India are covered.
- The CSR Programme also covers the existing components of Special Component Plan (SCP) and Tribal Sub Plan (TSP) for development of the SC and ST population besides development components for the entire population.

80% of the budgeted amount is spent within the radius of 25 Km of the Project Site/Mines/Area HQ/Company HQ and 20% of the budget is spent within the State.

Allocation of Fund

The fund for the CSR is allocated based on 2% of the average net profit of the Company for the three immediate preceding financial years or Rs. 2.00 per ton of Coal Production of previous year whichever is higher.

Scope

As per Schedule VII of New Companies Act 2013, the following are the Scope of Activities under Corporate Social Activities:

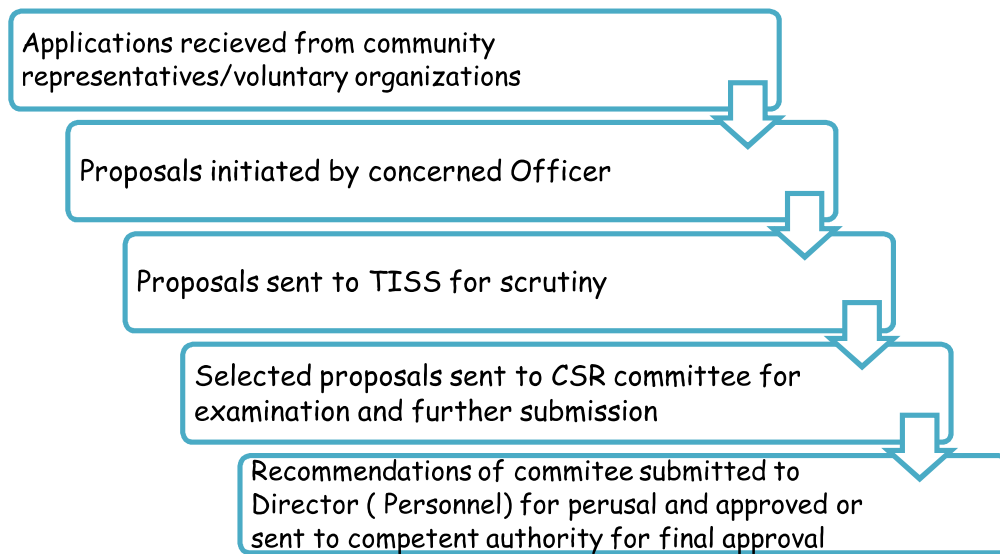
- i) Eradicating hunger, poverty and malnutrition, promoting healthcare including preventive health care and sanitation and making available safe drinking water.
- ii) Promoting education, including special education and employment enhancing vocation skills especially among children, women, elderly, and differently abled and livelihood enhancement projects;
- iii) Promoting gender equality, empowering women, setting up homes and hostels for women and orphans, setting up old age homes, day care centers and such other facilities for senior citizens and measures for reducing inequalities faced by socially and economically backward groups;
- iv) Ensuring environmental sustainability, ecological balance, protection of Flora and Fauna, animal welfare, agro-forestry, conservation of natural resources and maintaining quality of soil, air and water;
- v) Protection of national heritage, art and culture including restoration of buildings and sites of historical importance and works of art; setting up public libraries, promotion and development of traditional arts and handicrafts;
- vi) Measures for the benefit of armed forces veterans, war widows and their dependents
- vii) Training to promote rural sports, nationally recognized sports, Paralympics sports and Olympic sports;
- viii) Contribution to the Prime Minister's National Relief Fund or any other fund set up by the Central Government for socio-economic development and relief and welfare of the Scheduled Castes, the Scheduled Tribes, other backward classes, minorities and women;
- ix) Contributions or funds provided to technology incubators located within academic institutions which are approved by the Central Government;

x) Rural development projects

Implementation

- The investment in CSR is project based and for every project time framed periodic mile stones should be finalized at the outset.
- Project activities identified under CSR are implemented by Specialized Agencies. Specialized Agencies are made to work singly or in tandem with other agencies. Specialized agencies that are included presently for implementation of CSR projects in Cluster VII are through Contracted agencies for civil works.

Institutional Arrangement



KENDUAHDIH

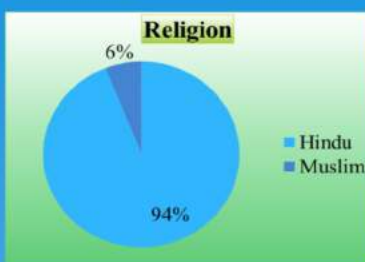
Tola: Kenduahdih (Ward 12) | Panchayat: Kenduahdih | Block: Dhanbad | District: Dhanbad

Census Year	2001
Households	150
Population	1300

Source of water	
Irrigation	None
Drinking Purpose	Tank, Public and private tap

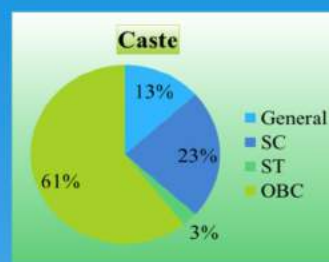
Crop Grown	
Paddy	
Maize	
Wheat	
vegetables	

Recreation / Common Facilities	
Playground	
Samaaj Mandir	
Cremation Place, community hall	



Migration Pattern	
Location	Status
Outside State (Agri Labour)	Few

Accessibility to Forest/Mining Produce	
Coal Collection, Firewood	
Cultivation	



Sources of Livelihood	
Own farm activities	
Agricultural labour	
Non-agri labour (rural)	
Salaried employment	
Petty business/trade	
Collect & sale forest/mining products, factory labor	
Rent/pension/remittance	

Common Transport Facilities	
Motor Cycle	
Bicycle	

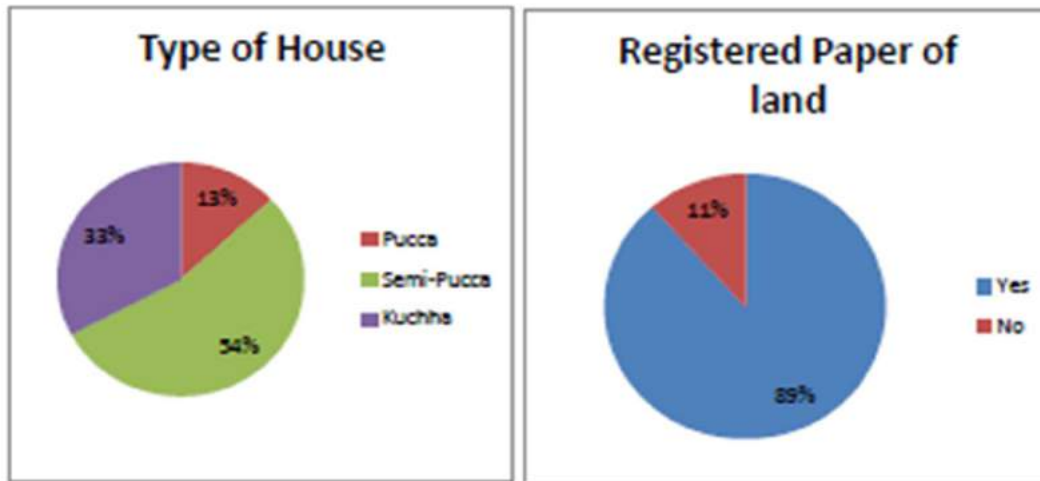
Facilities Located in Villages	
Cemented tar road	
PDS Shop	
Grocery Shop	
Pre-Pri/Nursery School	
Govt Primary School	
Pvt. Primary School	
Govt Secondary School	
Higher Sec School	
Pvt Clinic (RMP+)	
Asha worker	
Dai	

Facilities Located More Than 5 Kms	
Weekly Market	
Block Development Office (Dhanbad)	
District Headquarters (Dhanbad)	
Warehouse (Dhanbad)	
APMC/Mandi (Dhanbad)	
ITI/Polytechnic(Dhanbad)	
Health Sub – Centre (Karkend Mor)	
Primary Health Centre(Dhanbad)	
Veterinary Clinic(Karkend Mor)	

Facilities Located Within 5 Kms	
Bus Stop (Putki)	
Daily Evening Market (Boragarh)	
DTP/Xerox (Bhagabandh)	
Post Office (Bhagabandh)	
Railway Station (Bhagabandh)	
Police Station (Putki)	
Gram Panchayat Office (South Balihari)	
Cooperative Society (Putki)	
Bank for S/B account (Bhagabandh)	
Degree College(Jharla)	
CHC Govt /Gen Hospital (Bhagabandh)	
Private Hospital (Bhagabandh)	
Medical Shop/Chemist (Bhagabandh)	

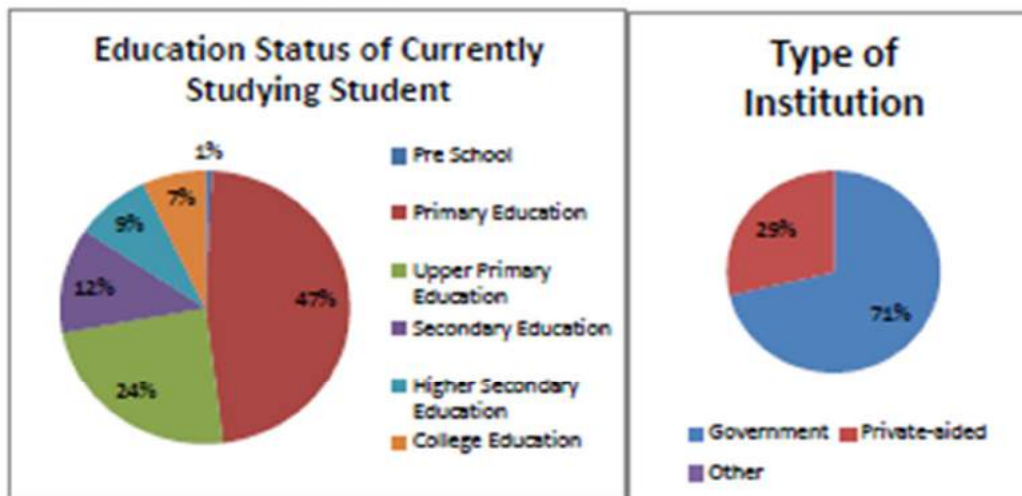
HOUSEHOLD STATUS

4.10.1.1 HOUSEHOLD STATUS



In Kenduahdih Basti, 40% of the households are found to be Semi- Pucca while 48% are Kuchha and 12% are Pucca. 95% of the houses are registered while only 5% was found to be non-registered. Nearly 85% of the houses in this village are electrified.

4.10.1.2 EDUCATION



In Kenduahdih Basti, it has been found that 35% of the students are enrolled in Primary education followed by 28% in Upper primary, 10% in secondary education, and 5% in higher secondary, 3% in college. Education after 12th standard is found comparatively less with any

Major Problems and Recommendations

AREA	MAJOR PROBLEMS AND RECOMMENDATIONS
Education	There is no road which can join schools to main working road
	No electricity and in-house circuiting of lights and fans in the class room of primary school
	Shakti Nath Mehto School needs school boundary and toilet in school premises
Water Supply	Pipeline already exists in this village. More number of pipelines are required in Harijan Basti of Kenduahdih
Health Care	Mobile medical Van should treat children every month in primary school
	Maternity health camp should be initiated through MMV
Social Empowerment	Nearly 5-6 SHG has been identified in this village. SHG (<i>Ma Saraswati Mahila Samuh</i>) already exist in the village. They need are trained in agriculture. They need support of land to start collective farming of horticultural crops. They are also trained in preparation <i>Agarbatti</i> and bangles made from lac.
	Vocational training school for girls and boys is needed in this village. School building of Shakti Nath Mehto School can be used for providing vocational training center in the weekends or after the school hours with prior permission of the school administration. Not only that the training center for women to start small enterprise can be establish in the same school premises.
Sanitation	No toilets in any of the households. Toilets is needed to construct
Infrastructural Development	There <i>Kuccha</i> road in the village which creates problem during rainy season
	On hand pump/tap point is needed in ICDC
	One kitchen room is required in primary school
	Playground boundary in needed with gate in primary school

4.10.2 BHAGABANDH

**Tola: Bhagabandh(Ward 12) | Panchayat:Bhagabandh| Block: Dhanbad
| District: Dhanbad**

Census Year 2001

Households	720
Population	4409

Source of water

Irrigation	None
Drinking Purpose	Tank, public and private tap

Crop grown

Paddy
Maize
Vegetables

Recreation / Common Facilities

Playground
Samaj Mandir
Crematorium Place

Religion**Migration Pattern**

Location	Status
Outside State (Agri Labour)	Rarely

Accessibility to Forest/Mining Produce

Coal Collection, fire wood
Cultivation

Caste**Sources of Livelihood**

Oven farm activities
Cattle rearing
Non-agri labour (rural)
Salaried employment
Petty business/trade
Collect & sale forest/mining products, factory labor
Rent/pension/retirement

Common Transport Facilities

Motor Cycle, Share Auto
Bicycle

Facilities Located Within the village

Cemented tar road
Grocery Shop
DTP/Aarog
PDS Shop
Post Office
Bank for S/B account
Pre-Pri/Nursery School
Govt Primary School
Govt Secondary School
Pvt. Secondary School
CHC Govt./Gen Hospital
Pvt Clinic (MBBS/BAMS+)
Medical Shop/Chemist
Asha worker
Dai (Trained/Untrained)
Pvt Clinic (RMP+)

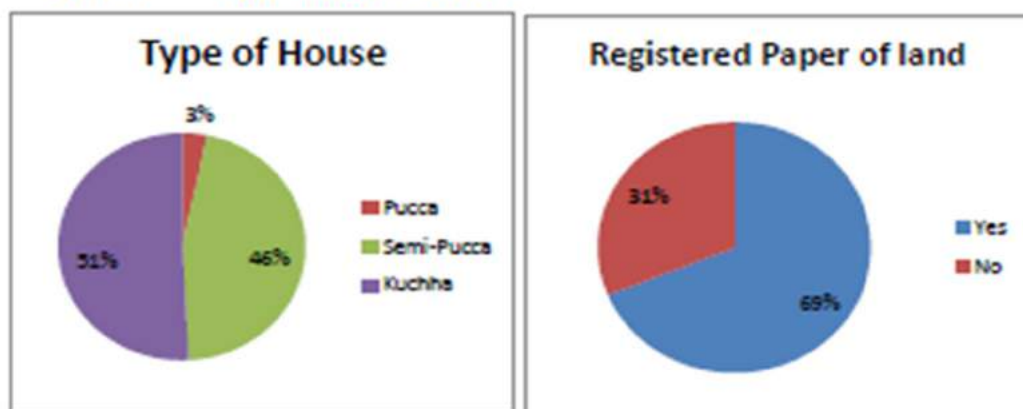
Facilities Located with 5 kms

Bus Stop (Putki)
Daily Evening Market (Putki)
Weekly Market (Putki)
Police Station (Putki)
Veterinary Clinic (Putki)
Health Sub - Centre (Putki)

Facilities Located more than 5 kms

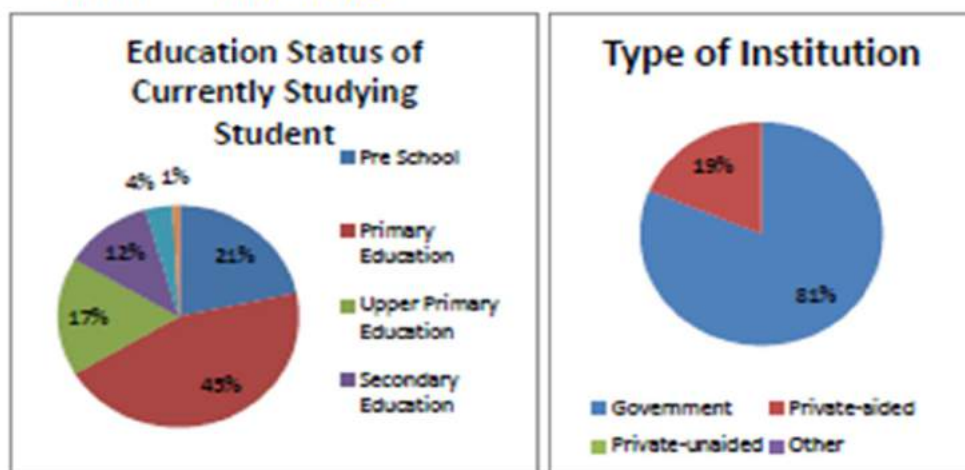
Railway Station (Dhanbad)
Block Development Office (Dhanbad)
District Headquarters (Dhanbad)
Warehouse (Dhanbad)
APMC/Mandi (Dhanbad)
Degree College (Dhanbad)
Primary Health Centre (Dhanbad)

4.10.2.1 HOUSEHOLD STATUS



In Bhagabandh Village, 3% of the sample is living in pucca house and 51% were having kuchha house while 46% were having semi -pucca house. Among the sample 69% of the people have registered paper of land while 31% of them do not have registered paper of land. 94% of the sample is living in electrified.

4.10.2.2 EDUCATION



In Bhagabandh Village, status of education does not seem positive as far as college education is considered, only 1% of the children among sample households are found at the time of data collection enrolled in higher education. Among the students of sample households who are currently studying, 45% are currently studying in primary school, 17% are in upper primary school, 12% in secondary school and another 4% is studying in

Major Problems and Recommendations

AREA	MAJOR PROBLEMS AND RECOMMENDATIONS
Education	There should scholarship for the children belongin to underprivileged section of the society who is going for education after matriculation to schools of Dhanbad by BCCL
	Library is required in this village
	Evening school has been requested by the people
Water Supply	More number of tap points are required in Manjhi Tola of Bhagabandh Basti
Health Care	Maternity health compa
	Regular check-up of primary school children
Rural Electrification	School should have in-house electric fitting of fans and light
Sports & Culture	Sports equipment should be provided to the sports club
Sanitation	No toilets in houses.
	There should be provision for garbage disposal By BCCL at regular interval along with fumigation
	Ponds should be cleaned with involving community by providing them daily wage as followed in MNREGS
Social Empowerment	SHG for women and men should be formed to start Income Generation activity
	Group activity on Piggery and poultry has been requested by the people. But for that a formal group has to be formed who have to register in the local bank
	Women who are not getting widow pension should be supported with livestock's like poultry, duckery and goatry
Infrastructural Development	Playground for children with boundary
	Repair of damage road should be done so that medical vans or ambulance should reach at the door step for pregnant women
	Playground with boundary should be constructed
	There is requirement of High school covering students from nearby villages like Bhagabandh. It can be done constructing additional school building in government secondary school in the village itself

CSR Activities (April'21 to September'21)

Relief work during Lockdown:

P.B Area through its CSR initiative carried out relief work within peripheral villages/wards in the form of distribution of dry ration and hygiene kits since phase one of Coronavirus induced lockdown.

The kits were distributed to the poor needy families of the community affected due to Covid-19 lockdown. Both ration kit and hygiene kit consisted of basic items; while ration kit had Sattu, Chana, Gur, Chura and Biscuits, hygiene kit included mask and soap. Covid-19 awareness sessions were also organized on social distancing, hand washing techniques and wearing mask in crowded places. Total 1000 ration kits distributed among needy families and 500 hygiene kits distributed among communities residing nearby villages of P.B Area office and Collieries.



Expenditure incurred in distribution of Ration Packet, Face Mask & Soap under CSR:

Sl. No.	Item	No. of Units Distributed	Expenditure (in Rs.)	Sanctioned Amount from HQ	Remarks
1.	Ration Packet	1000	1,99,500	2,00,000	
2.	Face Mask	500	11,025	15,000	Remaining amount returned to HQ CSR Fund
3.	Soap	500	12,375	34,840	

Details of ward/ panchayat wise No. of Beneficiaries covered for Food Packets

Area of BCCL	Name of Panchayat/Ward No.	Name of Village/ward	No. of Beneficiaries covered for Food Packet (APPROX.)
P.B Area	Aralgaria	Aralgaria	40
P.B Area	Ward No. 10	Bhagabandh	73
P.B Area	Ward No. 10	Kenduadih Basti	47
P.B Area	Ward No. 12	Kendua Bazar	58
P.B Area	Ward No. 09	Kerkend	33
P.B Area	Ward No. 35	Burragarh	25
P.B Area	Ward No. 35	Surrendranagar	45
P.B Area	Ward No. 11	Khaira	54
P.B Area	Ward No. 11	Kenduadih	68
P.B Area	Ward No. 09	Gopalichak	30
P.B Area	Aralgaria	Bauri Basti	70
P.B Area	Ward No. 12	Kendua Bazar/EB Section	100
P.B Area	Ward No. 10	South Balihari	50
P.B Area	Ward No. 10	Khapra Dhowra	28
P.B Area	Ward No. 10	Tina Dhowra	25
P.B Area	Ward No. 11	BNR Kustore	27
P.B Area	Aralgaria	Singh Tola	20
P.B Area	Pandarkanali	Dhobni, Parasia, Pandarkanali	77
P.B Area	Sialgudri	Sialgudri	80
P.B Area	Ward No. 12	Kendua No. 4	50
Total			1000

Details of ward/ panchayat wise No. of Beneficiaries covered for Face mask & Hand Wash/Soap				
Area of BCCL	Name of Panchayat/Ward No.	Name of Village/ward	No. of Beneficiaries for face masks	No. of Beneficiaries for Dettol soap
P.B Area	Aralgaria	Aralgaria	47	47
P.B Area	Ward No. 10	Bhagabandh, Kenduadih basti & Station Dhawra	100	100
P.B Area	Ward No. 10	Bihibari & Orao Patti	46	46
P.B Area	Ward No. 12	Kendua Bazar & EB Section	65	65
P.B Area	Ward No. 11	Khaira & Kenduadih	82	82
P.B Area	Pandarkanali	Dhobni, Parasia & Pandarkanali	85	85
P.B Area	Sialgudri	Sialgudri	75	75
Total			500	500

Transportation Route

Sl. No.	Mine	Existing siding	Other Transport Sites	Existing Transport distance (in KM)	Avg. Capacity of Dumper (T)
1.	Gopalichuck OC	Burragarh (but at present only Road dispatch is operational)		5.9	25
			Belatand	9-10	28.5
			Tata Washery		
			Jamadobha	9-10	28.5
Tata Washery					
*It includes departmental and contractual transportation					

ANNEXURE-V

COMPLIANCE OF DHANBAD ACTION PLAN

(1) Covering of loaded transport vehicles

It has been complied. The clause of covering of loaded coal transport vehicle has also been incorporated in the transport agreement/ contract.

(2) Coal transport roads shall be made pucca

Coal transport route are made pucca, route around weighbridge has been made pucca and wheel washing arrangement has also been made at coal stock yard.

(3) All drillings to be done with dust containment and suppression systems. Sprinklers will be installed including at all coal stock & sidings

Complied. At present mobile water sprinklers are used.

(4) Mobile Sprinklers

Sl. no.	Mine/Workshop	No. of Fixed Sprinklers	No. of Mobile Sprinklers	Total Capacity(KL)	Trips per day
1	Bhagabandh UG Mine	1 (At coal Unloading Site)	0	N.A	N.A
2	P.B. project Colliery UG Mine	1 (At coal Unloading Site)	1	70	2
3	Central Auto Workshop	Nil	2	8 and 12	2
4	Kendwadih Workshop	Nil	1	45	2

(5) The direction of surface run-off of the premises of collieries shall be diverted to created water bodies.

Creation of water bodies in coal bearing area will pose safety threats to nearby mine and it will be violation of mines act. However, artificial ponds have been created where, there are no chances of future coal extraction.



Pond Constructed for Villagers at KB 10/12 Colliery



Pond Created for Villagers at Kendwadih

(6) Dealing of mine fires

A Master plan for Dealing with fires and subsidence and rehabilitation in the leasehold of BCCL has been approved by Govt. of India vide letter no- 22020/1/2005-CRC dated 12 08 09. In fire patch of V/VI/VII/VIII

seam of Gareria Secn. At East Bassuriya about 1, 70,000 cu.m. mitti and non-combustible material has been filled, rest will be filled by quarry OB.

(7) The waste water shall be passed through oil separator-cum-filtration system

Complied. 1 number of Oil Separator has been constructed at P.B. Project Colliery.

(8) The removed OBs shall be utilized for low land filling or for making roads

It is backfilled and then reclaimed by plantation of native species

(9) Tree plantation on the dumps

Complied.

Plantation work on 12 Ha OB dump has been completed with the help of Forest Department (Approx.30000 saplings have been planted).

Approximately 1500 flower saplings have been planted on Gopalichuck dump slope



(10) All hazardous wastes shall be disposed off

Complied.

- a. All working units have applied for authorization as per Hazardous Wastes (Management, Handling and Trans boundary Movement) Rules.
- b. Burnt/used oil is disposed of as per rule.
- c. Disposal of Hazardous waste, burnt Oil / batteries is being done through E-auctioning to authorized recycler/ re-processor having valid authorization from CPCB/ SPCB. Return are also being filed.

(11) Monitoring and Reporting six monthly

Complied. Monitoring work is being done by CMPDI, Dhanbad as per work order issued by BCCL HQ. Six monthly air, water and noise monitoring data is submitted to governing bodies.

(12) Introduction of GIS/ GPS

GPS installed vehicles are used for transportation of coal. CMPDI, HQ has been given the job of satellite surveillance of the Jharia coal field through NRSA Hyderabad and the information is being uploaded in the website.

PM 10 Analyzer installed and working at Moonidih Colliery.



ANNEXURE-VI



झारखण्ड राज्य प्रदूषण नियंत्रण पर्वद्
Jharkhand State Pollution Control Board
HIG-1, Housing Colony, Dhanbad-826001

Ph: 0326-2204933

(7)

Letter No.... 2650

Dated 6/2/13

From,

Regional Officer,
Dhanbad

To,

HOD (Envt.),
M/s. B.C.C.L.,
Koyla Bhawan, Koyla Nagar,
Dhanbad.

Sub: **Fixing up monitoring station/Sampling location of Air, Water & Noise.**

Sir,

With reference to you letter no. GM(Envt.)/F-JSPCB/2013/783, dt. 06.07.2013 We have approved Air, Water & Noise monitoring Station/Sampling location after verification and return a copy of the map.

Encl-A/a.

Your's faithfully,

(Dinesh Prasad Singh)
Regional Officer.

Memo.....

Dhanbad, dated.....

Copy to: The Member Secretary, Jharkhand State Pollution Control Board for information & enclose a copy of the map for necessary action.

Encl-A/a.

(Dinesh Pd. Singh)
Regional Officer.



झारखण्ड राज्य प्रदूषण नियंत्रण पर्वद्
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Regional Officer.

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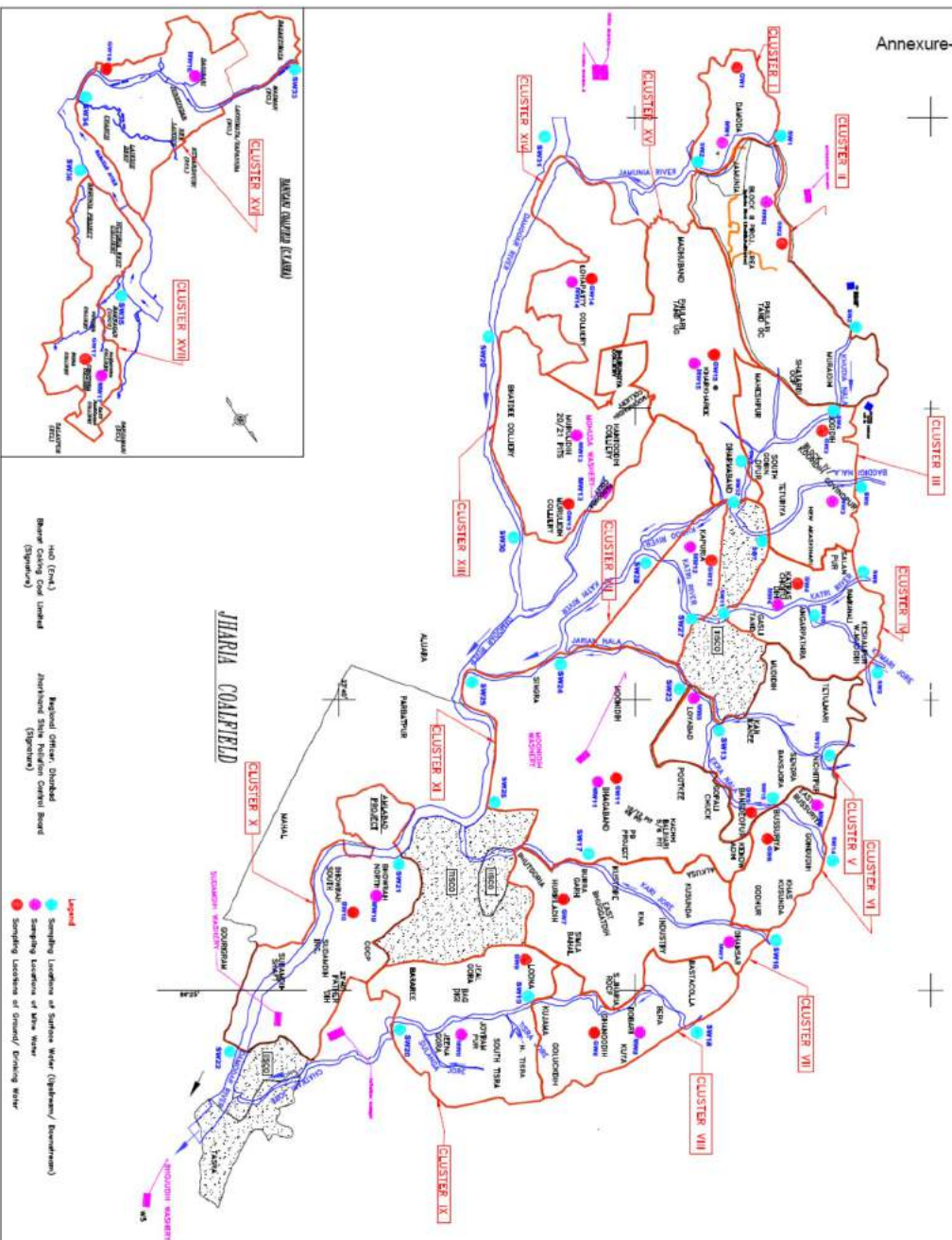
Copy to: The Member Secretary, Jharkhand State Pollution Control Board for information & enclose a copy of the map for necessary action.

Encl-A/a.

(Dinesh Pd. Singh)
Regional Officer.

Water Sampling Locations in BCCL

Annexure-03

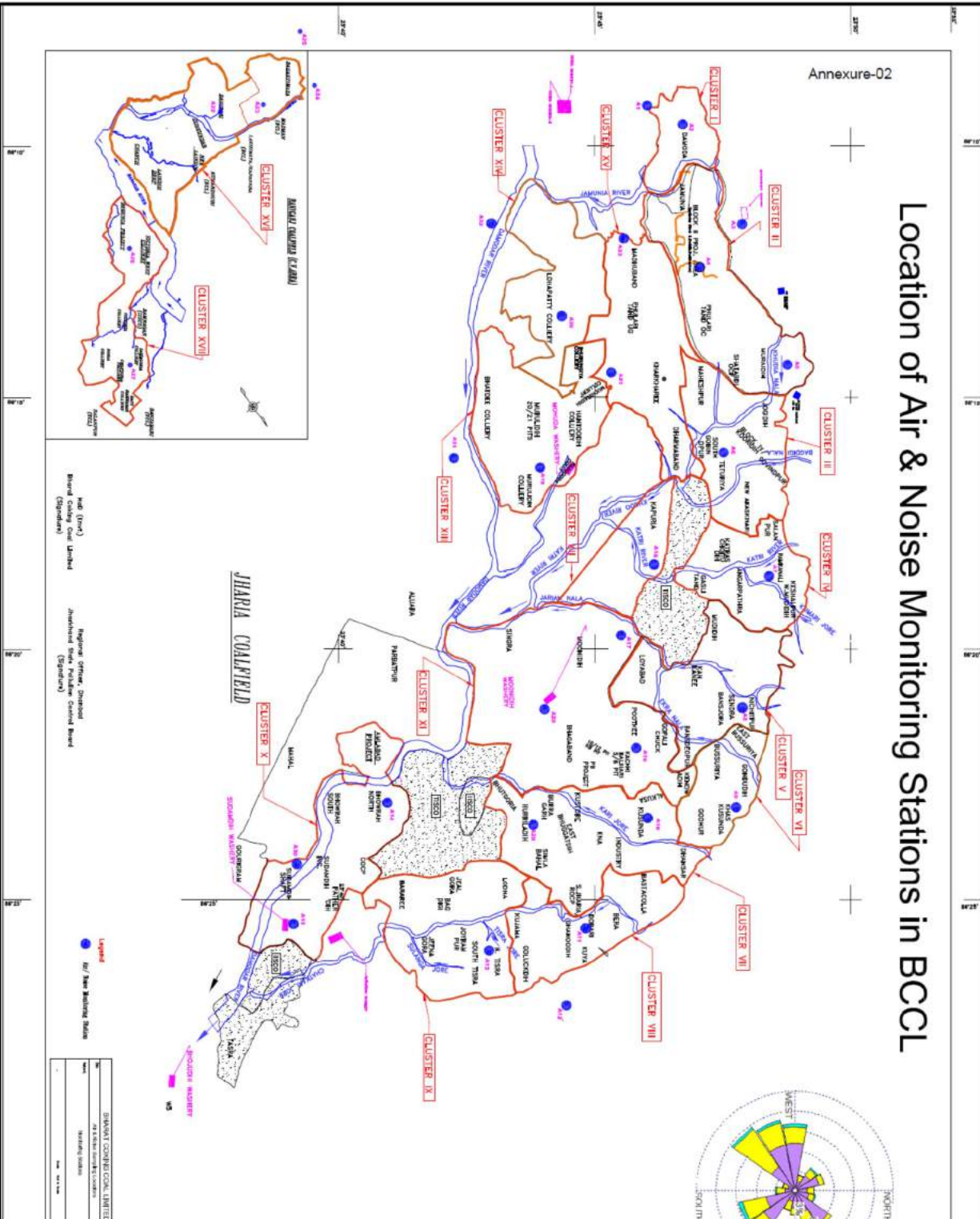


INDEX

Cluster	Location	Water Body	Sampling Location	Sampling Location	Sampling Location
I	SVW1	SVW1	SVW1	SVW1	SVW1
II	SVW2	SVW2	SVW2	SVW2	SVW2
III	SVW3	SVW3	SVW3	SVW3	SVW3
IV	SVW4	SVW4	SVW4	SVW4	SVW4
V	SVW5	SVW5	SVW5	SVW5	SVW5
VI	SVW6	SVW6	SVW6	SVW6	SVW6
VII	SVW7	SVW7	SVW7	SVW7	SVW7
VIII	SVW8	SVW8	SVW8	SVW8	SVW8
IX	SVW9	SVW9	SVW9	SVW9	SVW9
X	SVW10	SVW10	SVW10	SVW10	SVW10
XI	SVW11	SVW11	SVW11	SVW11	SVW11
XII	SVW12	SVW12	SVW12	SVW12	SVW12
XIII	SVW13	SVW13	SVW13	SVW13	SVW13
XIV	SVW14	SVW14	SVW14	SVW14	SVW14
XV	SVW15	SVW15	SVW15	SVW15	SVW15
XVI	SVW16	SVW16	SVW16	SVW16	SVW16
XVII	SVW17	SVW17	SVW17	SVW17	SVW17

Location of Air & Noise Monitoring Stations in BCCL

Annexure-02



Progress Report
1st Phase Air Monitoring report for
“Source apportionment of ambient air
particulate matter in Jharia coalfields region,
Jharkhand”

Sponsor
Bharat Coking Coal Limited (BCCL)



CSIR-National Environmental
Engineering Research Institute,
Nagpur
2019



1. Introduction

1.1 Project Background

Bharat Coking Coal Limited, a subsidiary of Coal India Limited, has been operating the majority of the coal mines in the Jharia coal field regions since its inception in 1972. Jharia coal mines are special for its low ash content and high calorific value coals. Therefore, they are often used directly in iron and steel plants for metal oxide reduction after washing. Although these coal mines are highly priced for their high quality coal, they are notorious for their mine fires, which causes lot of fugitive gaseous and PM emissions. Hence, Jharia region has been under scrutiny by various public authorities and common public with a vision to improve the ambient air quality.

Various sources contribute to high particular matter concentration in the Jharia region: vehicles, mining activities, re-suspended dusts, fugitive emissions, fuel oils, household LPGs, etc. The percentage contribution of these factors in the ambient depends exclusively on the economic activities of that particular region. In order to improve the existing ambient air quality, the major sources of PM emissions first need to be identified. Hence, the environmental clearance committee of MoEF has directed BCCL to conduct a source apportionment study for particulate matter. In this context, BCCL has approached CSIR-NEERI to conduct a source apportionment study of ambient air particulate matter in Jharia coalfields region in order to quantify the various sources PM emissions and suggest an effective environmental management plan.

1.2 Project objectives

The major objective of the study is to assess the current ambient air quality, sources of air pollution and propose the priorities for the actions for improvement of air quality. The study to include the entire Jharia Coalfield along with area up to 10 Km from the periphery / boundary of BCCL mines.

The detailed objectives are as following:

i. Ambient Air Monitoring

- ✓ Monitoring of ambient air quality at selected receptor locations for pollutants including PM₁₀, PM_{2.5}(limited), SO₂, NO_x, PAHs to establish the status of the air quality in Jharia Coalfields along with area up to 10 KM from the periphery/boundary of BCCL mines. Also, review of the available air quality monitoring data from Central Pollution Control Board (CPCB) /Jharkhand State Pollution Control Board (JSPCB).
- ✓ To calibrate dispersion modelling predictions using measured air quality parameters.

- ✓ To draw supportive data through specific site related monitoring regarding impact causing sources such as kerbside monitoring.
- ✓ To establish the impact of meteorological conditions on a few select indicator pollutants in different micro meteorological conditions of the Jharia Coalfields.
- ii. Emission Inventory related of Jharia Coalfields along with area up to 10 Km from the periphery / boundary of BCCL mines.
 - ✓ To identify the pollution load grid wise for point, line and area source
 - ✓ To establish possibilities of receptor level concentrations of air pollutants by matching dispersion modelling and air quality-monitoring data.
- iii. Source apportionment related
 - ✓ To identify and apportion the pollution load at receptor level to various sources in the Jharia Coalfields along with area up to 10 Km from the periphery / boundary of BCCL mines.
 - ✓ To carry out the source apportionment using molecular markers for a limited number of samples through a time resolved sample collection at various period of the day and day-of-the-week.
- iv. Any other item in consensus between both BCCL/CIL & NEERI evolved during the study.

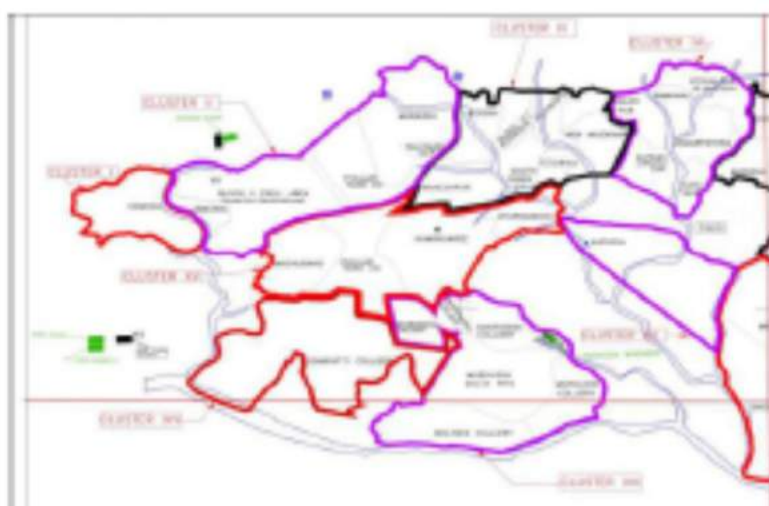
2. Field visit

In connection with the above objectives, the NEERI's team and BCCL's team visited BCCL's Jharia coal field for 3 days from 23 September to 27 September 2018. The team covered the entire Jharia coalfield, which spans roughly 30km in length and 22 km wide in three days with the following purpose.

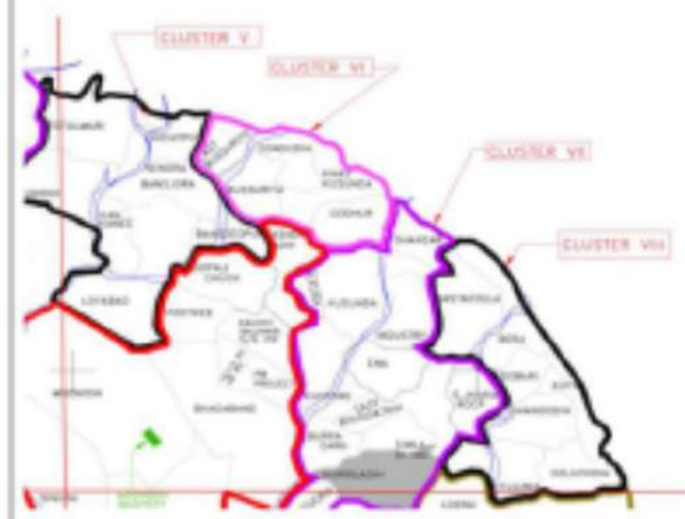
To identified the location for air monitoring station in entire Jharia Coal Field region.

2.1 Jharia coalfield maps:

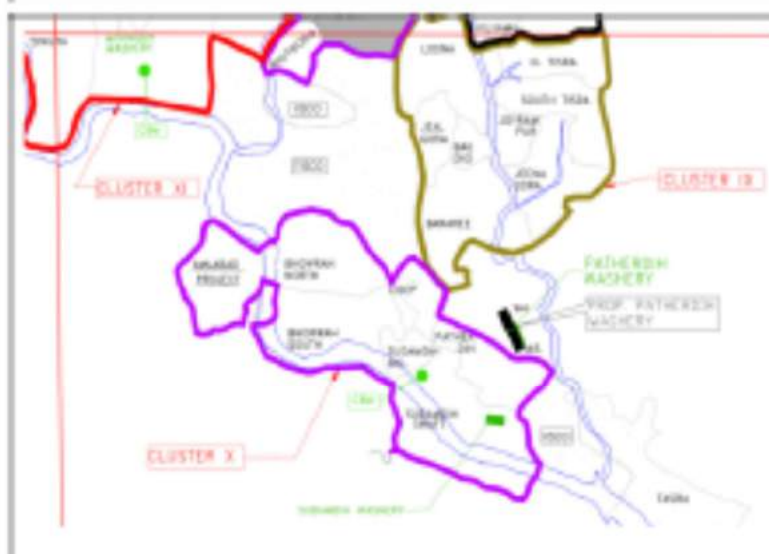
BCCL environmental department provided the map of the Jharia region. The site visit was carried out with assistance from BCCL's team. The 15 Jharia mines coal fields were segregated into three parts and details of the visit along with mine cluster names are given in Table 2.1.



Part 1:
Cluster VI, VII, VIII,
and X



Part 2: I, II, III, IV, V,
XI, XII, XIII, and XV



Part 3: Cluster IX

Table 2.1 Jharia coalfields Site visit on cluster-base

Based on the objectives and outcomes envisaged, the various mine areas were visited to identify sources of emissions such as dumpsite emissions, fugitive emissions, blasting emissions. Furthermore, the already existing PM monitoring sites of BCCL were also visited to explore the possibility of installing NEERI's PM monitoring stations.

2.2 Site Identification:

The Entire Jharia Coal Field (JCF) is divided into 16 clusters. Both opencast and underground mines are operational in JCF. Standard mining operations like drilling, blasting, hauling, accumulation, and transfer are the major sources of emissions and air pollution. Apart from that, a typical emission source, mine fire, is prevailing at JCF. Besides, JCF encompasses large non-mining regions, which have their own emission sources like vehicular emission in congested traffics, road dust, Power Plant emission, other industrial emissions (coke oven plants, brick kilns, stone crushers, etc.), crematoria, domestic burning, open burning etc.

Based on the preliminary field visit by CSIR-NEERI Scientists along with BCCL staffs, the following locations are selected for the establishment of Air Quality Monitoring Stations for source apportionment study:

Core Zone

1. Cluster XIV (Lohapatty) – nearby sources: Chandrapura Thermal Power Plant
2. Cluster VII (Mine rescue station)- nearby sources: Coal Mine, Industry
3. Cluster IV or Cluster V – Banssuriya or Katras
4. Cluster IX (Lodhna)
5. Cluster XI (Moonidih)
6. Cluster X (Patherdih): nearby sources: Coal Mine, Steel Industry
7. Cluster VIII (Bastacola)

Buffer Zone

8. Bank More
9. Harina
10. Bhuli
11. Sindri
12. Parbatpur Electrosteel/ Bhaga

13. Background site (Upwind & away from sources) and also secondary Data from DVC, CCL mines Sail Bokaro and Jharkhand pollution Control Board will be obtained.



Figure 2.1 Identified air monitoring station in Jharia Coalfield

3. Sampler Selection and Procurement

Standard equipment were catered for the parameter required towards ambient air particulate characterization and gaseous sampling in the initial phase of the project.

Table 3.1 Samplers Procured for Monitoring

Sampler	Brief Description of operating conditions
Fine Dust Sampler	Sampling Inlets- $PM_{2.5}$, PM_{10} and TSP Flow rate-16.7LPM
FRM Sampler	Versatile inlet configurations for $PM_{2.5}$, PM_{10} , or TSP sampling FRM quality 24-hour sampling at 16.7 LPM
Gaseous Sampler	Sampling Rate-0.5-1.0 LPM Operation time-8 hours

4. Monitoring parameters

Parameters of monitoring were decided based on the objectives of air pollution and source apportionment study. The source apportionment analysis required air monitoring for particulate matter ($PM_{2.5}$ and PM_{10}) and its chemical speciation to develop signature profiles of pollution sources that can be used in chemical mass balance models. The analysis data could also be used to interpret the overall loading of different chemicals contributed varied sources. Monitoring included air quality attributes such as Particulate matter, Sulphur Dioxide (SO_2) and Oxides of Nitrogen as NO_2 , to understand not only the regulatory compliance but also their inter-correlations with other species such as Heavy metals, EC, OC etc. Since the objective of source apportionment study is to determine the contributions from various sources such as industries, vehicular and other area sources additional parameters were also monitored such as Polycyclic Aromatic Hydrocarbons (PAHs). List of all parameters, sampling flow rate and analytical methods are provided in Table 4.1

Table 4.1 Ambient Air Quality Sampling/Analysis Methodology for Target Pollutants

Particulars	Parameters			
	PM_{10}	$PM_{2.5}$	NO_2	SO_2
Sampling Instrument	Fine Dust Sampler & FRM Sampler	Fine Dust Sampler & FRM Sampler	APM sampler	APM sampler
Sampling Principle	Cyclonic Flow Technique	Cyclonic Flow Technique/ WINS Impactor	Chemical absorption in suitable media	Chemical absorption in suitable media
Flow rate	16.7 LPM	16.7 LPM	0.5 LPM	0.5 LPM
Sampling Period	24 hourly	24 hourly	8 hourly	8 hourly
Sampling Frequency	10 days continuous, Teflon and quartz on alternate days	10 days continuous, Teflon and quartz on alternate days	10 days continuous	10 days continuous

Analytical Instrument	Electronic Micro Balance	Electronic Micro Balance	Spectrophotometer	Spectrophotometer
Analytical Method	Gravimetric	Gravimetric	Colorimetric Improved West & Gaeke Method	Colorimetric Improved West & Gaeke Method
Minimum reportable value	5 $\mu\text{g}/\text{m}^3$	5 $\mu\text{g}/\text{m}^3$	9 $\mu\text{g}/\text{m}^3$	4 $\mu\text{g}/\text{m}^3$

4.1 Monitoring Frequency

All pollutants exhibit diurnal and seasonal variations, which have been taken into account while determining the frequency of the sampling. In order to assess the impact of the diurnal variations in source contributions for a given meteorology of the day, 24 hourly monitoring plan was envisaged (8 hourly sampling for gaseous pollutants and 24 hourly sampling for particulate matter). The field study was planned for a period of 10 days at each monitoring site for the season to represent variation in air quality. The sampling frequency details are presented in Table 4.1.

Table 4.1.1 Frequency of Air pollutants sampling in Jharia Coalfield

Parameter	Number of Days	Change of Filter/ absorbing media	Reporting
PM ₁₀	10	24 hourly, Teflon: 05 days Quartz: 05 days	24 hourly
PM _{2.5}	10	24 hourly Teflon: 05 days Quartz: 05 days	24 hourly
NO ₂	10	8 hourly	8 hourly
SO ₂	10	8 hourly	8 hourly

The glimpses of air monitoring of some locations are shown in Figure 4.1.



Kataras



Lodhana



Moonidih



Pathardiha



Bastacola



Sindri

Figure 4.1 Glimpses of air monitoring of some locations

4.2 Filter handling and Weighing:

Teflon-membrane and quartz-fibre filter are most commonly used for chemical analysis. Each filter was individually examined prior to labelling for discoloration, pinholes, creases, separation of ring, chaff or flashing, loose material, or other defects.

Gravimetry measured the net mass on a filter by weighing the filter before and after sampling with balance in temperature and relative humidity controlled environment. To minimize particle volatilization and aerosol liquid water bias, $PM_{2.5}$ Filters were equilibrated for 24 hours at a constant (within $\pm 5\%$) relative humidity between 30% and 40% at a constant (within $\pm 2^\circ C$) temperature between $20^\circ C$ and $23^\circ C$. PM_{10} filters were equilibrated at 20% to 45% relative humidity ($\pm 5\%$) and $15^\circ C$ to $30^\circ C$ temperature ($\pm 3^\circ C$).

Methods of Chemical characterization:

Sulphur dioxide (SO_2)	: Modified West and Gaeke method
Nitrogen dioxide (NO_2)	: Sodium Arsenite method
Suspended Particulate Matter (SPM)	: High Volume method (Gravimetric method)
Respirable suspended Particulate Matter (RSPM)	: Gravimetrically with GFA/EPM 2000 filter paper using respirable dust sampler (Cyclonic Flow Technique)

5. Ambient Air Quality Monitoring

Core Zone

Site 1: Cluster XIV (Lohapatty)

The samplers were installed on the roof of area office of Lohapatty (Latitude 23.737066 and Longitude 86.210894). It was located near residential colony. Coal mine was 1 km away from the sampling site. Coal has been transported through railway line which is 1.5 km away on a daily basis and also through trucks. NH-32 construction was going on 500 m away from the site. The major fuel used for cooking is coal in the study area.

Site 2: Cluster VII Mine rescue Station

Monitoring station was positioned in Mine rescue station, Dhansar on the roof of office building (Latitude 23.768746 and Longitude 86.411141). Mine rescue station is next to

the state highway 12 where continuous movement of heavy vehicles takes place. Mining activities were also observed nearby the location.

Site 3: Cluster V Katras

In Katras, samplers were installed at Expert hostel (Latitude 23.811692 and Longitude 86.335910). There was a settlement residential area nearby. Mining activities was in progress within 500m area. Railway track was nearly at 150m distance from the site. Coal was used for cooking. Many other activities were observed during sampling in the nearby area which may contribute. 'Mela' and continuous 'Hawan' were going on within 100m area. Also road construction was in progress near 7km.

Site 4: Cluster IX (Lodhana)

Samplers were installed at office in Lodhna (Latitude 23.721713 and Longitude 86.410260). Near Lodhna, colliery was 2 km away from the site. Nearest Railway track was 1.5 km away. Coal was mostly used for cooling.

Site 5: Cluster XI (Moonidih)

Moonidih mine is one of the underground mine of BCCL. Sampler was stationed in Area office of Moonidih mine (Latitude 23.742228 and Longitude 86.349494). Since monitoring location was 250-300m from the mine, movement of heavy vehicles was continuous. There is washery also at distance of 500m where trucks and conveyor were used for transportation of coal. So the mining activities nearby contributes to particulate matter emission.

Site 6: Cluster X (Patherdih)

Samplers were stationed in guest house of BCCL in Patherdih area (Latitude 23.693577 and Longitude 86.398728). It is situated beside highway where continuous movement of heavy vehicles observed. TATA steel coal mine is situated 1km away from the location where continuous mining activities takes place. Transportation of coal through railway wagons in same area also contributes to particulate matter emission.

Site 7: Cluster VIII (Bastacola)

The samplers were positioned in area office of Bastacola mine (Latitude 23.763966 and Longitude 86.433635). Here also, coal was used as a cooking media. Railway track was

at Jodaphata which was 3-4 km away from the site. Residential area was nearly 0.5-1km. Mine was situated 3km from the site but no Mining activity was observed during monitoring.

Buffer zone

Site 8: Bank More (BCCL Colony)

Sampling station was installed in BCCL colony, Jawahar Nagar on the roof of a resident (Latitude 23.789463 and Longitude 86.407448). No mining activities were observed but the colony was beside the NH 18 highway so it may contribute to particulate matter emission.

Site 9: Harina

At Harina, the site chosen for air sampling was BCCL colony (Latitude 23.806308 and Longitude 86.212641). Since it was BCCL residential area, fuel used for cooking purpose was LPG. Settlement residential area was observed nearby where coal was used as a media for cooking. Colliery and Railway track were 3km and 2 km away from the site respectively. Highway was 1km away from the site and Coal washery at distance of 4.5km.

Site 10: Bhuli

The samplers were installed on the roof of Saraswati Vidya Mandir, Bhuli (Latitude 23.819554 and Longitude 86.386647). The location was in residential area. Mining activity was going at a distance of 8-10km. A closed Brick factory was located in the nearby area. Fuel used for cooking was mostly coal. Railway track used for coal transportation was 4km from the site. Construction of highway was also going on within 1.5km area during the monitoring.

Site 11: Sindri

Air samplers were installed at BIT Sindri college campus (Latitude 23.653214 and Longitude 86.473022). Transportation of coal was done by railway wagons at distance of 2km from monitoring site. LPG was mostly used for cooking rather than coal. A construction activity was going on nearby. The site was near the highway at a distance of <100m.

Site 12: Parbatpur

The sampling station was installed on roof of a house (Latitude 23.696296 and Longitude 86.348609). Mining activity was no longer going nearby. Coal was primarily used for cooking.

Site 13: Background

The air monitoring samplers were installed on roof of resident's house which was near to the highway at a distance of less than 1 km (Latitude 23.776180 Longitude 86.160177). Construction activities were going on nearby the location. Heavy rainfall also occurred during monitoring period. Mine activities were also observed in radius of 2-3km. Settlement resident's uses coal for cooking purposes.

Sample collection Transportation and Preservation

Ambient $PM_{2.5}$ and PM_{10} samples were collected using suitable sampler at a desired flow rate. Filters were wrapped carefully with aluminium foil and stored in re-sealable plastic bags. At sampling site, the filter that collected the particle sample on the previous day was taken out of the filter holder and immediately wrapped with aluminium foil and sealed. The sample filters were transported back to the laboratory in an isolated cooler container with ice and then frozen at $-10^{\circ}C$ until analysis.

Table 5. 1 Physical and Chemical components for characterization of Particulate matter

Components	Filter Matrix	Analytical Methods
PM10/ PM2.5	Teflon/Quartz filter paper	Gravimetric
Elements (Na, Mg, Al, Si, P, S, Cl, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pd, Ag, Cr, Cd, In, Sn, Sb, Ba, La, Hg, Ti, and Pb)	Teflon/Quartz filter paper	ICP-OES
Ions (NO_2^- , NO_3^- , SO_4^{2-} , K^+ , NH_4^+ , Na^+)	Teflon/Quartz filter paper	Ion chromatography with conductivity detector
Carbon Analysis (OC, EC)	Quartz filter paper	TOR/TOT method
PAHs	Teflon/Quartz filter paper	Extraction followed by GC-MS analysis with and without derivatization

ANNEXURE-VII



Point XVI

cmpdi

A Mini Ratna Company

सेंट्रल माइन प्लानिंग एंड डिजाइन इंस्टीट्यूट लिमिटेड
(कोल इंडिया लिमिटेड की अनुबंधी कम्पनी / भारत सरकार की एक लोक उपक्रम)
पंजीकृत कार्यालय : गोनदवाना प्लेस , कॉक रोड , राँची - 834031 (झारखण्ड) भारत
क्षेत्रीय संस्थान-2, पत्रा. बीसीसीएल टाउनशिप, कोयला नगर, धनबाद 826005 (झारखण्ड) भारत
Central Mine Planning & Design Institute Limited
(A Subsidiary of Coal India Limited / Govt. of India Public Sector Undertaking)
Registered Office : Gondwana Place, Kanke Road, Ranchi -834031(Jharkhand)
Regional Institute-II, P.O. BCCL Township, Koylanagar, Dhanbad 826005(Jharkhand) India
Corporate Identity No. U14292JH1975GOI001223

पत्रांक: आर.आई.-2/पर्यावरण/एम-30/1150

दिनांक: 20.06.2015

सेवा में,
उप महाप्रबंधक (पर्यावरण)
बी. सी. सी. एल.
कोयला भवन
धनबाद ।



विषय: Study of installation of Rail-cum-Conveyor System in BCCL for transportation of coal.

महोदय,

This has reference to your letter no. BCCL/GM(Env.)/F-EC/13/622, dated 25.05.2013 for conducting the study and preparation of plan for installation of Rail-cum-Conveyor System for coal transportation in BCCL as a part of compliance of environmental clearance (EC) conditions stipulated by MoEF & CC in EC orders of different clusters. In this regard, we would like to inform you the following:

- As per EC clearance order transportation plan for Rail-cum-Conveyor system should dovetailed with Jharia Action Plan (Master Plan). The system of transportation is required to be installed in 2nd phase of EC implementation i.e. after completion of Master Plan (10 years) and 5 years of gestation period.
- JRDA has issued direction to RITES for traffic survey and data collection to initiate feasibility study regarding Diversion of Railway lines from fire affected and subsidence prone areas
- Coal transportation route / conveyor installation layout will be finalized after liquidation of coal mine fire, rehabilitation of 595 unstable sites, road and rail route alignment and location of Rly. Sidings of BCCL.

CMPDI will be able to submit the plan / study for installation of Rail-cum-Conveyor System in BCCL for transportation of coal only after diversions and re-alignments of roads and railway lines and relocation of railway sidings

This is for your kind information.

Sd/- Anantashu 26
for compliance purpose.

[Signature]
23/6/15

भवदीय
[Signature]
(वि. कु. सिन्हा)
क्षेत्रीय निदेशक



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ईमेल / Email : ri2@cmpdi.co.in

ANNEXURE - VIII

सीएसआईआर-केन्द्रीय खनन एवं ईंधन अनुसंधान संस्थान

(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद)
बरवा रोड, धनबाद - 826 015, झारखण्ड, भारत
एक आई एस ओ 9001 प्रमाणित संस्थान



CSIR-Central Institute of Mining and Fuel Research

(Council of Scientific and Industrial Research)
Barwa Road, Dhanbad - 826 015, Jharkhand, India
An ISO 9001 Certified Institute

संदर्भ संख्या/Ref.No.BDIL/PME/CNP/4466/2016-17

कर द्वारा

25

दिनांक/Dated: 12th मई /May'2017

सेवा में

मेसर्स इंदु - एससीसीएल - सीजीएमइ कंसोर्टियम / M/s INDU-SCCL-CGME Consortium
साईट ऑफिस मूनीडीह - 828129 / Site Office Moonidih - 828129

विषय/Sub:- अनुसंधान एवं विकास परियोजना के संबंध में अन्तिम प्रतिवेदन/Final Report in respect of R&D Project entitled "Advice for finding the effect of subsidence due to coal extraction in XV seam at Moonidih and design the workings in XV(T) & XV(B) sections with no subsidence impact on surface".

आपके संदर्भ संख्या/Your Ref No.: MND/PO/9/2016/180 दिनांक 26/04/2016

प्रिय महाराज/ Dear Sir,

कृपया ध्यान दें, आपके संगठन द्वारा प्रायोजित उपरोक्त अनुसंधान एवं विकास जांच पूरा हो चुकी है और इसकी अन्तिम प्रतिवेदन आपके अवलोकन के लिए संलग्न की जा रही है। मैं प्रतिवेदन के साथ एक फॉर्मेट संलग्न कर रहा हूँ, आपके द्वारा भरा जाना है (फॉर्मेट के प्रत्येक पंक्ति के उपयुक्त बॉक्स में टिक निशान लगाएँ) जो अनिवार्य रूप से ग्राहकों की संतुष्टि के उद्देश्य के साथ अनुसंधान एवं विकास परियोजनाओं के मूल्यांकन के लिए हमारे पैतृक संगठन सीएसआईआर मुख्यालय को अनिवार्य रूप से इसकी आवश्यकता है।

Please note that the above R&D investigation, sponsored by your organization, has been completed and its final report is enclosed for your kind perusal. Along with the report I am enclosing a format for getting it filled by you (tick mark the appropriate box in each row) which is mandatorily required by CSIR, our parent body, with the purpose of evaluating customer satisfaction of R&D projects undertaken by this CSIR Laboratory.

मैं आपका अत्यंत आभारी रहूँगा यदि आप कृपया आगे की कार्रवाई हेतु भरा हुआ फॉर्मेट हमें भेजने का कष्ट करेंगे। वांछित जानकारी कृपया अधोहस्ताक्षरी को या फैक्स के माध्यम से (0326) 2296025/ 2296021/2296033 भेजें।
It will be highly appreciated if you would kindly extend your co-operation by advising your good office for sending the filled up format to us for taking further action. The desired information may kindly be sent to the undersigned or fax to (0326) 2296025/2296021/2296033.

धन्यवाद,

Thanking you,

आपका विश्वासी/Yours faithfully

संलग्न/Encl: रिपोर्ट की दो प्रतियाँ/two copies of the report,

ग्राहक संतुष्टि फीडबैक फॉर्म/Customer Satisfaction Feedback Form

(तपन कुमार मंडल)

प्रधान तकनीकी अधिकारी/Principal Technical Officer

परियोजना प्रकोष्ठ/Project Cell

प्रतिलिपि/Copy to:- 1) श्रीमान परियोजना अधिकारी (मूनीडीह कोलियरी), परियोजना अधिकारी कार्यालय, मूनीडीह कोलियरी, पोस्टऑफिस: मूनीडीह, डिस्ट्रिक्ट: धनबाद, झारखंड - 828129

2) डॉ. सत्येन्द्र. के. सिंह, मुख्य वैज्ञानिक

1.0 INTRODUCTION

With the prime objective to have no adverse mining-induced subsidence on the surface, the extraction in XV (Top) and XV (Bottom) seams at Moonidih Mine, Bharat Coking Coal Limited (BCCL), need to be planned keeping two aspects in view, namely,

- (a) the extraction spans should be suitably designed to have subsidence strain less than 3mm/m and
- (b) the chain/barrier pillars between the extraction spans should have factor of safety (FOS) more than 2.0, i.e., long term stable or stable forever.

These norms are as per guidelines from regulatory authorities/inspectorates. Moonidih colliery of BCCL in Jharia coalfield is the only colliery of India, which is planned for total exploitation of coal seams by longwall with caving only. At localities, wherever there were old overlying goaves of XVII, XVI or such overlying seams, managing no-adverse subsidence seemingly becomes a challenge to the researchers as detailed in this study report.

It is obvious that planning an extraction of width less than the non-effective width (NEW). NEW is the maximum width till which there is no mining-induced subsidence on the surface or a plane of reference, would certainly result into ‘completely’ no subsidence on the surface. However, the safe limit of 3mm/m mining-induced subsidence strain may also mean “no adverse subsidence impact” on the surface. In latter case, there would obviously be better recovery of coal in comparison. It is, therefore, proposed to take up the latter approach to achieve the prime objectives as mentioned above. In the way, it is also necessary to check, as to whether the planned extraction spans i.e., of 250m face-width [1], would result in 3mm/m subsidence strains or less. If not, the research addresses the issues of possible remedial measures. While taking up this comprehensive research studies as detailed in the text, the aspects of parting stability, especially while extracting XV (Bottom) seam below settled goaf of XV (Top) seam have also been considered with the help of numerical modelling.

Keeping above in view, a research study has been taken up by CSIR-CIMFR. This study report, therefore, includes aspects of subsidence engineering, specifically aspects related to (a) & (b) above and stability of parting between XV (T) and XV (B) seams during extraction. The conclusions and recommendations drawn in this study report would allow the mine operator INDU-SCCL-CGME Consortium to extract longwall panel no. 1-5 belowground in XV (T) and/or XV(Bottom) seams, as the analysis so suggests at Moonidih mine, BCCL without the need to acquire surface land.

2.0 OBJECTIVES

The objectives of this research study include:

- a. To design suitable extraction spans to have subsidence strain less than 3mm/m (the safe limit) at the surface, so as to effect no adverse mining-induced subsidence on the surface.

- b. To design the chain/barrier pillars between the extractions spans to have a factor of safety (FOS) more than 2.0, i.e., long-term stable.
- c. To assess parting stability while longwalling in XV (B) seam below the respective settled goaf of XV (T) Seam.
- d. In the case of non-fulfilment or partial fulfilment of (a), (b) or (c), to suggest the remedial measures and associated issues.

3.0 GEO-MINING DETAILS

Plans and sections of the proposed extraction areas of XV (Top) and XV (Bottom) seams at Moonidih colliery were studied with particular attention towards the stability of the immediate roof, caving behaviour of goaf during longwalling and observable conditions of barrier pillars and chain pillars from stability points of view. The geo-mining details are given in Table 1. The mine layout of proposed panels is shown in Fig. 1.

Table 1: Geo-mining details of the coal seams at Moonidih Colliery

1	Workable seams	2 Nos.: XV(T) and XV(B)
2	Thickness of the seam	XV(T):Min.:1.53mMax.: 4.18m XV(B):Min.:1.93mMax.: 7.20m
3	Longwall face width, proposed by the mine management	XV(T): 250 m XV(B): 238.6 m
4	Depth range (By and large)	XV(T): 644 – 782 m XV(B): 647 – 756 m
5	Single chain pillar size (avg.) formed in XVI seam	160 x 55m (corner-to-corner)
6	Width of Tail and Main gate in XV seam	5.7 m (average)
7	% of extraction in the panel	90%
8	Strength of coal tested of XV Seam	5.88 MPa

4.0 FIELD INVESTIGATIONS

XV Seam has been developed in Moonidih mine in the areas from where coal samples were taken for physico-mechanical properties evaluation. To confirm the tested values, twice the sample were collected and evaluation of physic-mechanical properties were revisited. The analysis of plans, sections and earlier submitted reports were led to the conclusion that the proposed area of longwalling in XV (T) and XV (B) were not significantly affected by geological anomalies. Accordingly, the numerical modelling exercises (sections 10.0) did not account for simulation of geological anomalies separately. The latter were subsumed in Rock-mass estimation as detailed in section 10.

Recent visits were made to observe the strata behaviour in overlying longwall panels being extracted at XVI seam in the Moonidih mine. It was observed that the roof caving is regular. The goaf is getting completely packed, more so in the middle of the panel. There was no adverse load coming on the support and the supports were behaving properly even during periodic and local mainfall. No problem is reported till date from supports. This may be perhaps due to regular caving behind the goaf edges as one of the important reasons. The surface properties above the proposed panels were visited and it

was of the opinion that these important properties need to be protected from mining-induced subsidence point of view. At the moment, the mine-management finds the other alternative, i.e., shifting these properties and acquiring the land, not a viable option and therefore research study as detailed in this study report is need of the hour.

5.0 SUBSIDENCE ENGINEERING ASPECTS

Subsidence prediction nomograms/formulations were developed by CSIR-CIMFR, based on extensive scientific subsidence monitoring studies over caved and stowed panels (> 200 in numbers) and subsequent analysis and mathematical treatments [2-7]. These studies included Longwall panels of Moonidih (XVII-Top & XVI-Top seams, caving extraction) with varying depths (H) from 327m to 450m, having w_p/H ratio varying from 0.33 to 1.36. Understandably, width of the panel (w_p) is the face width of the longwall.

Principles of subsidence engineering state that when the width of extraction belowground exceeds a threshold value (depending on the nature of the strata and other geo-mining details), there will be a significant symptom of subsidence (i.e. 5mm or more) on the surface. This value is called as Non-effective width (NEW), expressed as a w_p/H ratio, where w_p = width of extraction-span (or width of a panel) and H = the depth of cover. An important observation in this regard is that harder strata (of all types, not only sandstones) will give a greater value of NEW [2, 3 & 4]. The concept of NEW is simplified to be two-dimensional, although subsidence is associated with three-dimensional (rock) movements. The range of NEW observed in Jharia coalfields is 0.3-0.6 [2]. The critical width (C_w), also expressed as a w_p/H ratio, is defined as the width of extraction belowground for which there will be maximum possible subsidence recorded, at least on one point, at surface or on the plane of reference. The observed value of C_w in Jharia coalfields is found to be 1.1 to 1.3 [2].

Let us take the minimum value of NEW i.e. 0.33 (in terms of w_p/H) for single seam (say the topmost seam) extraction, as per the scientific observations undertaken by CSIR-CIMFR (erstwhile CMRI) in the past. Understandably, if the proposed w_p/H ratio of longwall panels is less than 0.33 for single seam-extraction situation, there will not be any subsidence on the surface due to extraction of such seams. In case of XV (T) seam extraction, five panels namely P-1, P-2, P-3, P-4 and P-5 are planned to be extracted. The panels P-1, P-2 and P-3 have a settled overlying goaf of XVII (T) seam. The panels P-4 and P-5 are not significantly affected by overlying extracted seam(s) i.e., above the proposed XV (T) seam extraction, there is no caved goaf. Hence, XV (T) & XV (B) seams in these 2 panels can be considered as multi-seam-extraction for the purpose of subsidence parameter calculations. When the XV (B) seam is also extracted below the settled goaf of XV (T) seam, then the total seam thickness of both the seams will be considered for subsidence calculation as the parting is found to be failing, as detailed in section 10.0 of this report.

To account for seam XV (T) in panels P-1, P-2 and P-3, we need to consider XVII (T) seam as goaved out immediately located above the XV (T) seams. Based on the earlier studies [3,5,6,7], a 40% reduction in NEW value has to be incorporated for the

consideration that overlying strata above the extracted XVII (T) seam were regarded as fractured rock types before the proposed extraction in XV(T) may be started. The adjusted NEW for either of lower seams i.e. XV (T) for panels P-1, P-2 and P-3 are given as:

$$NEW' = \frac{[0.6*NEW*(H-P)+NEW*P]}{H} \quad (1)$$

Where, NEW is the non-effective width for single-seam extraction situation, m; P = thickness of intact parting, m; H = depth of the seam, m.

5.1 Empirical subsidence formulation

$$x = \frac{\text{width-to-depth ratio}}{NEW} = \frac{(w_p/H)}{NEW} \quad (2)$$

Single-seam cases:

$$\frac{S}{h*e} = 0.33 * [1 + 1.1 * \tanh\{1.4(x - 1.8)\}] \quad (3)$$

Multi-seam cases (i.e., below goaved out overlying workings):

$$\frac{S}{h*e} = 0.12 * [1 + 5.9 * \tanh\{0.38(x - 1.45)\}] \quad (4)$$

Where, w_p = width of the panel, m; NEW = non-effective width (as determined) or NEW' (as per eqn. 1), as the case may be, m; S = maximum subsidence, m; h = extraction height, m; e = extraction ratio, 0.9, considering for 90% extraction as may be extracted during longwalling.

Note: For maximum severity to be considered, the minimum depth (and not the average depth) of the seam [here, XV (T)] in the proposed panel should be considered from subsidence management point of view.

The index of determination (R^2) was obtained as 0.85 and 0.86 respectively, for eqns. (3) and (4), which may be regarded as quite satisfactory. It is obvious that the equations are significantly different. A word of caution regarding eqn. (4) is necessary. It may be noted that in multi-seam extractions, the overlying goaf (s) may or may not overlap the extraction panel and also can have widely different and irregular shapes. Eqn. (4), therefore, is only approximate and provides a maximum possible value [6, 7].

$$G = K_1 \frac{S}{H} \quad (5)$$

$$E_{(-)} = K_2 \frac{S}{H} \quad (6)$$

$$E_{(+)} = K_3 \frac{S}{H} \quad (7)$$

Where, G = maximum slope, mm/m; $E_{(-)}$ = maximum compressive strain, mm/m; $E_{(+)}$ = maximum tensile strain, mm/m; and H = depth of cover, m.

The calculations made for different panels in XV (Top) and XV (Bottom) seams are given in Table 2. It has been observed that the nature of subsidence at Moonidih would be of continuous one (Fig. 2), as calculated with the help of data in Table 2. Thus, it is reasonable to predict subsidence parameters due to the extraction of these seams. K_1 , K_2 and K_3 constants are calculated from the nomograms developed by CSIR-CIMFR (erstwhile CMRI) based on extensive subsidence monitoring and discussed in detail elsewhere [5, 6, 7] – for single seam and multi-seam situations [Fig. 3(a) and 3(b) respectively] [3, 4, 7]. The subsidence damage classification, followed worldwide is taken into consideration while designing coal extraction in XV (T) and XV (B) seams, as listed in Table 3. The safe limit 3mm/m would keep the class of damage in the zone of Sl. No. 1 of Table 3.

Table 2: Subsidence calculations for Panels 1-5 in XV (Top) and XV (Bottom) seams

Panel name	H	P	NEW' (eq. 1)	w_p	x (eq. 2)	h	S (eq. 3 & 4)	K_3	$E_{(+)}$ (eq. 7)	Remarks
Panels in XV (Top)										
Panel 1	564	164	0.236	250	1.88	3	0.633	2	2.247	Multi-seam
Panel 2	640	240	0.247	250	1.58	3	0.418	1.5	0.98	
Panel 3	676	276	0.252	250	1.47	3	0.336	1.5	0.746	
Panels in XV (Bottom)										
Panel 4	704	--	0.33	238.6	1.08	7*	0.329	1	0.467	Single seam
Panel 5	742	--	0.33	238.6	1.02	7*	0.255	1	0.343	

***Note:** The heights of extraction in XV (T) and XV (B) seams were added to be 7m as mentioned against Panel-4 and Panel-5 in Table 2 only for subsidence calculation purpose.

Table 3: Subsidence Damage Classification [2]

Sl. No.	Change in length of structure	Class of damage	Description of typical damage
1	Up to 30 mm	Very slight or negligible	Hair cracks in plaster. Perhaps isolated slight fractures in the buildings, not visible on the outside.
2	30 – 60 mm	Slight	Several slight fractures visible inside the building. Doors and windows may stick slightly. Repairs to decoration probably necessary.
3	60 – 120 mm	Appreciable	Slight fractures visible on outside of buildings (or one main fracture). Doors and windows sticking; service pipes may fracture.
4	120 – 180 mm	Severe	Service pipes disturbed. Open fractures requiring rebending and allowing weathering into the structure. Windows and door frames distorted; floors sloping noticeably. Some loss of bearing in beams. If compressive damage, overlapping of roof joints out lifting of brickwork with open horizontal fractures.
5	More than	Very severe	As above, but worse, and requiring partial or complete

	180 mm		rebuilding. Roof and floor beam loose bearings and needs sharing up. Windows were broken with distortion. Severe slopes on the floor. If compressive damage, severe buckling and bulging of the roof and walls.
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As obvious from Table 2, the Panels 1, 2, and 3 are to be extracted either in XV (T) or XV (B) depending on subjective judgements based on quality of coal and thickness of seam in comparison. In this situation, the land above the panels need not to be acquired as the subsidence strain is less than 3mm/m, the safe limit. However, if it is decided to extract both the seams in these panels also, the land over the panels are to be acquired. It may be noted that with the chain pillar size as detailed in section 9, both XV (T) and XV (B) seams may be extracted for a depth range of 670 m and above without affecting surface. Meaning hereby, the future panels on the dip side of Panels 4 and 5 as proposed at the moment, would not require land to be acquired even for double section extraction in XV (T) and XV (B) seams.

6.0 BOREHOLE LITHOLOGY AND PHYSICO-MECHANICAL PROPERTIES OF THE OVERLYING ROOF ROCKS

The borehole no. 1 lies in the center of Panel 5 (Fig. 1), thus its lithology (as shown in Fig. 4) and physico-mechanical properties (given in Table 4), have been considered for numerical modelling exercises undertaken in this report. The lithology of borehole no. 1, has been analysed to get the major bedding planes overlying the seam under consideration and to estimate the immediate roof and main roof so as to get an idea of the variation in the strata over the coal seam. The immediate roof is the fractured lower roof, which readily caves behind the supports forming the goaf during the fracturing process. The main roof can induce vertical load on the supports and cause periodic weighting, if regular caving is not effected after progressive coal extraction during longwalling.

The beds up to a height of 46.45 m above the coal seam are laminated beds of sandstone, shale and carbonaceous shale with a weighted average compressive strength of 44.5 MPa, tensile strength of 8.7 MPa and caving index of 3175. This indicates that the cavability of the roof overlying the coal seam within the caving zone is good and due to the high depth of the coal seam, the goaf will be normally packed behind the supports.

Table 4: Litholog and physico-mechanical properties of Borehole No. 1

<u>Rock Bed Characteristics</u>	Bed	Depth above XV coal seam, (m)	Thickness of bed, t (m)	RQD, %	Avg. Length, est. L (cm)	Density (t/m³)	Weighted comp. Str., □_c (Kg/cm²)	Weighted tens. Str., □_t (Kg/cm²)	Caving Index
Coal Seam XV	XV Seam	-3.65	-3.65	100.0	24.2	1471	59	12	543
Grey Shale	Bed 1	0	5.45	64.8	12.6	2417	333	68	1954
Sandstone fine to medium grained	Bed 2	5.45	1.2	83.3	18.7	2631	577	107	4242
Sandstone fine to medium grained	Bed 3	6.65	2.2	80.9	17.9	2601	487	95	2581
Sandstone fine to medium grained	Bed 4	8.85	1.9	92.6	21.7	2631	577	107	6407
Grey Shale	Bed 5	10.75	3.7	77.0	16.6	2442	365	74	2332
Sandstone medium grained	Bed 6	14.45	2.87	78.8	17.2	2611	516	99	5302
Grey Shale	Bed 7	17.32	2.88	43.8	5.6	2417	333	68	858
Sandstone fine grained	Bed 8	20.2	1.26	54.0	9.0	2681	699	103	1760
Grey Shale	Bed 9	21.46	1.67	65.9	12.9	2417	333	68	1113
Sandstone medium grained	Bed 10	23.13	2.02	90.1	20.9	2601	487	95	5786
Carbonaceous Shale	Bed 11	25.15	2.9	63.1	12.0	2486	420	83	1715
Sandstone fine grained	Bed 12	28.05	1.17	84.6	19.1	2681	699	103	5212
Carbonaceous Shale	Bed 13	29.22	1.54	92.2	21.6	2463	392	78	2139
Sandstone fine to medium grained	Bed 14	30.76	1.34	88.8	20.5	2631	577	107	5556
Very coarse grained Sanstone	Bed 15	32.1	2.2	82.7	18.5	2586	484	99	2652
Sandstone medium grained	Bed 16	34.3	0.76	73.7	15.5	2601	487	95	2906
Grey Shale	Bed 17	35.06	1.91	99.0	23.8	2361	269	63	1774
Sandstone medium grained	Bed 18	36.97	1.88	99.5	24.0	2601	487	95	6050
Shaly Sandstone	Bed 19	38.85	3.22	87.9	20.2	2498	437	91	3164
Sandstone medium grained	Bed 20	42.07	1.16	91.4	21.3	2601	487	95	4125
Sandy Shale	Bed 21	43.23	1.42	80.3	17.7	2517	458	90	1927
Sandstone medium grained	Bed 22	44.65	1.8	92.8	21.8	2601	487	95	5272
Grey Shale	Bed 23	46.45	17.99	92.8	21.8	2478	421	87	7784
Sandstone medium to coarse grained	Bed 24	64.44	3.51	87.2	19.9	2624	403	90	5486
Alternate Shale & Sandstone	Bed 25	67.95	1.77	85.9	19.5	2591	452	100	2659
Sandstone medium grained	Bed 26	69.72	1.35	85.9	19.5	2601	487	95	4003
Coal Seam XV	Bed 27	71.07	1.08	100.0	24.2	1646	110	23	551
Sandstone medium grained	Bed 28	72.15	1.6	83.1	18.6	2601	487	95	4112
Grey Shale	Bed 29	73.75	1.8	81.1	17.9	2381	281	66	1354
Sandstone medium grained	Bed 30	75.55	0.9	97.8	23.4	2601	487	95	4069
Grey Shale	Bed 31	76.45	2.2	90.5	21.0	2582	461	98	2873
Sandstone medium grained	Bed 32	78.65	2.2	86.4	19.7	2601	487	95	5156
Grey Shale	Bed 33	80.85	5.7	85.8	19.5	2558	451	95	4196

7.0 BARRIER PILLAR DESIGN

For the stability of the workings, barrier pillar design is the major requirement for any successful longwall mining endeavour. Such a design is made using the safety factor concept of structural mechanics, which consists of estimating load and strength of the pillars and linking the two through a proper safety factor.

7.1 Pillar Strength

The barrier pillars or chain pillars designed so far in all the Indian sites are primarily using CIMFR empirical equation, owing to the confidence gained over a couple of decades of its use in real cases and obtained results. The strength of the chain pillars can be estimated using the CIMFR pillar strength equation as given below [8]:

$$S = 0.27\sigma_c h^{-0.36} + \left(\frac{H}{250} + 1\right) \left(\frac{W_e}{h} - 1\right) \quad (8)$$

$$W_e = \frac{2ww_1}{w + w_1}$$

Where, S = pillar strength, MPa, σ_c = compressive strength of 1" coal cube, MPa, h = working height, m, H = depth of cover of the seam, m, w = width of rectangular pillar, m, w_1 = length of rectangular pillar, m, W_e = effective width of pillar, m

7.2 Calculation of Load on chain pillars

With reference to longwall extraction, chain pillar loading has been established by Wilson who analysed roof-to-floor convergence measurements behind caved longwall faces. Based on these, he proposed a linear rise in the vertical goaf stress starting from zero at the rib-side or face to the cover pressure γH at a distance of $0.3-0.4H$ [9]. American findings from extensive measurements propose this distance of goaf settlement on an average as $0.38H$ [10]. This range can thus be accepted for normally caveable strata. In India, the value of $0.3H$ is taken for normally caveable strata. For hard, difficult to cave strata, it is assumed that no caving takes place and the goaf does not offer any support. Some differences in this distance can obviously exist depending on the nature of strata. Some observations at CIMFR, Dhanbad have put this distance of $0.2H$ for stowed panels.

7.2.1 Chain pillar load for both-side goaf

The chain pillar load can be estimated based on the 'vertical stress balance' concept of Wilson. According to this concept, since no part of the cover is added or removed during mining, the total vertical load before mining must remain the same as the total vertical load after mining. This implies that the load reduction in the goaf area must be compensated for by an increase in the load at rib-sides or on chain pillars. If the general

pattern of load distribution is known, knowledge of the one can lead to an estimate of the other.

A typical chain pillar, during its life, will be subjected to the following types of loads:

- (a) Development load before extraction starts.
- (b) Front abutment load, when the face is at the pillar.
- (c) Side abutment load, when the face advances further from the pillar.

If goaf exists on both sides, the pillars will be subjected to loads (b) and (c) twice during their life period. If the panel width is less than $2fH$, the load in the centre will not reach cover load. If goafs exist on both sides of the pillar chain, the average pillar load could be obtained from the equation below. In this case, $2fH = 2 \times 0.3 \times 862 = 517.2$ i.e., > Panel width (L_1, L_2) as shown in Fig. 5.

$$P = \frac{\gamma(w_1 + B)}{ww_1} \left[H \left(w + \frac{L_1 + L_2}{2} \right) - \frac{1}{8f} (L_1^2 + L_2^2) \right] \quad (9)$$

Where, P = Chain pillar load, MPa, γ = rock load density, MPa/m, H = depth below surface, m, B = gate road width, m, w = width of rectangular pillar, m, w_1 = length of rectangular pillar, m, $L_1=L_2=L$ = width of panels, m, $f = 0.3$ (for caving)

7.3 Safety Factor

The safety factor of the pillars can be calculated as given below:

$$\text{Safety Factor, } S.F. = \frac{\text{Strength of barrier pillar}}{\text{Pillar Load}} = \frac{S}{P} \quad (10)$$

Chain pillar sizing should normally be done on the basis of the safety factor. It is felt that if the pillars have an adequate safety factor, the chain pillars should remain stable during first-panel extraction i.e. under one-sided goaf loading. During extraction of a neighbouring panel, these chain pillars will undergo both-side goaf loading and it is desirable that they remain short term stable or yield. For short term stability of this chain pillar, the pillar size should be calculated so as to have a safety factor of greater than 1.5 with goaf on both sides; and the safety factor should be greater than 2.0 with goaf on one side. However, to prevent mining-induced subsidence impact at the surface the pillars must be long-term stable. Hence, in this study, the pillar size has been calculated so as to have a safety factor, more than 2.0 with goaf on both sides.

Had this long-term (i.e., stable for ever) stability not ensured, the face width of one panel would combine with the width of the neighbouring panel along with failing chain pillar. On long term basis, w_p (now) = 250 + 55 (say) + 250 + 10 (gallery width) = 565m, and $H = 742$ m, i.e., $w_p/H = 0.76$, which is much more than NEW. Therefore, in case of not-long-term stable chain pillars or arrays of pillars, the subsidence would eventually take place even if the extraction span of each longwall panel is less than NEW. Thus, it is

prudent to opt for numerical modelling to assess the load on pillars, especially when there is extraction nearby and depth of cover is more than 300m as shown in Table 7.

8.0 CALCULATIONS BASED ON WILSON'S MODEL

Pillar stability calculations are based on mine management proposal of the inter-panel barrier of pillar size of 55 m x 160 m corner to corner. Table 5 gives the calculated average load on the pillar, its strength and safety factor as explained in section 7. The depths of the inter-panel barriers have been considered according to those shown in Fig. 6.

Taking $\sigma_c = 5.9$ MPa, $\gamma = 0.025$ MPa/m, $h = 3.5$ m, $L_1=L_2=L=250$ m, $B = 5.7$ m, $f = 0.3$ for caving, $H = 862$ m

Table 5: Calculation of barrier pillar load and safety factor based on Wilson's formula

Width (m)	Length (m)	Load (MPa)	Strength, MPa	S.F.
70	195	81.59	122.09	1.50
75	195	77.62	128.57	1.66
80	195	74.14	134.81	1.82

It has been found that Wilson's formulae overestimate the load on pillars as it is based on tributary area method. The overestimation in a typical case study may be as high as 40% [11].

9.0 NUMERICAL MODELLING PROCEDURE

This part of the report deals with numerical modelling to study the stability of inter-panel barriers and its effect on longwall workings.

Numerical modelling using FLAC^{3D} software [12] has been done for analysis of the stability of the barrier pillars (Fig. 6) for the depth of 862 m corresponding to the maximum depth of Panel No. 5. The modulus of elasticity and Poisson's ratio values of the goaf material are taken based on its values assumed for numerical modelling in published literature.

To have a better understanding of the problem a fine mesh/grid was prepared at the zone of interest. Fig. 7(a) shows the mesh/grid of the numerical models of the barrier pillar with applied load on the surface of the model before the start of the extraction of longwall panels. The boundary of the model lies on the centre line of the two longwall panels on both sides of the line of the barrier pillar. The model boundary, coal seam and the rock beds are shown in the figure. The boundaries are placed sufficiently far away from the area of interest and the behaviour in the area of interest is not affected. Fig. 7(b) shows the mesh/grid of the numerical model after drive of the gate roads. Fig. 7(c) shows the numerical model to estimate the load on the barrier pillar with goaf present on both sides.

Table 6 lists the different rock beds obtained from analysis of the litholog of Borehole No. 1 (Table 4). Bed 2 corresponds to coal of the XV seam and Bed 3 to Bed 1 (grey

shale) of Table 4. Bed 4 comprises of Bed nos. 2 to 4 of Table 4. Bed 5 consists of Bed nos. 5 to 13, Bed 6 is made up of Bed nos. 14 to 16, Bed 7 comprises of Bed nos. 17 to 22. Bed 8 corresponds to Bed no. 23 of Table 4. Bed nos. 24 to 26 constitute the Bed 9. Bed 10 corresponds to Bed no. 27, Bed 11 comprises of Bed nos. 28 to 32 and Bed 12 corresponds to Bed no. 33 of Table 4.

Table 6: Physico - mechanical properties of different rock beds considered for numerical modelling

Bed No.	Bed (Table 4)		Bed Thickness (m)	Young's Modulus (Pa)	Density	Comp. Str. (Pa)	Tens. Str. (Pa)
	From	To					
N_Bed 1 (Floor)	-		50	6E+09	2313	3.61E+07	7.30E+06
N_Bed 2 (Coal)	Coal XV seam		3.65	2E+09	1471	5.90E+06	1.20E+06
N_Bed 3	1	1	5.45	5E+09	2417	3.33E+07	6.80E+06
N_Bed 4	2	4	5.3	6E+09	2619	5.40E+07	1.02E+07
N_Bed 5	5	13	20.01	7E+09	2514	4.42E+07	8.40E+06
N_Bed 6	14	16	4.3	9E+09	2603	5.14E+07	1.01E+07
N_Bed 7	17	22	11.39	8E+09	2521	4.33E+07	8.80E+06
N_Bed 8	23	23	17.99	8E+09	2478	4.21E+07	8.70E+06
N_Bed 9	24	26	6.63	8E+09	2610	4.33E+07	9.40E+06
N_Bed 10	27	27	1.08	2E+09	1646	1.10E+07	2.30E+06
N_Bed 11	28	32	8.7	8E+09	2551	4.38E+07	9.00E+06
N_Bed 12	33	33	5.7	8E+09	2558	4.51E+07	9.50E+06

9.1 In-situ Stress field Initialisation

In the absence of measurements of the in-situ stress values, theoretical values were calculated by the following equation [13]:

$$K = \frac{S_h}{S_v} = \frac{\nu}{1-\nu} + \frac{\alpha EG}{(1-\nu)\gamma} \left(1 + \frac{1000}{H}\right) \quad (11)$$

Where, K= ratio of in-situ horizontal to vertical stress, ν = Poisson's ratio, α = Coefficient of thermal expansion of rock= $0.3 \times 10^{-5}/^{\circ}\text{C}$, E= Modulus of elasticity, Mpa, G= Thermal Gradient = $0.03^{\circ}\text{C}/\text{m}$, γ = Volumetric density $0.025 \text{ MPa}/\text{m}$, H= Depth of cover, m.

9.2 Steps for Numerical Modelling

- STEP-1** : a. Grid generation;
b. Selection of appropriate material behaviour model;
c. Incorporation of material properties, in situ stresses and boundary conditions;

- d. The model is run in virgin state;
- STEP-2** : Development of roadway excavations in the model; The gallery of width 5 m and height 3.65 m was driven on both sides of the barrier pillar in the coal seam.
- STEP-3** : Panel 1 is extracted and is filled with goaf.
- STEP-4** : The adjoining longwall panel is also extracted and is filled with goaf.

9.3 Numerical Modelling Result

Numerical modelling was carried out to estimate the average load on the barrier pillars considering the different width of the pillars. Pillar strength was calculated using CIMFR pillar strength eqn. (8) mentioned above. From the above two parameters safety factor was determined to analyse the stability of the barrier pillars of various width using eqn. (10).

Option I:

Numerical modelling was carried out considering different values of barrier pillar width viz. 70 m, 75 m and 80 m. The result of this activity is tabulated below.

Taking $\sigma_c = 5.9$ MPa, $\gamma = 0.025$ MPa/m, $h = 3.5$ m, $L_1=L_2=L=250$ m, $B = 5.7$ m, $f = 0.3$ for caving, $H = 862$ m.

Table 7: Pillar load and safety factor obtained from numerical modelling

Barrier width (m)	Barrier length (m)	Modelled Load (MPa)	Strength (MPa)	S.F.
70	195	70.76	122.09	1.72
75	195	67.45	128.57	1.91
80	195	64.48	134.81	2.09

From the above study, as shown in Fig. 8, it is evident that for long-term stability, the width of the inter-panel barriers has to be 80 m (rib to rib). The idea behind long-term stable chain/barrier pillar rests on the fact that if barrier pillars(s) or an array of barrier pillars fails [having F.O.S less than 2.0], say at much later period after completion of coal extraction in the panel, the load, before failure, are shared among these pillars, would now be redistributed, resulting into higher abutments on non-failed barrier pillars. This redistribution may make non-failed pillars more vulnerable to failure. Eventually, there can be likely subsidence on the surface, although not expected. Ensuring long-term stable-designed chain pillars is therefore very important, not only from operational working reasons but also from surface subsidence management aspects.

Option II:

As per the approved mine plan, the dimensions of inter-panel barriers are suggested to be 55 m width and 160 m length (both rib to rib). Due to operational convenience, the mine operator has insisted on the approved mine plan dimensions for chain/barrier pillar.

Numerical modelling was also carried out using the above-mentioned pillar dimensions the result of which is given below.

Taking $\sigma_c = 5.9$ MPa, $h = 3.65$ m, $H = 862$ m, $w = 55$ m, $w_1 = 160$ m.

$$W_e = \frac{2 * w * w_1}{w + w_1} = \frac{2 * 55 * 160}{55 + 160} = 81.86$$

$$\begin{aligned} \text{Pillar Strength}(S) &= 0.27\sigma_c h^{-0.36} + \left(\frac{H}{250} + 1\right) \left(\frac{W_e}{h} - 1\right) \\ &= 0.27 * 5.9 * 3.65^{-0.36} + \left(\frac{862}{250} + 1\right) \left(\frac{81.86}{3.65} - 1\right) \\ &= 96.309 \text{ MPa} \end{aligned}$$

As in Option I, numerical modelling was carried out to assess the average load on the barrier pillar.

Average load on barrier pillar (P) = 84.88 MPa

$$\text{Safety Factor} = \frac{S}{P} = \frac{96.309}{84.88} = 1.13$$

Option III:

As the safety factor of the barrier pillar calculated using option II is quite low, it will be necessary to increase the pillar strength by employing side bolting. The best policy is to install bolts such that the top and bottom ones in a vertical row enter the roof and floor at an angle. To prevent both spalling and robbing it will be necessary to place the bolts over a wire mesh. Grouted or resin-anchor pre-tensioned bolts should be preferred to other types. The strength of the bolted pillar is given by eqn. (12) [13].

$$S_b = S + \frac{20A_s(q-1)}{\sigma_c a^2} S \quad (12)$$

Where, S_b = strength of bolted pillar, S = strength of unbolted pillar, A_s = anchorage strength of rock bolts, T, $q = 3.4$, σ_c = uniaxial compressive strength of coal, T/m², a = spacing between rock bolts, m.

The anchorage strength of rock bolts depends, among other things, upon the care adopted during bolting operation. Considering anchorage strength of 15 T, σ_c of 5.9 MPa = 590 T/m² and spacing of 1.25 m, the strength of bolted barrier pillar is calculated in the following manner.

$$\begin{aligned}
S_b &= S + \frac{20A_s(q-1)}{\sigma_c a^2} S \\
&= 96.309 * \left(1 + \frac{20 * 15 * (3.4 - 1)}{590 * 1.25^2} \right) \\
&= 171.528
\end{aligned}$$

$$\text{Safety Factor} = \frac{S_b}{P} = \frac{171.528}{84.88} = 2.02$$

Therefore, for long-term stability of 55 m wide barrier pillars, bolting needs to be carried out at a spacing of 1.25 m. There are various patterns as shown in Fig. 9 in which side bolting can be done.

Further Option I is recommended for the size of chain pillars/arrays of pillars including barrier pillars in XV (T) and XV (B) seams at Moonidih colliery. However, if there is insipient side-falls expected and/or observed from instrumentation-data analysis then side bolting/suitable side supports, if necessary with more support-reinforcement may be put in place at such locations.

10.0 NUMERICAL MODELLING FOR EVALUATION OF PARTING STABILITY

This part of the report deals with numerical modelling for evaluation of parting stability during extraction of Panels 4 and 5 in XV (Bottom) seam.

Numerical modelling using FLAC 3D software has been done for analysis of the stability of the parting between top and bottom section of the XV seam in two stages-

Stage I: Extraction of the Top Section and Goaf formation

Stage II: Extraction of the Bottom Section under stabilised goaf of Top Section

The model is prepared at the centre line of the longwall panel, along the section BB', as shown in Fig. 6. It is 200 m along the X-axis and 3 m along the Y axis. The beds as given in Table 4 are along the Z-axis. A fine mesh/grid of 1 m along X-axis and 1 m along Y-axis was prepared. Fig. 10(a) shows the mesh/grid of the numerical model before the start of the extraction of Top and Bottom Section. The model boundary, coal seam (Top Section Bed 6 and Bottom Section Bed 2) and the rock beds are shown in the figure. The Bed 3 (coal), Bed 4 (sandstone) and Bed 5 (coal) of thickness 1 m each constitute the parting of total thickness 3 m.

The boundaries are placed sufficiently far away from the area of interest and the behaviour in the area of interest is not affected. Fig. 10(b) shows the typical mesh/grid of the numerical model during extraction of Top section. Fig. 10(c) shows the numerical model to estimate the stability of the parting during extraction of Bottom section. Longwall Powered supports are modelled as nodal forces as shown in Fig. 10(d).

The elastic properties assumed in the model are given below in Table 8.

Table 8: Elastic properties of goaf used in the model

Sl. No.	Rock Bed	Young's Modulus 'E' (Pa)	Poisson's ratio 'v'
1.	Goaf	0.6 e 9	0.1
2.	Stabilised Goaf	1.0 e 9	0.1

10.1 In-situ Stress field initialization

In the absence of measurements of the in-situ stress values, theoretical values were calculated by the following equation [13]:

$$K = \frac{S_h}{S_v} = \frac{\nu}{1-\nu} + \frac{\alpha EG}{(1-\nu)\gamma} \left(1 + \frac{1000}{H}\right) \quad (11)$$

Where, K= ratio of in-situ horizontal to vertical stress, ν = Poisson's ratio, α = Coefficient of thermal expansion of rock=0.3x10⁻⁵/OC, E= Modulus of elasticity, Mpa, G= Thermal Gradient = 0.03oC/m, γ = Volumetric density 0.025 MPa/m, H= Depth of cover, m.

10.2 Steps for Numerical Modelling**Stage I: Extraction of the Top Section and Goaf formation**

- STEP-1** : a. Grid generation
b. Selection of appropriate material behaviour model
c. Incorporation of material properties, in situ stresses and boundary conditions
d. The model is run in virgin state
- STEP-2** : The face is advanced to 68 m with caved goaf behind. The goaf behind the face is simulated with modulus of elasticity as 0.6 GPa.
- STEP-3** : The face is advanced in stages with 8 m advance and progressive goaf filling till 196 m.
- STEP-4** : The face is advanced 4 m and thereby entire Top Section is extracted and goaf is formed up to a height of 105 m.

Stage II: Extraction of the Bottom Section under stabilised goaf of Top Section

- STEP-1** : The face is advanced to 68 m with caved goaf behind. The goaf behind the face is simulated with modulus of elasticity as 0.6 GPa. The stabilised goaf of the Top Section is simulated with modulus of elasticity as 1 GPa.
- STEP-2** : The face is advanced in stages with 8 m advance and progressive goaf filling till 92 m.
- STEP-3** : The face is advanced in stages with 2 m advance and progressive goaf filling till 108 m.

10.3 Safety Factor Calculations

The best way to know about the roof stability of the working area and its caving characteristics in the goaf is by calculating the safety factor for each element in the

overlying strata using the induced principal stress obtained from the output of the numerical model. Safety factor calculation was done using the Sheorey criterion for jointed rock masses developed at CIMFR for this purpose.

$$\sigma_{cm} = \sigma_c \exp\left(\frac{RMR-100}{20}\right)$$

$$\sigma_{tm} = \sigma_t \exp\left(\frac{RMR-100}{27}\right)$$

$$b_m = b \frac{RMR}{100}$$

Where,

- σ_1 & σ_3 are major and minor principal stresses induced on an element at failure
- σ_c is intact rock compressive strength, MPa
- σ_t is intact rock tensile strength, MPa
- b is constant for rock type
- RMR is Bieniawski's Rock Mass Rating

The safety factor 'F' is obtained as-

$$F = \frac{\sigma_1 - \sigma_{3i}}{\sigma_{1i} - \sigma_{3i}}$$

Except when $\sigma_{3i} > \sigma_{tm}$,

$$F = \frac{\sigma_{tm}}{-\sigma_{3i}}$$

10.4 Numerical Modelling Result

Numerical modelling was done to understand the stress redistribution during extraction of the bottom section below the caved goaf of the top section of XV seam. The observations from numerical modelling are plotted in the following figures:

- Fig. 11(a)** : Contour of Major Principal Stress
The maximum major principal stress (σ_1) of magnitude 122 MPa is observed in the abutment zone and the minimum σ_1 of 3.7 MPa is observed in the cantilever behind the supports.
- Fig. 11(b)** : Contour of Minor Principal Stress
The maximum minor principal stress (σ_3) is compressive of magnitude 33.6 MPa is observed in the abutment zone and the minimum σ_3 is tensile with magnitude of 7.7 MPa which is observed over the canopy behind the supports.
- Fig. 11(c)** : Principal Stress Vectors and orientation
The orientation are in line with the observed principal stresses in the

- abutment zone and in the cantilever roof
- Fig. 11(d)** : Contour of Vertical Stress
The maximum vertical stress (σ_{zz}) of magnitude 117 MPa is observed in the abutment zone which is approximately 5 times the cover load.
- Fig. 11(e)** : Safety Factor Contour
The major portion of the parting overlying XV (Bottom) seam, especially in the cantilever section over the powered supports has a safety factor of less than 0.5 which indicates that the coal roof is expected to be fractured and will be prone to cavity formation primarily due to high vertical stress at such high depth of cover. The stone roof is having a safety factor of more than 0.6 which indicates that it will be stable on a short-term basis. The canopy of the powered supports should be kept within 0.2-0.3 m out-bye from the face at all times to prevent any shear fracture and cavity formation ahead of the supports. This may facilitate ease of coal extraction in XV(B) seam below caved goaf of XV(T) seam.
- Fig. 11(f)** : Distribution of vertical stress along the panel
The distribution of vertical stresses all along the panel is plotted. As can be seen, cover pressure in a distant inbye from the abutment zone is re-established within the goaf and the coal block pillar, proposed to be extracted,.

It may be recommended to opt for the instrumentation plan with a suite of geotechnical instruments as mentioned in Fig. 13 on a “design by measurement” mode and Annexure I. Based on instrumentation data, parting stability should be ensured with respect to gate-road stability and its maintenance. The strata evaluation, monitoring and management should be done by the mine management under supervision of a scientific body. As understandable, the gate road has a better stability if the adjoining chain pillars and array of pillars are stable, meaning hereby, that the FOS should be more than 2.0. As already mentioned in section 8.0 of the report, with forward analysis of eqn. (10), the strength of barrier pillar is calculated using eqn. (8) and chain pillar load by the use of numerical modelling as described in section 9.0. It is pertinent to highlight that the prime objective of this research project was to suggest a method of extraction with an aim to have no mining-induced subsidence impact on the surface. The extensive numerical modelling exercise were executed with focus on extraction areas, and the parting stability while extracting in, longwall panels of XV (B) seam below caved goaf of XV(T) seam. The issues of parting stability affecting gate road stability, especially in XV (B) seam would require therefore a separate treatment of research where the strength of pillars has to be estimated using numerical modelling on one hand and on the other hand, the focus area of modelling need to be concentrated on roof and floor of gate road in addition to the chain pillars.

11.0 CONCLUSIONS AND RECOMMENDATIONS

1. Subsidence strain is calculated to be less than 3 mm/m, the safe limit. Here two types of considerations have been made: (a) single-section extraction in Panel nos. 1, 2 and

- 3 – subjective solution based primarily on the thickness of XV (Top) and XV (Bottom) seams and the quality of coal, and (b) double-section vertically-superimposed extraction in XV (Top) and XV (Bottom) seams, where the latter would be below settled goaf. Understandably the surface land need not to be acquired based on details of subsidence study in Section 5 of the report.
2. Subsidence monitoring for suitably laying out the monitoring stations over each panel of extraction on the surface needs to be undertaken during and one year after the completion of extraction in the respective panel(s).
 3. In case it is feasible to acquire the surface land, scientific study needs to be conducted with new objectives and applicable guidelines. For example, the stability requirement of chain/barrier pillars would be reduced from a factor of safety of 2 or more to a new requirement.
 4. Based on the stability criteria of chain/barrier pillars, it is recommended that chain pillars of width at least 80 m be left between longwall panels having length not less than 195 m for the long-term stability of the pillars.
 5. Due to operational constraints as envisaged by the mine operator and as communicated to CSIR-CIMFR, the length of the chain pillars was modified to 160 m where the width of the chain pillar should not be less than 55 m as approved in the mine plan. Taking these two parameters, the FOS of the chain pillars was calculated to be 1.135, i.e., less than the design criteria of FOS 2.0. A pattern of side bolting therefore is recommended in this case, with a grid spacing of not more than 1.25 m (as per Fig. 9) so that pillar has adequate enhanced strength and for which the FOS calculated was 2.02.
 6. As a corollary to (5) above, it is recommended to opt for side-bolting of chain pillars as per Fig. 9, not only to ensure stability of chain/barrier pillars but also to prevent side falls that may happen at high stress regime of such high depth of cover as in XV (T) and XV (B) seams of Moonidih Colliery.
 7. Once the chain pillars are developed, the above recommendations (4-6) shall be suitably revisited depending on the ‘design by measurement’ approach using a suite of geotechnical instruments as per instrumentation plan. As per discussions with DGMS and recommendations of a technical workshop conducted at DGMS Dhanbad on 20.01.2017 on latest trends in strata control in longwall mining with a special reference to strata monitoring techniques, the instrumentation plan for longwall is given in Annexure I. The recommended plan shall be put in place pillar-after-pillar. The modifications can be either reducing or increasing the spacing of side bolts or using the calculated anchorage test values which may be higher than 15 T taken in this study report, supposing the better practice of side-bolting put in place at the mine sites.
 8. The XV (B) seam can be worked with not less than 3 m thick parting in between.
 9. After extraction of the XV (T) seam, it is observed from numerical modelling exercises (please refer to Section 10) that the safety factor of the 3 m parting is varying between 1.0 and 2.5. Accordingly, the width of the barrier/chain pillars in bottom section will be increased by 11.4 m (2 x 5.7 m) compared to those of the top section as shown in Fig. 12. The width of gate roads is recommended to be 5.7 m.
 10. During development and final extraction, the relevant guidelines of Coal Mines Regulations should be followed, maintaining straight line of extraction all along.

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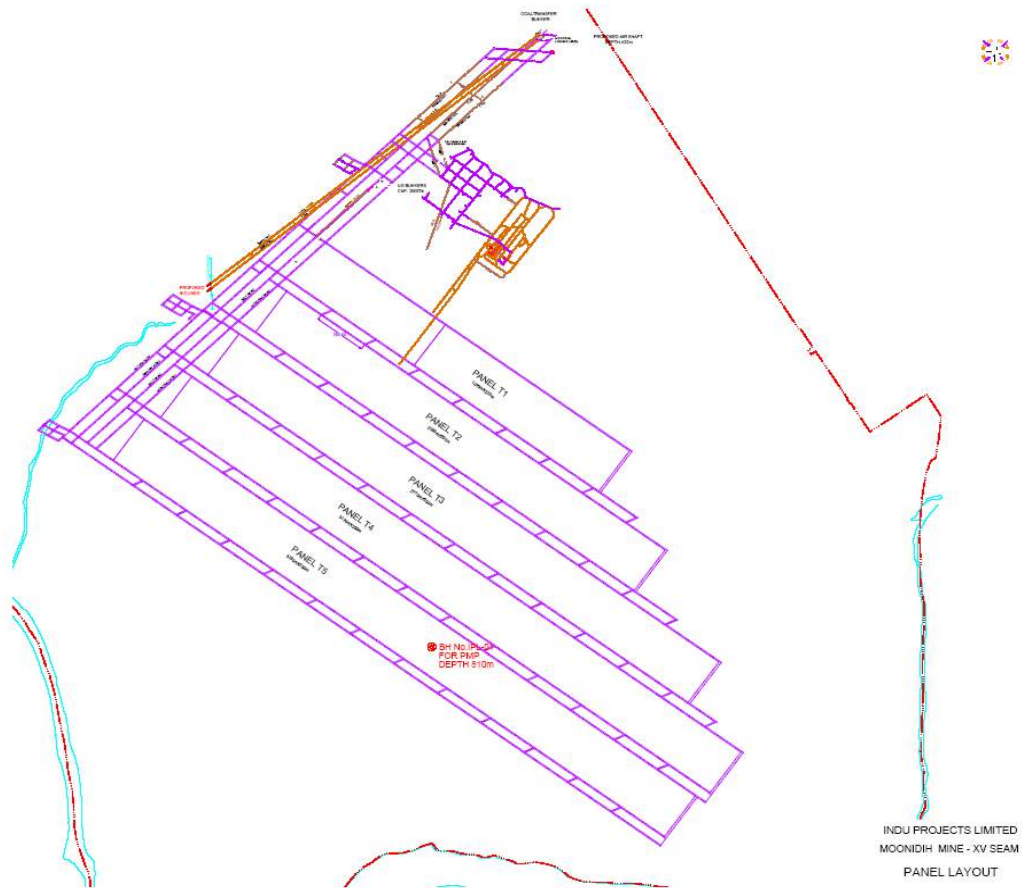


Fig. 1: Mine layout showing workings of XV seam

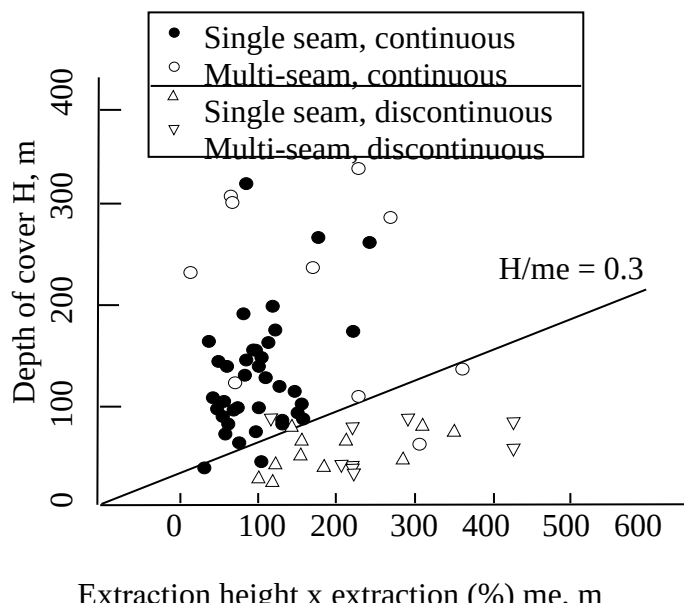


Fig. 2: Line of demarcation between continuous and discontinuous subsidence

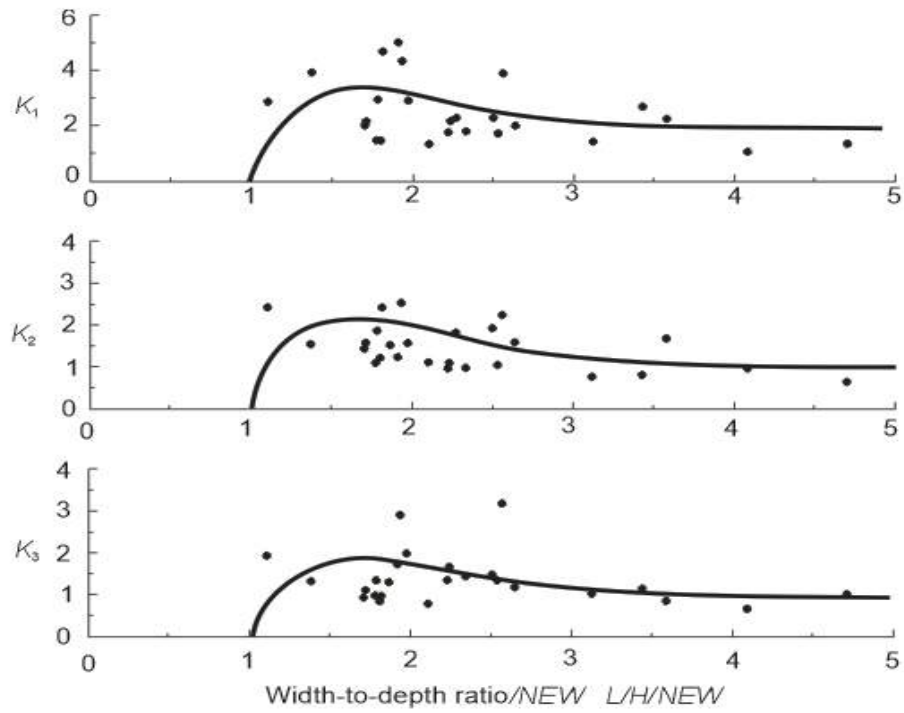


Fig. 3(a): Reference graph for estimation of K_1 , K_2 and K_3 constants for Single Seam

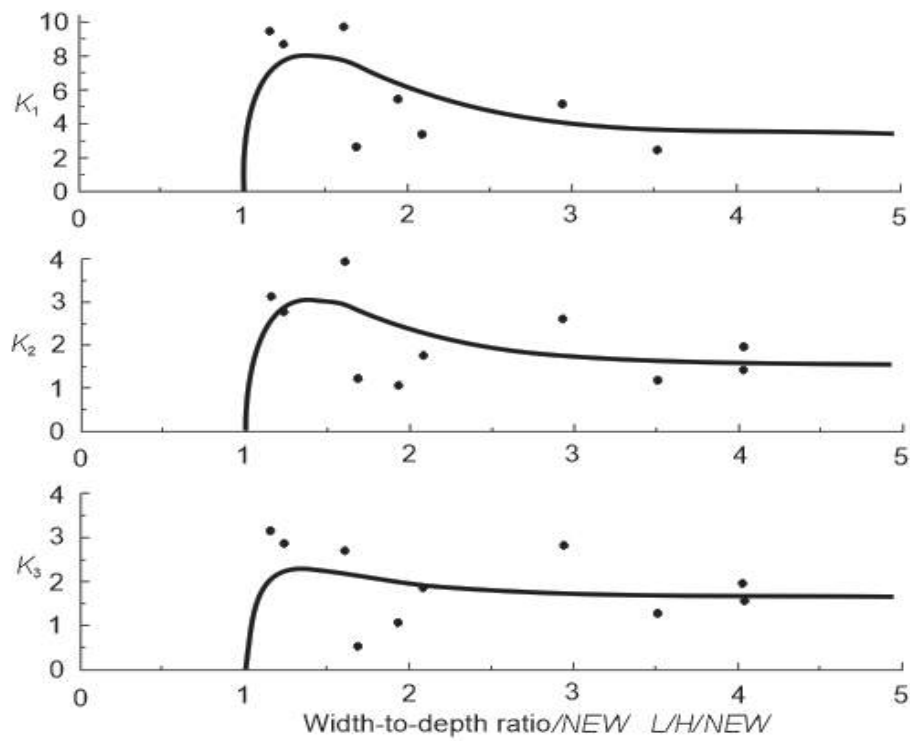


Fig. 3(b): Reference graph for estimation of K_1 , K_2 and K_3 constants for multi-seam

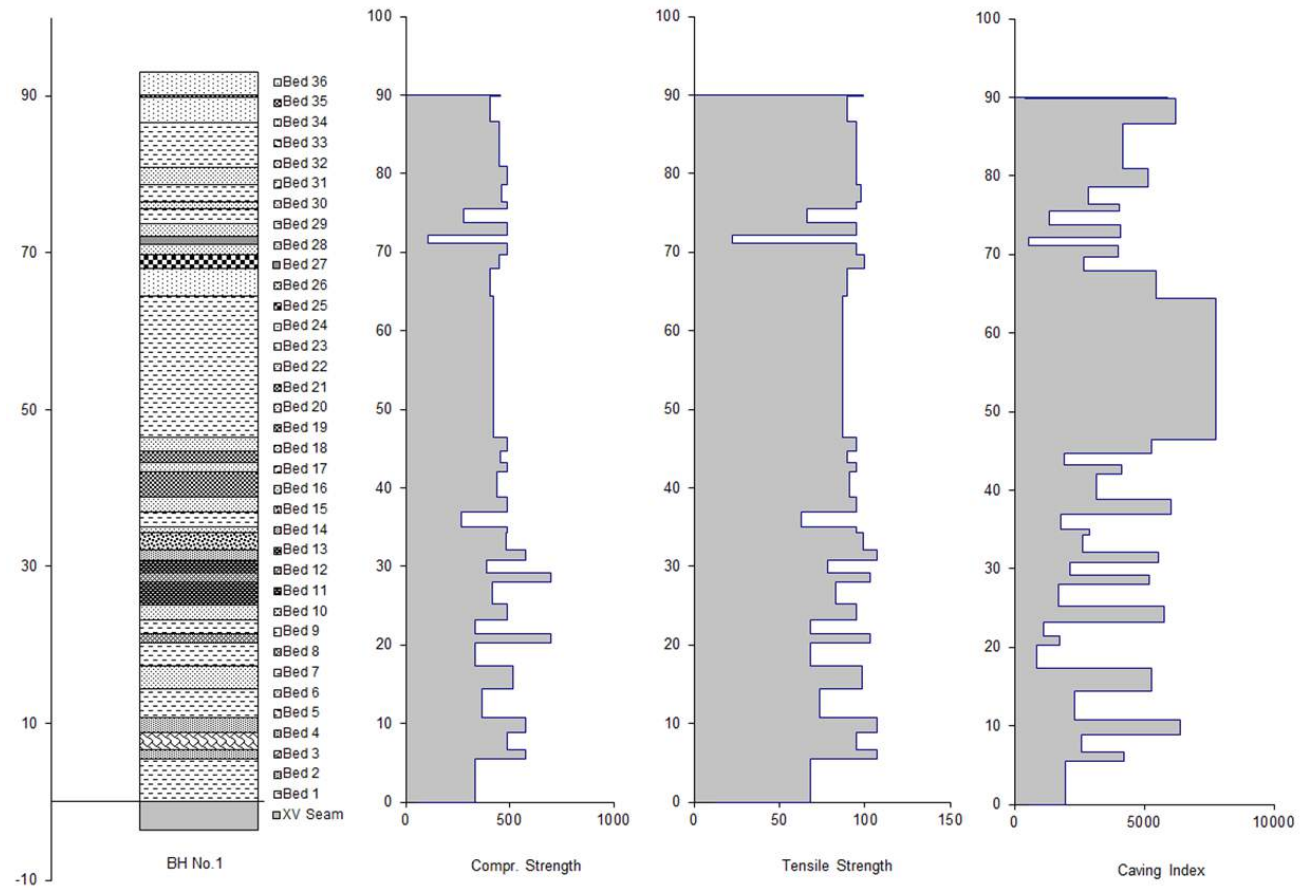


Fig. 4: Histogram of physico-mechanical properties and caving index for different rock beds overlying XV seam at Moonidih Mine as per Borehole No. 1. More intricate and sub-divided beds are listed above, for modelling purpose the beds are suitably merged as listed in Table 4 with determined properties.

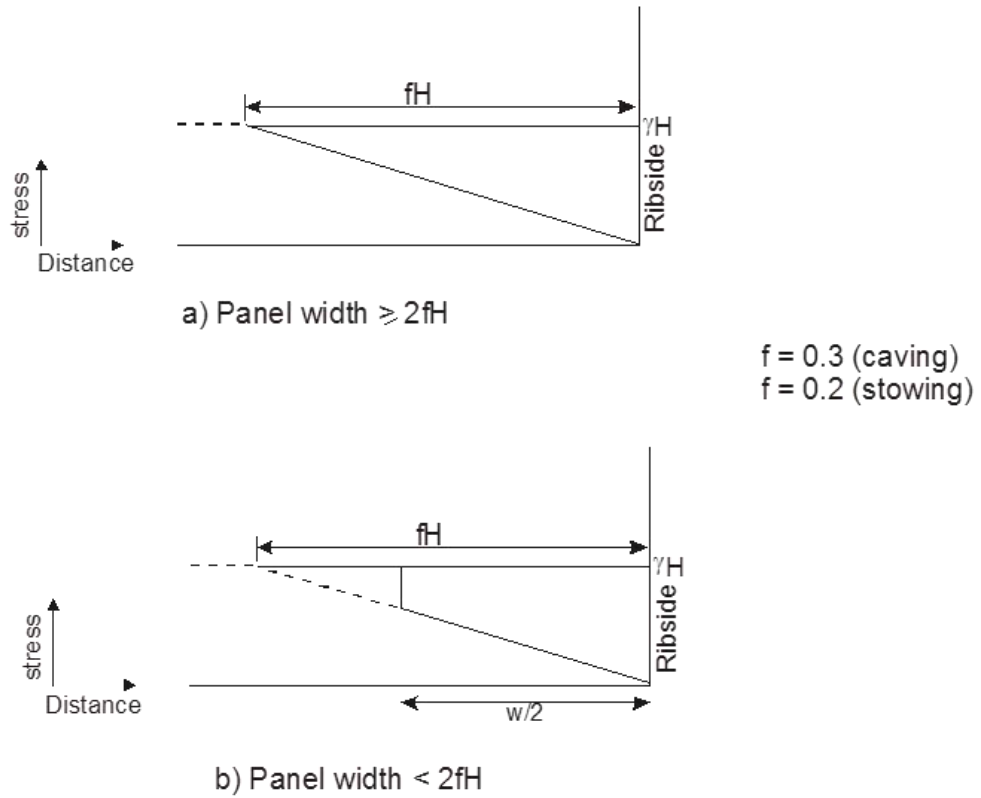


Fig. 5: Stress distribution in the goaf: a) panel width $\geq 2fH$ b) panel width $< 2fH$

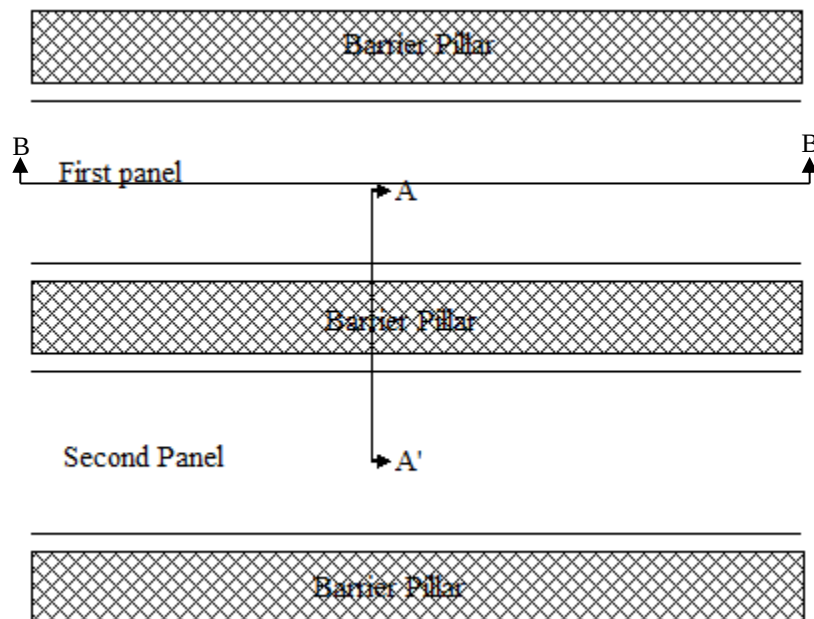


Fig. 6: Schematic diagram showing proposed Longwall panels (Plan view)

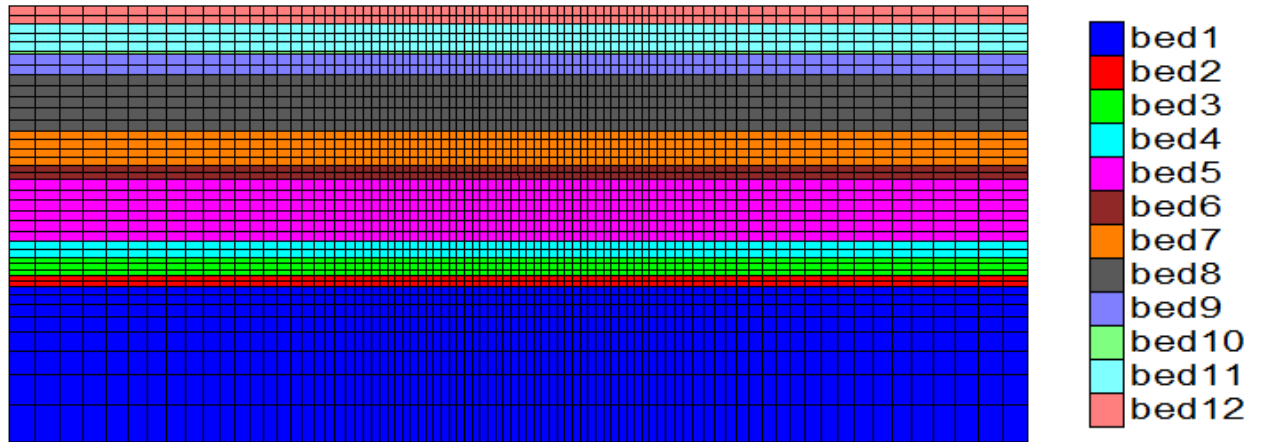


Fig. 7(a): Mesh/grid of the numerical models at virgin state

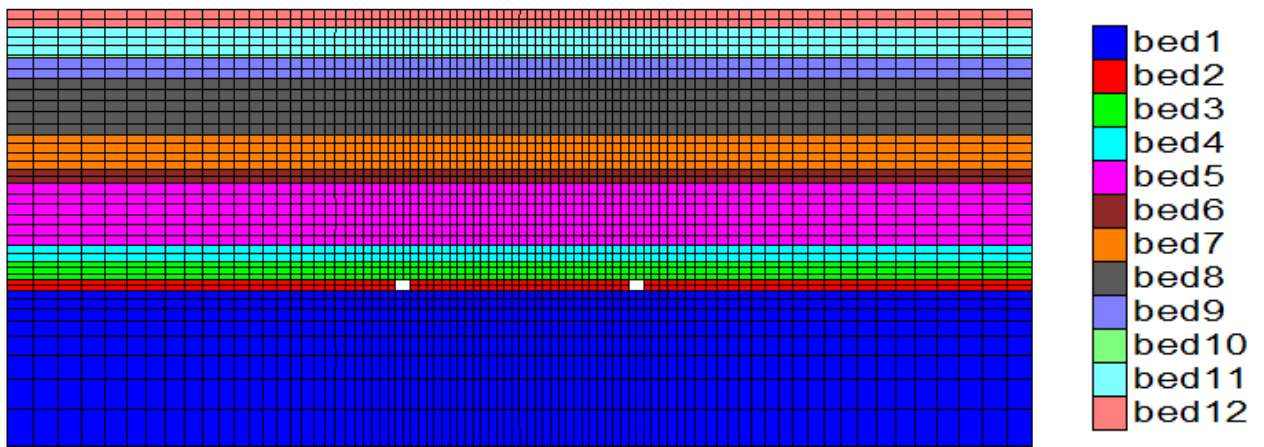


Fig. 7(b): Mesh/grid of the numerical models after drive of the gate roads

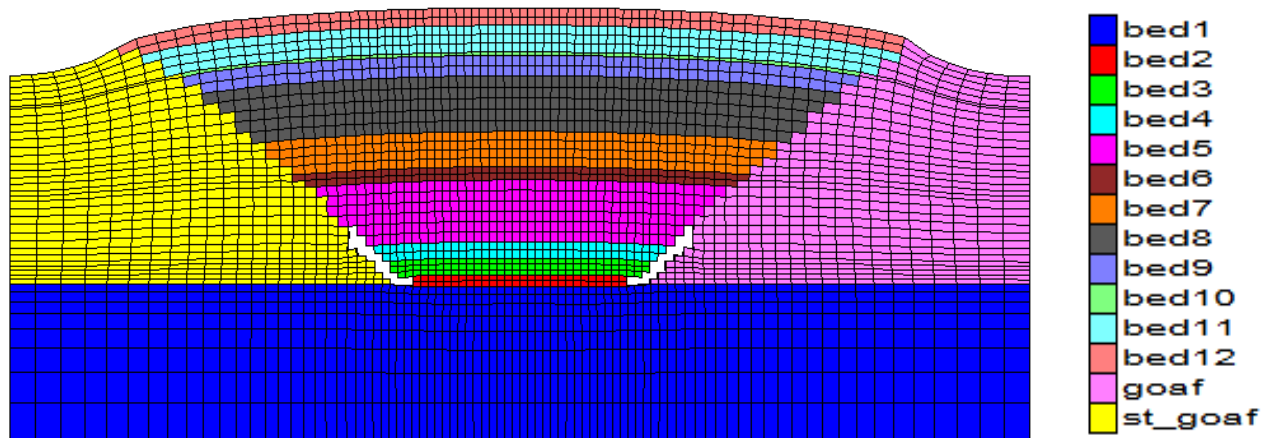


Fig. 7(c): Mesh/grid of the numerical models to study the stability of the barrier pillar with goaf on both sides

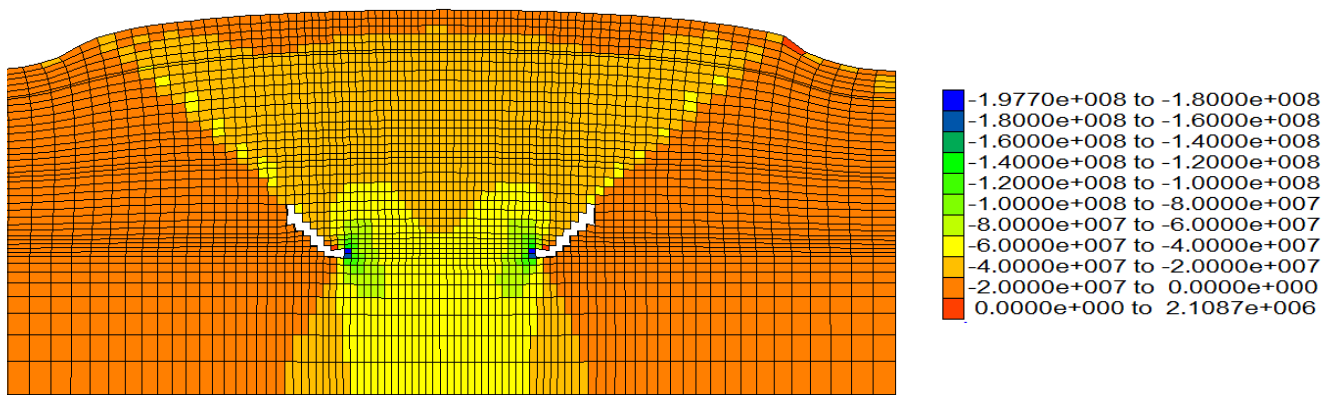


Fig. 8: Block contour of vertical stresses

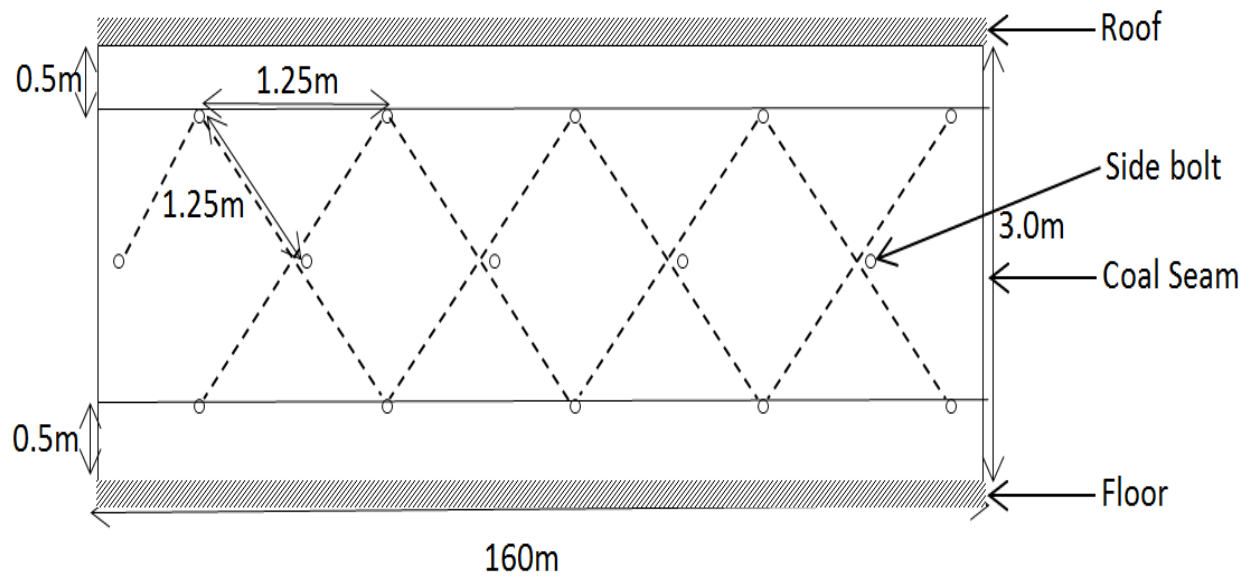


Fig. 9: Pattern of side bolting (not to scale)

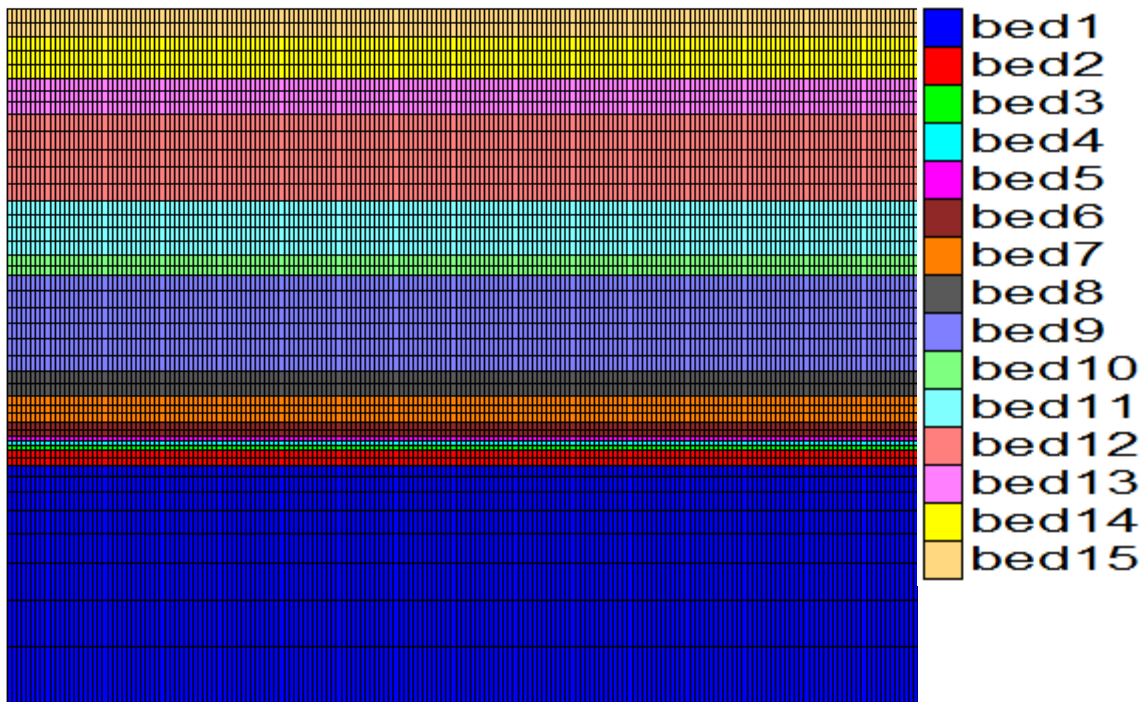


Fig. 10(a) : Mesh/grid of the numerical model in virgin condition

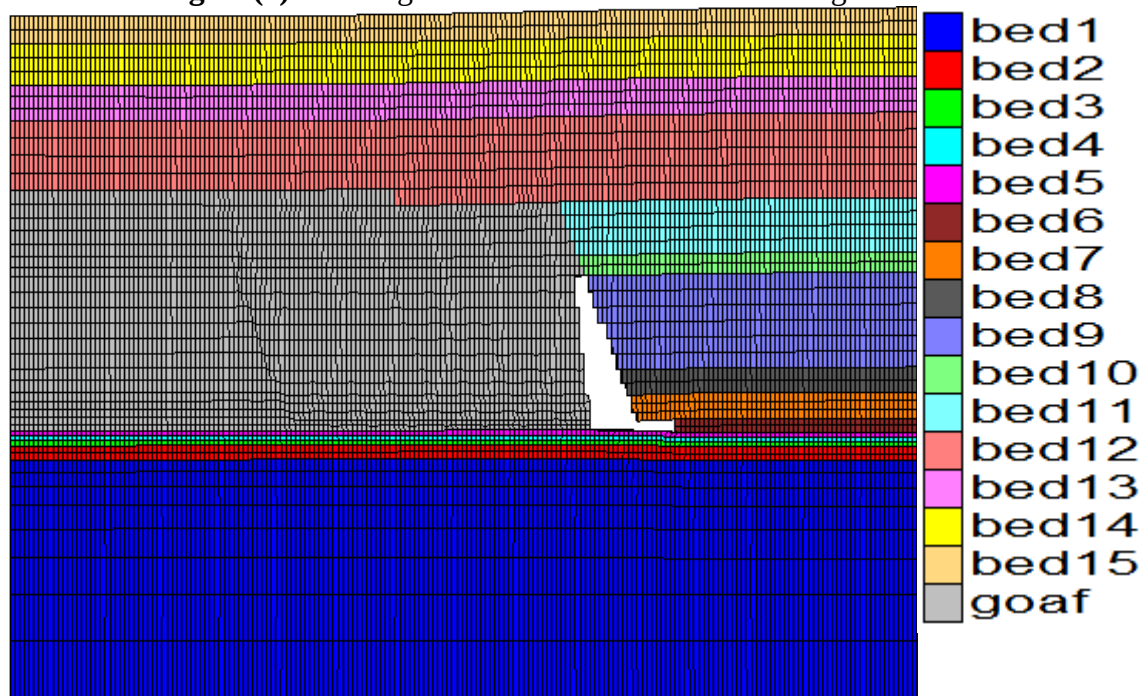


Fig. 10(b): Mesh/grid of the numerical model during extraction of Top section

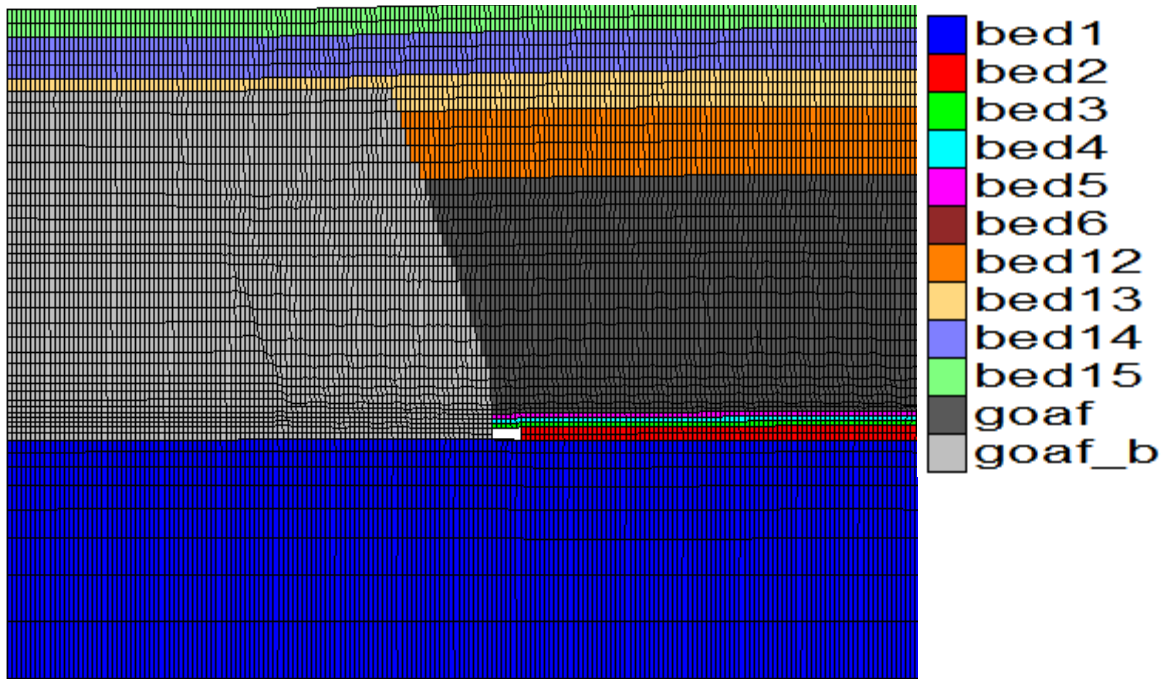


Fig. 10(c): Mesh/grid of the numerical model during extraction of Bottom section

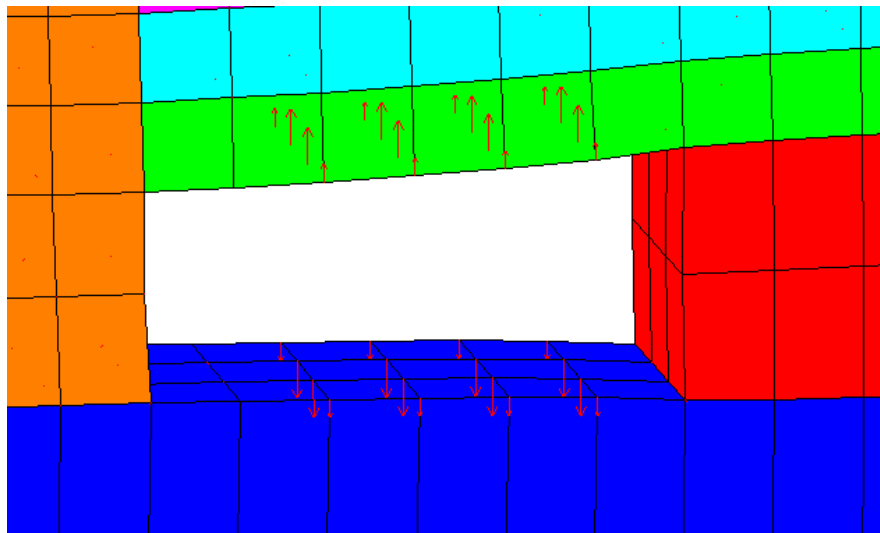


Fig. 10(d): Longwall Powered supports are modelled as nodal forces



Fig. 11(a): Contour of Major Principal Stress

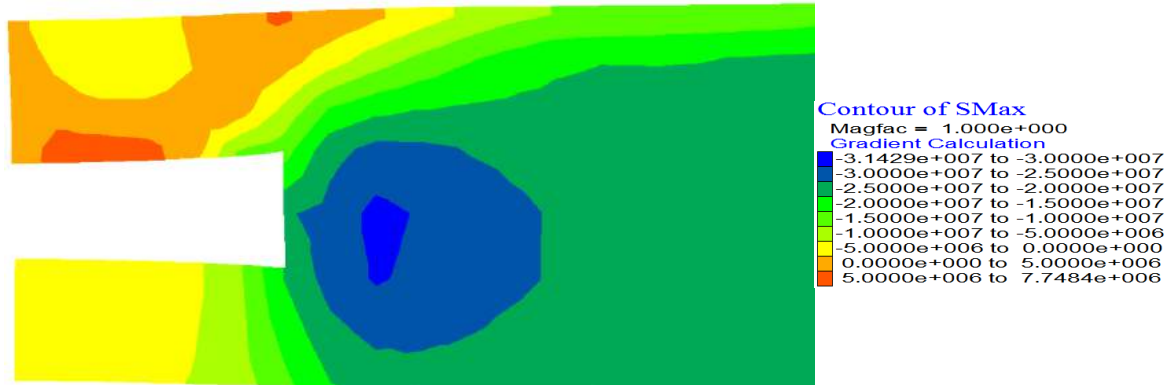


Fig. 11(b): Contour of Minor Principal Stress

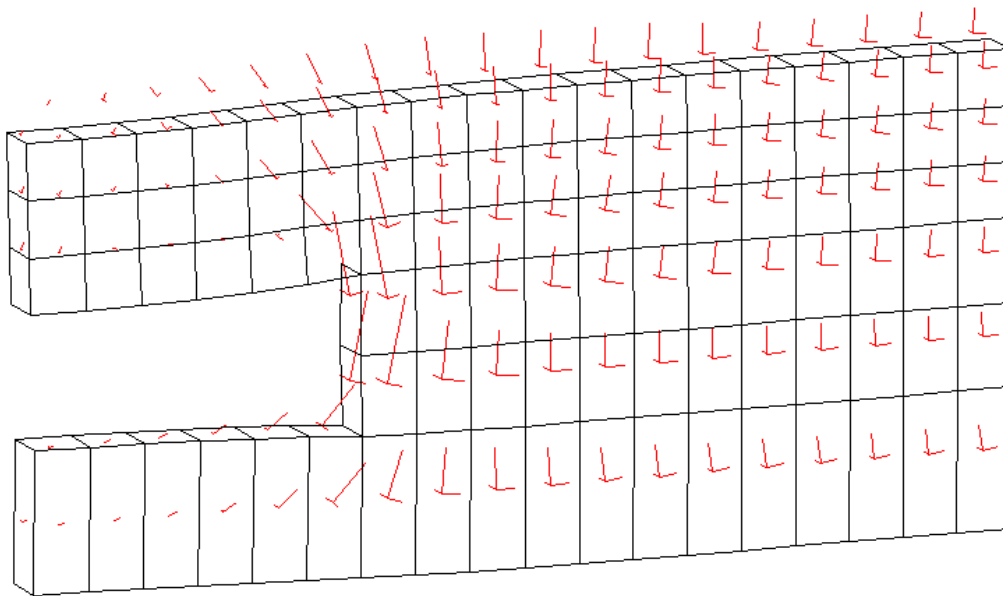


Fig. 11(c): Principal Stress Vectors and orientation

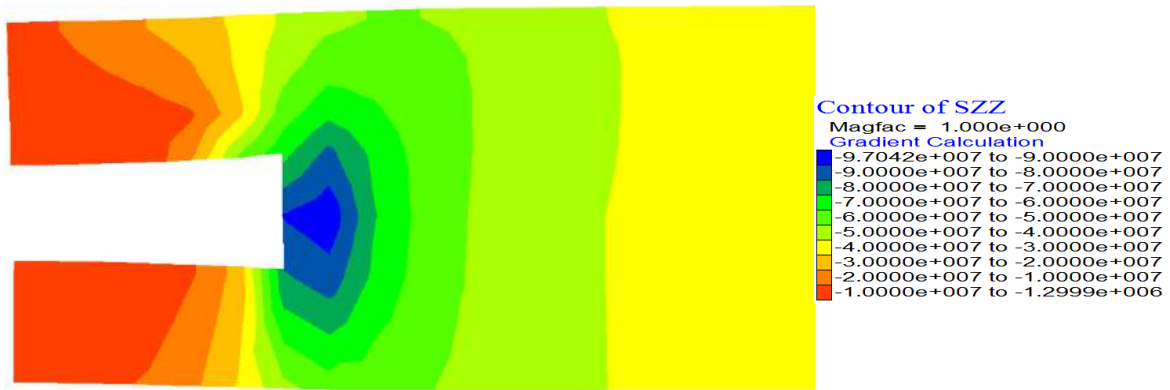


Fig. 11(d): Contour of Vertical Stress

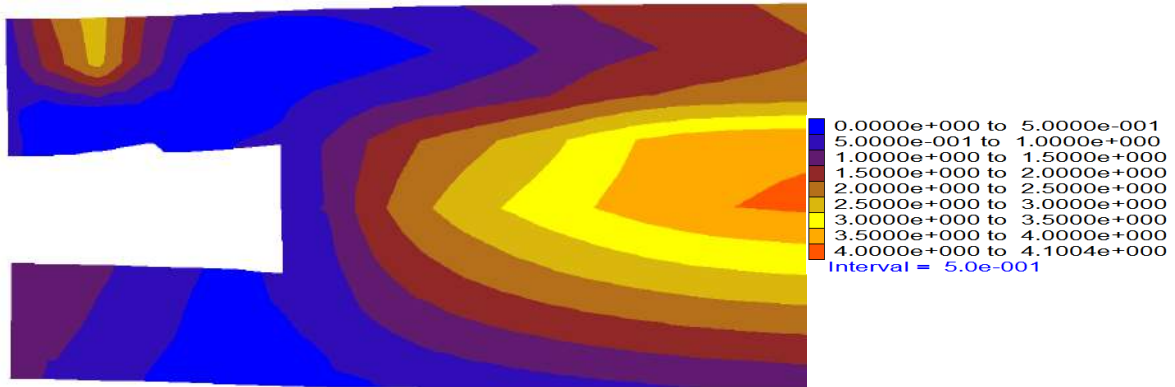


Fig. 11(e): Safety Factor Contour

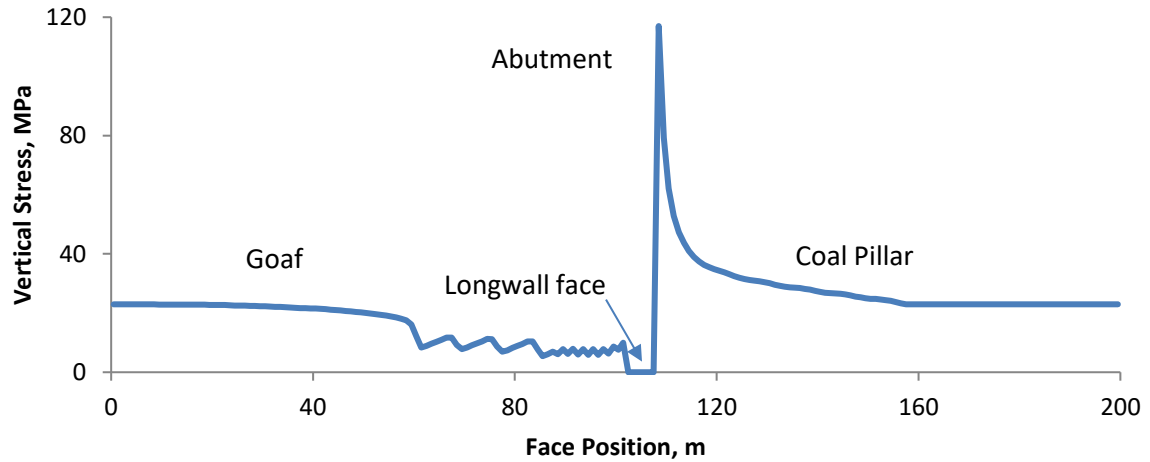


Fig. 11(f): Distribution of vertical stress along the panel

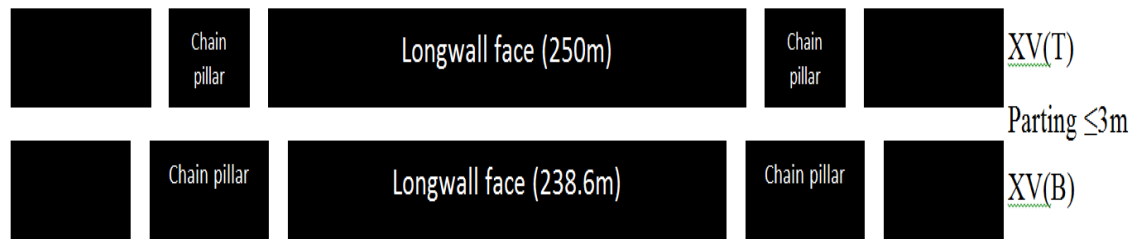


Fig. 12: Schematic diagram of multiple sections working of longwall face (not to scale)

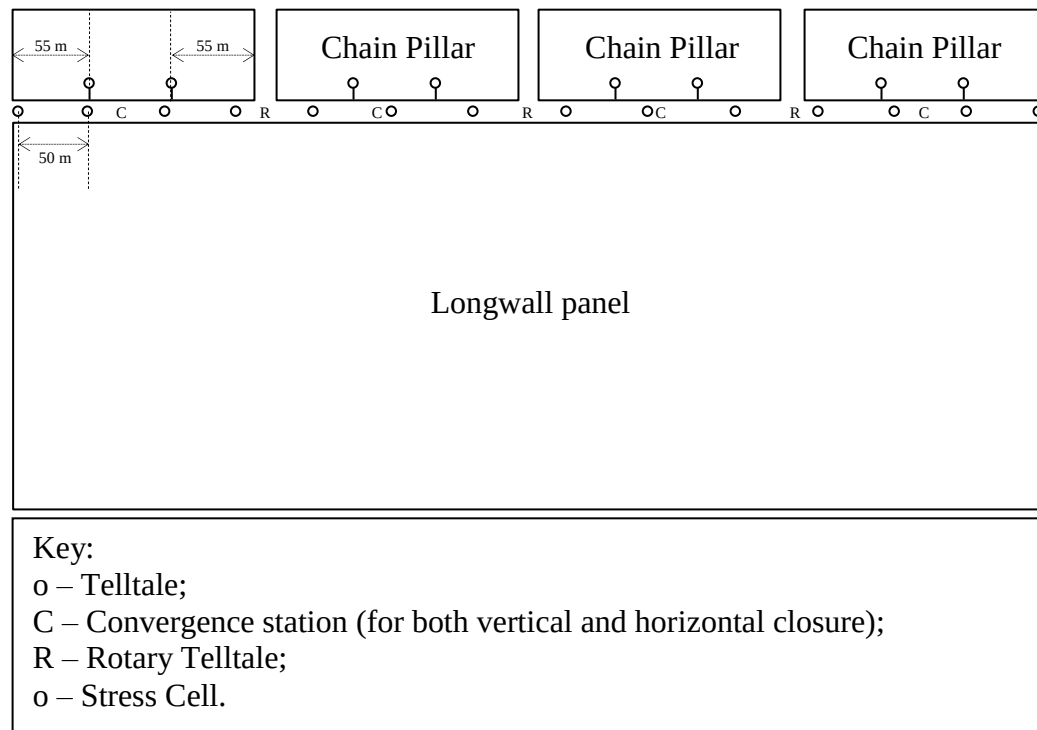


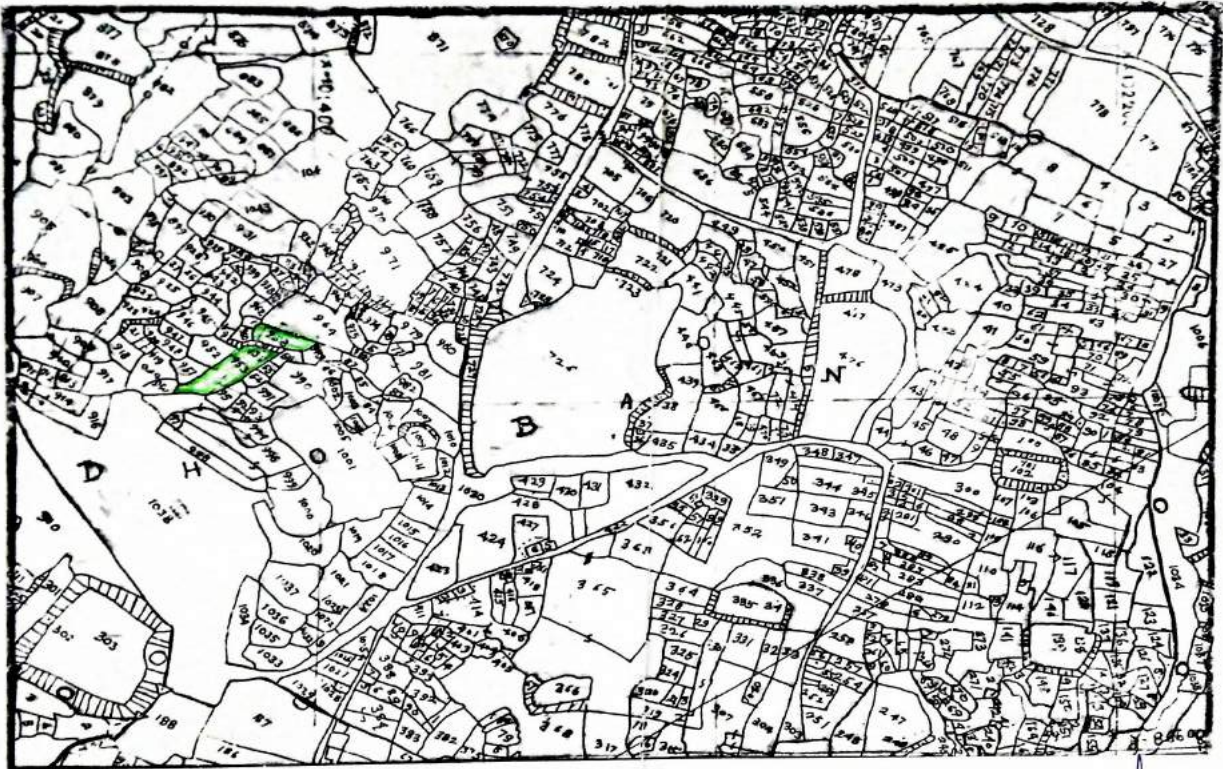
Fig. 13: Schematic diagram of instrumentation plan (not to scale)

ANNEXURE I: Instrumentation Plan

1. Roof to floor convergence and floor heaving of gate roadways shall be monitored on regular basis (once at least in every shift) up to a distance of minimum 40m from the face at an interval not exceeding 10m by convergence indicators.
2. Floor heaving of gate roads in XV (T) seam should be additionally monitored if XV (B) seam is planned to be extracted below.
3. Load cells shall be installed in main-gate and tail gate roadways up to a distance of minimum 40m from the face at an interval not exceeding 10m on Open-circuit (OC) props or with the roof bolts as the case may be. Readings of the load cells shall be recorded in every shift in a bound-paged book kept for the purpose.
4. At least 2 to 3 instrumented roof bolts shall also be installed in each gate roadway at strategic places to monitor the loading pattern on the bolts and their performance.
5. Multi point extensometers/Tell tales/Rotary tale tales/Sonic probe extensometers shall be installed in main-gate and tailgate roadways at interval not exceeding 50m to monitor dilation/ bed separation at least up to 400m from the face.
6. To predict abutment stresses in longwall pillar under extraction, stress cells shall be installed in the longwall pillar from main gate road and tail gate roadways up to a distance of minimum 400m from the face at 100 m intervals. The first stress cell shall be installed at the expected main fall position.
7. To monitor the stability of the barrier/chain pillars and predict magnitude and location of the abutment stresses, stress cells shall be installed in the barrier/chain pillars from main gate road and tail gate roads up to a distance of minimum 400m from the face at 200 m intervals. The first stress cell shall be installed at the expected main fall position.
8. The instrumentation suggest as above is primarily related to gate roads and chain pillars for their detailed evaluation and should be done under the guidance of a reputed scientific institution having expertise in this subject.

ANNEXURE - IX

Mauza Plan of Dhobni Showing Plantation Site in Moonidih for the year of 2020-21



[Signature]
29/5/21
Area Survey Officer
Moonidih Colliery

[Signature]
Mine Manager
Moonidih Colliery

[Signature]
29-5-21
Area Manager (Estate)
W.J. Area

[Signature]
27/05/2021
Area Manager (Env.)
W.J. Area

ANNEXURE - X

June'2020 2020

MOONIDIH COLLIERY, W. J. AREA

*** 1 Div. = 0.40 mm

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain Fall this month In mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks Tel. No. Hq- 0326- 2230205
1.	01.06.2020						Nil	Nil	Nil	20.00	
2.	02.06.2020						Nil	Nil	Nil	30.00	
3.	03.06.2020						Nil	Nil	Nil	30.00	
4.	04.06.2020						Nil	Nil	Nil	30.00	
5.	05.06.2020						Nil	Nil	Nil	30.00	
6.	06.06.2020						Nil	Nil	Nil	30.00	
7.	07.06.2020						10.00	10.00	10.00	30.00	
8.	08.06.2020						Nil	10.00	10.00	30.00	
9.	09.06.2020						Nil	10.00	10.00	30.00	
10.	10.06.2020						20.00	30.00	30.00	30.00	
11.	11.06.2020						Nil	30.00	30.00	42.00	
12.	12.06.2020						25.00	55.00	55.00	42.00	
13.	13.06.2020						28.00	83.00	83.00	42.00	
14.	14.06.2020						10.00	93.00	93.00	42.00	
15.	15.06.2020	2.00	95.00	NIL	95.00	NIL	2.0	95.00	95.00	43.00	Luahab
16.	16.06.2020	NIL	95.00	3.00	98.00	NIL	3.0	98.00	98.00	44.00	Luahab
17.	17.06.2020	NIL	98.00	NIL	98.00	2.0	2.0	100.00	100.00	44.00	Luahab
18.	18.06.2020	NIL	100.00	NIL	100.00	7.0	7.0	107.00	107.00	44.00	Luahab
19.	19.06.2020	NIL	107.00	NIL	107.00	NIL	NIL	107.00	107.00	44.00	Luahab
20.	20.06.2020	NIL	107.00	27.00	134.00	NIL	27.00	134.00	134.00	46.00	Luahab

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain Fall this month In mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks
21.	21.06.2020	2.00	136.00	NIL	136.00	2.00	4.00	138.00	138.00	61.00	Luahab
22.	22.06.2020	1.00	139.00	NIL	139.00	NIL	1.0	139.00	139.00	89.00	Luahab
23.	23.06.2020	NIL	139.00	NIL	139.00	NIL	NIL	139.00	139.00	99.00	Luahab
24.	24.06.2020	NIL	139.00	NIL	139.00	NIL	NIL	139.00	139.00	99.00	Luahab
25.	25.06.2020	NIL	139.00	21.0	160.00	4.0	25.0	164.00	164.00	99.00	Luahab
26.	26.06.2020	NIL	164.00	16.00	180.00	NIL	16.00	180.00	180.00	99.00	Luahab
27.	27.06.2020	NIL	180.00	NIL	180.00	12.0	12.00	192.00	192.00	99.00	Luahab
28.	28.06.2020	NIL	192.00	NIL	192.00	NIL	NIL	192.00	192.00	135.00	Luahab
29.	29.06.2020	NIL	192.00	NIL	192.00	NIL	NIL	192.00	192.00	135.00	Luahab
30.	30.06.2020	NIL	192.00	NIL	192.00	NIL	NIL	192.00	192.00	136.00	Luahab
Total=											

1.7.2020 NIL NIL

*** 1 Div. = 0.40 mm

July'2020

MOONIDIH COLLIERY, W. J. AREA

*** 1 Div. = 0.40 mm

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain Fall this month In mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks Tel. No. Hq- 0326- 2230205
1.	01.07.2020	Nil	192.00	Nil	192.00	Nil	✓ Nil	Nil	✓ 192.00	142.00	Leashab
2.	02.07.2020	NIL	NIL	NIL	NIL	NIL	NIL	NIL	192.00	146.00	
3.	03.07.2020	NIL	NIL	4.0	4.00	NIL	4.0	4.00	196.00	146.00	Leashab
4.	04.07.2020	NIL	4.0	NIL	4.00	NIL	NIL	4.00	196.00	146.00	Leashab
5.	05.07.2020	NIL	4.0	1.0	5.0	1.0	2.0	6.0	198.00	156.00	Leashab
6.	06.07.2020	10.0	16.0	7.0	23.00	NIL	17.0	23.00	215.00	161.00	Leashab
7.	07.07.2020	3.0	26.0	NIL	26.00	4.0	7.0	30.00	222.00	168.00	Leashab
8.	08.07.2020	NIL	30.0	4.0	34.00	2.0	6.0	36.00	228.00	168.00	Leashab
9.	09.07.2020	3.0	39.0	21.0	60.00	NIL	24.0	60.00	252.00	179.00	Leashab
10.	10.07.2020	5.0	65.00	2.0	67.00	1.0	8.0	68.00	260.00	180.00	Leashab
11.	11.07.2020	4.0	72.00	10.0	82.0	NIL	14.0	82.00	274.00	204.00	Leashab
12.	12.07.2020	1.0	83.00	NIL	83.00	NIL	1.0	83.00	275.00	204.00	Leashab
13.	13.07.2020	5.0	88.0	1.0	89.0	NIL	6.0	89.00	281.00	204.00	Leashab
14.	14.07.2020	NIL	89.00	3.0	92.0	NIL	3.0	92.00	284.00	204.00	Leashab
15.	15.07.2020	10.0	102.00	NIL	102.00	NIL	10.0	102.00	294.00	204.00	Leashab
16.	16.07.2020	NIL	102.00	NIL	102.00	NIL	NIL	102.00	294.00	209.00	Leashab
17.	17.07.2020	NIL	102.00	NIL	102.00	NIL	NIL	102.00	294.00	224.00	Leashab
18.	18.07.2020	NIL	102.00	NIL	102.00	NIL	NIL	102.00	294.00	224.00	Leashab
19.	19.07.2020	NIL	102.0	7.0	109.00	NIL	7.0	109.00	301.00	224.00	Leashab
20.	20.07.2020	NIL	109.00	2.0	111.00	36.0	38.0	147.00	339.00	224.00	Leashab

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain Fall this month In mm	To-Date/ Progressive In mm ✓	Rain fall last Year In mm	Remarks
21.	21.07.2020	15.00	162.00	5.00	167.00	8.0	28.0	175.0	367.00	224.00	Luahab
22.	22.07.2020	NIL	175.00	8.0	183.00	NIL	08.0	183.00	375.00	225.00	Luahab
23.	23.07.2020	NIL	183.00	NIL	183.00	NIL	NIL	183.00	375.00	239.0	Luahab
24.	24.07.2020	NIL	183.00	1.0	184.00	NIL	1.0	184.00	376.00	260.00	Luahab
25.	25.07.2020	NIL	184.00	NIL	184.00	NIL	NIL	184.00	376.00	264.00	Luahab
26.	26.07.2020	NIL	184.00	06.0	190.00	NIL	06.0	190.0	382.00	289.00	Luahab
27.	27.07.2020	NIL	190.00	16.00	206.00	20.0	36.00	226.00	418.00	302.00	Luahab
28.	28.0.2020	NIL	226.00	7.00	233.00	13.0	20.00	246.00	438.00	319.00	Luahab
29.	29.07.2020	NIL	246.00	NIL	246.00	NIL	NIL	246.00	438.00	322.00	Luahab
30.	30.07.2020	NIL	246.00	3.0	249.00	NIL	3.0	249.00	441.00	325.00	Luahab
31.	31.07.2020	NIL	249.00	15.0	264.00	10.0	25.0	274.00	466.00	325.00	Luahab
	Total=										

*** 1 Div. =0.40 mm

August'2020

MOONIDIH COLLIERY, W. J. AREA

*** 1 Div. = 0.40 mm

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain fall this month in mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks Tel. No. Hq- 0326-2230205
1.	01.08.2020	NIL	NIL	NIL	NIL	NIL	NIL	NIL	466.00	325.00	Leakab
2.	02.08.2020	NIL	NIL	NIL	NIL	NIL	NIL	NIL	466.00	325.00	Leakab
3.	03.08.2020	NIL	NIL	NIL	NIL	NIL	NIL	NIL	466.00	326.00	Leakab
4.	04.08.2020	NIL	NIL	38.00	38.00	2.0	40.00	40.00	506.00	326.00	Leakab
5.	05.08.2020	4.00	44.00	14.00	58.00	5.0	23.0	63.00	529.00	345.00	Leakab
6.	06.08.2020	NIL	63.00	03.00	66.00	NIL	03.00	66.00	532.00	348.00	Leakab
7.	07.08.2020	NIL	66.00	NIL	66.00	NIL	NIL	66.00	532.00	354.00	Leakab
8.	08.08.2020	NIL	66.00	NIL	66.00	NIL	NIL	66.00	532.00	369.00	Leakab
9.	09.08.2020	NIL	66.00	20.0	86.00	NIL	20.00	86.00	552.00	373.00	
10.	10.08.2020	NIL	86.00	NIL	86.00	NIL	NIL	86.00	552.00	373.00	Leakab
11.	11.08.2020	NIL	86.00	NIL	86.00	NIL	NIL	86.00	552.00	398.00	Leakab
12.	12.08.2020	14.0	100.00	NIL	100.00	5.0	19.00	105.00	571.00	435.00	Leakab
13.	13.08.2020	NIL	105.00	03.00	108.00	NIL	03.00	108.00	574.00	443.00	Leakab
14.	14.08.2020	NIL	108.00	NIL	108.00	NIL	NIL	108.00	574.00	455.00	Leakab
15.	15.08.2020	1.0	109.00	2.00	111.00	5.0	8.0	116.00	582.00	455.00	Leakab
16.	16.08.2020	3.0	119.00	8.00	127.00	NIL	11.00	127.00	593.00	457.00	Leakab
17.	17.08.2020	12.0	139.00	NIL	139.00	NIL	12.00	139.00	605.00	480.00	Leakab
18.	18.08.2020	NIL	139.00	NIL	139.00	NIL	NIL	139.00	605.00	495.00	Leakab
19.	19.08.2020	NIL	139.00	2.0	141.00	NIL	2.0	141.00	607.00	495.00	Leakab
20.	20.08.2020	13.00	154.00	15.0	169.00	NIL	28.0	169.00	635.00	502.00	Leakab

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain fall this month in mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks
21.	21.08.2020	20.0	189.00	3.0	192.00	2.0	25.0	194.00	660.00	502.00	Leakage
22.	22.08.2020	1.0	195.00	13.0	208.00	NIL	14.0	208.00	674.00	552.00	Leakage
23.	23.08.2020	NIL	208.00	2.0	210.00	NIL	2.0	210.00	676.00	552.00	Leakage
24.	24.08.2020	NIL	210.00	8.0	218.00	1.0	9.0	219.00	685.00	557.00	Leakage
25.	25.08.2020	NIL	219.00	NIL	219.00	4.0	4.0	223.00	689.00	590.00	Leakage
26.	26.08.2020	NIL	223.00	2.0	225.00	5.0	7.0	230.00	696.00	591.00	Leakage
27.	27.08.2020	5.0	235.00	33.00	268.00	NIL	38.00	268.00	734.00	595.00	Leakage
28.	28.08.2020	NIL	268.00	NIL	268.00	NIL	NIL	268.00	734.00	600.00	Leakage
29.	29.08.2020	NIL	268.00	NIL	268.00	NIL	NIL	268.00	734.00	600.00	Leakage
30.	30.08.2020	NIL	268.00	NIL	268.00	NIL	NIL	268.00	734.00	600.00	Leakage
31.	31.08.2020	NIL	268.00	NIL	268.00	NIL	NIL	268.00	734.00	600.00	Leakage
Total=											

1.9.2020 1.0 1.0 3.0 4.0 NIL 4.0 4.0 738.00 618.00 *** 1 Div. = 0.40 mm

September'2020

MOONIDIH COLLIERY, W. J. AREA

*** 1 Div. =0.40 mm

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain fall this month in mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks Tel. No. Hq- 0326-2230205
1.	01.09.2020	1.00	1.00	3.00	4.00	NIL	4.00	4.00	738.00	618.00	hushab
2.	02.09.2020	2.00	6.00	NIL	6.00	NIL	2.00	6.00	740.00	619.00	hushab
3.	03.09.2020	NIL	6.00	NIL	6.00	NIL	NIL	6.00	740.00	628.00	hushab
4.	04.09.2020	NIL	6.00	NIL	6.00	NIL	NIL	6.00	740.00	639.00	hushab
5.	05.09.2020	NIL	6.00	NIL	6.00	NIL	NIL	6.00	740.00	640.00	hushab
6.	06.09.2020	NIL	6.00	2.00	8.00	NIL	2.00	8.00	742.00	653.00	hushab
7.	07.09.2020	NIL	8.00	2.00	10.00	NIL	2.00	10.00	744.00	659.00	hushab
8.	08.09.2020	NIL	10.00	1.00	11.00	NIL	1.00	11.00	745.00	674.00	hushab
9.	09.09.2020	NIL	11.00	6.00	17.00	NIL	6.00	17.00	751.00	674.00	hushab
10.	10.09.2020	NIL	17.00	NIL	17.00	NIL	NIL	17.00	751.00	674.00	hushab
11.	11.09.2020	NIL	17.00	5.00	22.00	NIL	5.00	22.00	756.00	685.00	hushab
12.	12.09.2020	NIL	22.00	NIL	22.00	NIL	NIL	22.00	756.00	721.00	hushab
13.	13.09.2020	NIL	22.00	NIL	22.00	NIL	NIL	22.00	756.00	721.00	hushab
14.	14.09.2020	NIL	22.00	NIL	22.00	NIL	NIL	22.00	756.00	721.00	hushab
15.	15.09.2020	NIL	22.00	NIL	22.00	NIL	NIL	22.00	756.00	721.00	hushab
16.	16.09.2020	NIL	22.00	NIL	22.00	NIL	NIL	22.00	756.00	721.00	hushab
17.	17.09.2020	NIL	22.00	NIL	22.00	60.00	60.00	82.00	816.00	721.00	hushab
18.	18.09.2020	10.00	92.00	NIL	92.00	NIL	10.00	92.00	826.00	741.00	hushab
19.	19.09.2020	NIL	92.00	NIL	92.00	NIL	NIL	92.00	826.00	741.00	hushab
20.	20.09.2020	NIL	92.00	NIL	92.00	NIL	NIL	92.00	826.00	741.00	hushab

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain fall this month in mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks
21.	21.09.2020	12.00	104.00	3.00	107.00	7.00	22.00	114.00	848.00	741.00	
22.	22.09.2020	0.50	114.50	32.00	146.50	9.00	41.50	155.50	889.50	754.00	
23.	23.09.2020	Nil	155.50	nil	155.50	nil	nil	155.50	889.50	754.00	
24.	24.09.2020	nil	155.50	nil	155.50	nil	nil	155.50	889.50	782.00	
25.	25.09.2020	nil	155.50	18.00	173.50	nil	18.00	173.50	907.50	799.00	
26.	26.09.2020	nil	173.50	nil	173.50	nil	nil	173.50	907.50	807.00	
27.	27.09.2020	nil	173.50	nil	173.50	nil	nil	173.50	907.50	851.00	
28.	28.09.2020	nil	173.50	nil	173.50	nil	nil	173.50	907.50	946.00	
29.	29.09.2020	nil	173.50	nil	173.50	nil	nil	173.50	907.50	979.00	
30.	30.09.2020	nil	173.50	1.00	174.50	nil	1.00	174.50	908.50	985.00	
	Total=										

*** 1 Div. =0.40 mm

June'2021

MOONIDIH COLLIERY, W. J. AREA

*** 1 Div. = 0.40 mm

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain Fall this month In mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks Tel. No. Hq- 0326- 2230205
1.	01.06.2021						NIL	NIL	194.00	Nil	
2.	02.06.2021						8.0	8.0	202.40	Nil	
3.	03.06.2021						NIL	8.0	202.40	Nil	
4.	04.06.2021						NIL	8.0	202.40	Nil	
5.	05.06.2021						NIL	8.0	202.40	Nil	
6.	06.06.2021						NIL	8.0	202.40	Nil	
7.	07.06.2021						NIL	8.0	202.40	10.00	
8.	08.06.2021						NIL	8.0	202.40	10.00	
9.	09.06.2021						12.20	20.20	214.60	10.00	
10.	10.06.2021						34.0	54.20	248.60	30.00	
11.	11.06.2021						22.40	76.60	271.00	30.00	
12.	12.06.2021						5.0	81.60	276.00	55.00	
13.	13.06.2021						24.00	105.60	300.00	83.00	
14.	14.06.2021	NIL	105.60	5.00	110.60	NIL	5.00	110.60	305.00	93.00	
15.	15.06.2021	12.00	122.60	4.00	126.60	1.0	17.00	127.60	322.00	95.00	Luahab
16.	16.06.2021	30.0	157.60	7.00	164.60	NIL	37.00	164.60	359.00	98.00	Luahab
17.	17.06.2021	36.0	200.60	4.00	204.60	NIL	40.00	204.60	399.00	100.00	Luahab
18.	18.06.2021	6.0	210.60	20.0	230.60	7.0	33.00	237.60	432.00	107.00	Luahab
19.	19.06.2021	5.0	242.60	NIL	242.60	NIL	5.00	242.60	437.00	107.00	Luahab
20.	20.06.2021	1.0	243.60	9.0	252.60	NIL	10.0	252.60	447.00	134.00	Luahab

Sl. No.	Date	1st Shift 6AM to 2 PM	Progressive	2 nd Shift 2 PM to 10 PM	Progressive	3 rd Shift 10 PM to 6 AM	Rain fall On-date	Rain Fall this month In mm	To-Date/ Progressive In mm	Rain fall last Year In mm	Remarks
21.	21.06.2021	NIL	252.60	42.00	294.60	NIL	42.00	294.60	489.00	138.00	Lushab
22.	22.06.2021	NIL	294.60	5.0	299.60	NIL	5.00	299.60	494.00	139.00	
23.	23.06.2021	2.0	301.60	NIL	301.60	NIL	2.0	301.60	496.00	139.00	Lushab
24.	24.06.2021	NIL	301.60	32.00	333.60	NIL	32.00	333.60	528.00	139.00	Lushab
25.	25.06.2021	NIL	333.60	NIL	333.60	NIL	NIL	333.60	528.00	164.00	Lushab
26.	26.06.2021	NIL	333.60	NIL	333.60	NIL	NIL	333.60	528.00	180.00	Lushab
27.	27.06.2021	NIL	333.60	NIL	333.60	NIL	NIL	333.60	528.00	192.00	Lushab
28.	28.06.2021	NIL	333.60	NIL	333.60	NIL	NIL	333.60	528.00	192.00	Lushab
29.	29.06.2021	NIL	333.60	NIL	333.60	NIL	NIL	333.60	528.00	192.00	Lushab
30.	30.06.2021	NIL	333.60	1.0	334.60	NIL	1.0	334.60	529.00	192.00	Lushab
	Total=									192.00	

1.7.2021 NIL NIL NIL NIL NIL NIL NIL NIL 529.00 192.00 *** 1 Div. = 0.40 mm Lushab

MOONIDIH COLLIERY, WJ.AREA

Sl.No	Date	1 st Shift 6AM to 2PM	Progressi ve	2 nd Shift 2PM to 10PM	Progressi ve	3 rd Shift 10PM to 6AM	Rain fall On-date	Rain fall this month in mm	To- Date/Pro gressive in mm	Rain fall last Year in mm	Rain fall On Date Last Year	Remarks Tel.No.H q-0326- 2230205
1.	01.07.2021	NIL	NIL	NIL	NIL	NIL	NIL	NIL	529.00	192.00	NIL	Lushab
2.	02.07.2021	NIL	NIL	13.00	13.00	NIL	13.00	13.00	542.00	192.00	NIL	Lushab
3.	03.07.2021	NIL	13.00	NIL	13.00	NIL	NIL	13.00	542.00	196.00	4.0	Lushab
4.	04.07.2021	NIL	13.00	NIL	13.00	NIL	NIL	13.00	542.00	196.00	NIL	Lushab
5.	05.07.2021	NIL	13.00	5.0	18.00	NIL	5.00	18.00	547.00	198.00	2.0	Lushab
6.	06.07.2021	NIL	18.00	NIL	18.00	NIL	NIL	18.00	547.00	215.00	17.0	Lushab
7.	07.07.2021	NIL	18.00	1.0	19.00	NIL	1.0	19.00	548.00	222.00	7.0	Lushab
8.	08.07.2021	NIL	19.00	14.0	33.00	NIL	14.0	33.00	562.00	228.00	6.0	Lushab
9.	09.07.2021	NIL	33.00	NIL	33.00	NIL	NIL	33.00	562.00	252.00	24.0	Lushab
10.	10.07.2021	NIL	33.00	NIL	33.00	NIL	NIL	33.00	562.00	260.00	8.0	Lushab
11.	11.07.2021	NIL	33.00	NIL	33.00	NIL	NIL	33.00	562.00	274.00	14.0	Lushab
12.	12.07.2021	NIL	33.00	NIL	33.00	NIL	NIL	33.00	562.00	275.00	1.0	Lushab
13.	13.07.2021	NIL	33.00	1.0	34.00	NIL	1.0	34.00	563.00	281.00	6.0	
14.	14.07.2021	NIL	34.00	1.0	35.00	NIL	1.0	35.00	564.00	284.00	3.0	Lushab
15.	15.07.2021	NIL	35.00	NIL	35.00	NIL	NIL	35.00	564.00	294.00	10.0	Lushab

		2PM		10PM		to 6AM	date	month in mm	in mm	Year in mm	Date Last Year	0326- 2230205
16.	16.07.2021	NIL	35.00	NIL	35.00	NIL	NIL	35.00	564.00	294.00	NIL	Leahab
17.	17.07.2021	NIL	35.00	NIL	35.00	1.0	1.0	36.00	565.00	294.00	NIL	Leahab
18.	18.07.2021	NIL	36.00	2.0	38.00	NIL	2.0	38.00	567.00	294.00	NIL	Leahab
19.	19.07.2021	NIL	38.00	NIL	38.00	3.0	3.0	41.00	570.00	301.00	7.0	Leahab
20.	20.07.2021	2.00	43.00	5.00	48.00	NIL	7.0	48.00	577.00	339.00	38.0	Leahab
21.	21.07.2021	2.00	50.00	NIL	50.00	NIL	2.0	50.00	579.00	367.00	28.0	Leahab
22.	22.07.2021	NIL	50.00	NIL	50.00	NIL	NIL	50.00	579.00	375.00	8.0	Leahab
23.	23.07.2021	6.0	56.00	4.0	60.00	15.0	25.0	75.00	604.00	375.00	NIL	Leahab
24.	24.07.2021	3.0	78.00	NIL	78.00	NIL	3.0	78.00	607.00	376.00	1.0	Leahab
25.	25.07.2021	NIL	78.00	NIL	78.00	NIL	NIL	78.00	607.00	376.00	NIL	Leahab
26.	26.07.2021	NIL	78.00	NIL	78.00	16.0	16.0	94.00	623.00	382.00	6.0	Leahab
27.	27.07.2021	10.0	104.00	18.00	122.00	NIL	28.0	122.00	651.00	418.00	36.0	Leahab
28.	28.07.2021	NIL	122.00	6.0	128.00	1.0	07.00	129.00	658.00	438.00	20.0	Leahab
29.	29.07.2021	NIL	129.00	08.0	137.00	50.0	58.00	187.00	716.00	438.00	NIL	Leahab
30.	30.07.2021	26.00	213.00	72.00	285.00	36.00	134.00	321.00	850.00	441.00	3.0	Leahab
31.	31.07.2021	1.0	322.00	NIL	322.00	NIL	1.0	322.00	851.00	466.00	25.0	Leahab

ANNEXURE-XI

Study of Occupational diseases and Hearing impairments of Coal Mines workers of BCCL directly involved in active mining operations

CMS
699(2)
11/10/19



Dr. Rajiv
P. D. Singh
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Ahmedabad
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11/10/19

GM (Environment)

REGIONAL OCCUPATIONAL HEALTH CENTRE (EASTERN), KOLKATA

&

NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH, AHMEDABAD

(Indian Council of Medical research)

Study of Occupational diseases and Hearing impairments of Coal Mines workers of BCCL directly involved in active mining operations



**REGIONAL OCCUPATIONAL HEALTH CENTRE (EASTERN), KOLKATA
&
NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH, AHMEDABAD
(Indian Council of Medical research)**

CONTENTS

Title	Page No.
Participating staff	03
Background	04
Introduction	05
Objectives	07
Methodology	08
Results and Discussion	
Consolidated report of both mining areas	16
Report of Kustore mining area	26
Report of Baghmara mining area	36
Conclusion and recommendations	45
References	49
Executive summary	50
Annexure	56

LIST OF PARTICIPANTS

Investigators

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Dr R R Tiwari, Ex- Scientist E (Involvement in initial planning and framing the project, write up)

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BACKGROUND

Although coal remains a major energy resource worldwide, coal mining causes environmental problems, whereas the inhaled coal particles at the work place may lead to the development of coal workers' pneumoconiosis (CWP). Typically, coal workers' pneumoconiosis takes many years to develop and to be manifested. Further, once initiated the disease is progressive in nature, often leading to lungfunction impairment, disability. The workers' exposure to coal dust generally occurs during mining operations. Coal mining can also increase the risk of developing asthma and chronic obstructive pulmonary disease (COPD), such as emphysema and chronic bronchitis. It is suggested that coal mining operations may also induce noise induced hearing impairment among the workers.

A request was received from Bharat Coking Coal Limited, Dhanbad to assess the health status of their workers involved in the mining activities in Cluster 11 and 15 areas around Dhanbad. About 10% of the subjects involved in mining activities were to be included in this study. The workers were to be assessed for their health status, presence of any occupational disease and hearing impairments. Under this circumstance, in consultation of the scientists of National Institute of Occupational Health (NIOH) and the concerned officers of Bharat Coking Coal Limited, it was decided that an epidemiological study would be carried out involving workers involved in mining activities.

INTRODUCTION

Coal is an aggregate of heterogeneous substances composed of organic and inorganic materials. The four major coal types ranked in order of increasing heat value are lignite, sub-bituminous, bituminous, and anthracite. The inorganic portion of coal can range from a few percent to >50% (by weight) and is composed of phyllo-silicates (kaolinite, illite, etc.), quartz, carbonates, sulfides, sulfates, and other minerals. In general, aluminum and iron are the main metals in the coals. Arsenic, nickel, zinc, cadmium, cobalt, and copper are trace metals that represent only a very small fraction of the mineral matter¹.

Coal mining in India has a long history of commercial exploitation covering nearly 220 years starting in 1774 in the Raniganj Coalfield along the Western bank of river Damodar. However, for about a century the growth of Indian coal mining remained sluggish for want of demand but the introduction of steam locomotives in 1853 gave a fillip to it. As on 2011, India had 285 billion tonnes of resource. The production of coal was 532.69 million tonnes in 2010-11. The production of lignite was 37.73 million tonnes in 2010-11. As on 2011, India ranked 3rd in world coal production.²

Coal remains a major energy resource worldwide. In the United States, > 50% of electricity is generated in coal-fired power plants. However, coal mining causes environmental problems such as acid mine drainage, whereas the inhaled coal particles at the work place may lead to the development of coal workers' pneumoconiosis (CWP).^{3,4} Typically, coal workers pneumoconiosis takes many years to develop and be manifested requiring a surveillance for a longer duration. Further once initiated the disease is progressive in nature often leading to lung function impairment, disability, and premature death.

Coal mining can also increase the risk of developing asthma and chronic obstructive pulmonary disease (COPD), such as emphysema and chronic bronchitis.⁵⁻⁷ It is suggested that coal dust stimulates the recruitment of neutrophils to the lungs and both these neutrophils and resident alveolar macrophages show evidence of activation, secreting free radicals and proteolytic enzymes, plausible mediators of tissue injury in emphysema⁸⁻¹⁰.

Considering the environmental – occupational hazards involved, regular and periodic monitoring of environmental conditions and the health status of the workers is always advised and recommended. A request was received from Bharat Coking Coal Limited, Dhanbad to assess the health status of their workers involved in the mining activities in Cluster 11 and 15 areas around Dhanbad. The workers were to be assessed for their health status, presence of any occupational disease and hearing impairments. Under this background the present project is developed with the aim of studying the coal mining as well as coal dust related health effects in the mining workers.

AIM AND OBJECTIVES

AIMS

To study the coal mining as well as coal dust related health effects in the coal mining workers.

OBJECTIVES

1. To understand health status of workers through questionnaire survey, health examination.
2. To study respiratory health in coal field mining workers.
3. To assess ventilatory functions of coal field mining workers.
4. To analyze hearing ability through audiometric evaluation.

METHODOLOGY

An occupational health study was conducted involving different mines of Cluster 11 and 15 of Bharat coking Coal Limited, Dhanbad. This study was undertaken among the exposed workers mainly from active mining activity. Representative sample from workers working in such occupations is included in this study. Initially the aim of the study was explained to the workers, informed consent was obtained after which they were enrolled for this study. Every individual subject was interviewed with a pre-designed questionnaire to collect information in relation to personal, occupational and morbidity details of the workers. The participants of this study were subjected to following interview/examination/investigations:

- Detailed personal, occupational and medical history.
- Clinical examination with special emphasis on examination of respiratory system.
- Haematological examination.
- Lung function test.
- Audiometry.
- Ophthalmological assessment.

Study design: Cross sectional study

Study subjects: This study covered 351 subjects from Kustore sector and 140 subjects from Bagmara sector of BCCL Collieries. Among the subjects of Kustore sector 49 were from Kachi Balihari mines, 51 from Bhagabandh mines, 40 from Gopali Chawk mines and 100 from Munidi mines. PB project mines contributed 111 subjects. Similarly among the subjects of Bagmara sector, Kharkharee mines and Phularitand mines contributed 75 subjects and 65 subjects respectively. Workers actively involved in mining actively were mainly included in this study. However, few subjects of this study were enrolled from supervisory staffs in order to have a complete and comprehensive understanding of the occupational health condition. These workers were randomly selected from the total workforce in the selected clusters and mines.

Data collection: The information regarding demographic, occupational and clinical history was collected on a pre-designed and pre-tested proforma through interview of subject. This was followed by complete clinical examination, spirometry, audiometry and chest radiography of each subject. The audiometer and spirometer were brought by NIOH team while for chest radiography the facilities at BCCL hospitals were used. The processing of exposed films was done by the technicians at BCCL hospital. The ophthalmological examination and haematological – biochemical estimations were also done using facilities and expertise at BCCL hospitals.

Data analysis: Data entry and analysis were done in standard statistical software. The statistical analysis included calculation of differences, proportions and application of tests of significance etc, to ascertain health effects especially respiratory health conditions.

Lung function test was carried out in all subjects. Forced vital capacity (FVC), and Peak Expiratory Flow Rate (PEFR) were recorded by Spirovit-sp-10 (Schiller Health Care Ltd, Switzerland). Three successive recording of FVC and PEFR were made in standing posture and the nose clip was used. The best of the three performances was considered for calculation purpose. The different flow volumes like FEV_1 , $FEV_1\%$ was calculated from the same tracings. All volumes

obtained were expressed in body temperature on atmospheric pressure of air saturated with water vapour (BTPS). Body height and body weight were measured in bare feet on a standard scale. Pulmonary function test values were predicted from the standard prediction equation. The instrument was calibrated every day before starting the experiment.

Blood was collected from each worker by venipuncture taking all aseptic precautions. Hematological and biochemical analysis was carried out using standard procedure.

Audiometric Evaluation of Hearing:

The following criteria were maintained for non- inclusion of workers as subjects in audiometry:

- Whose present hearing level was not amenable to quantitative description, who had served in the armed forces, or had been exposed to gunfire, or whose past noise exposure was different from that of their present occupation.
- Who were known to have existing or previous ear disease or abnormality.
- Head injury with history of unconsciousness or skull fracture.

Criteria for acceptance (inclusion criteria) as test subjects:

The following criteria were applied for categorizing ears as acceptable for the test

- Tympanic membrane intact
- No history of congenital or acquired conditions associated with sensory neural hearing loss e.g. congenital deafness, meningitis, unconsciousness, treatment with ototoxic drugs, vertigo, etc.

Criteria for normal hearing:

Hearing impairment is considered to occur when the average of the hearing threshold levels at audiometric frequencies of both ears exceed 25 dBA. Pure tone air conduction hearing threshold

was obtained in a quiet room. Threshold of hearing is defined as the minimum decibel level (dB) at which the subjects respond at least two times on ascending trial. The data for each subject was obtained. Pure tone threshold were obtained using descending- ascending threshold crossing technique. The data was analyzed for each ear of the subjects for all test frequencies. Hearing threshold at test frequencies was averaged for all subjects to assess hearing sensitivity.

Measurement of hearing:

Pure tone audiometry was carried out for the present investigation. In the individual experiment, subjects were briefed about the nature and purpose of the study. He was then seated in a chair, the earphones were fitted on his ears, and the door of the room was closed. They were instructed to respond by raising their fingers when they could just hear the tone lasting for 2 sec. The pulsing of the tone was set at 0.5/ sec. The intensity of the tone was raised by 5 dB until the threshold of hearing was determined at each test frequency viz 125Hz, 250Hz, 500Hz, 1KHz, 1.5KHz, 2KHz, 3KHz, 4KHz, 6KHz.and 8KHz. The actual measurement was started following a brief practice trial session. The better ear followed by the other ear was tested. The right ear was tested first in cases where both the ears were reported to be nearly equal in hearing sensitivity. It was ensured that the subject would fully cooperate. Care was taken to ensure reliable reporting of the subjects' 'just audible sound'. Misses (error of omission) and false alarms (error of commission) were avoided.

Equipment (Audiometer):

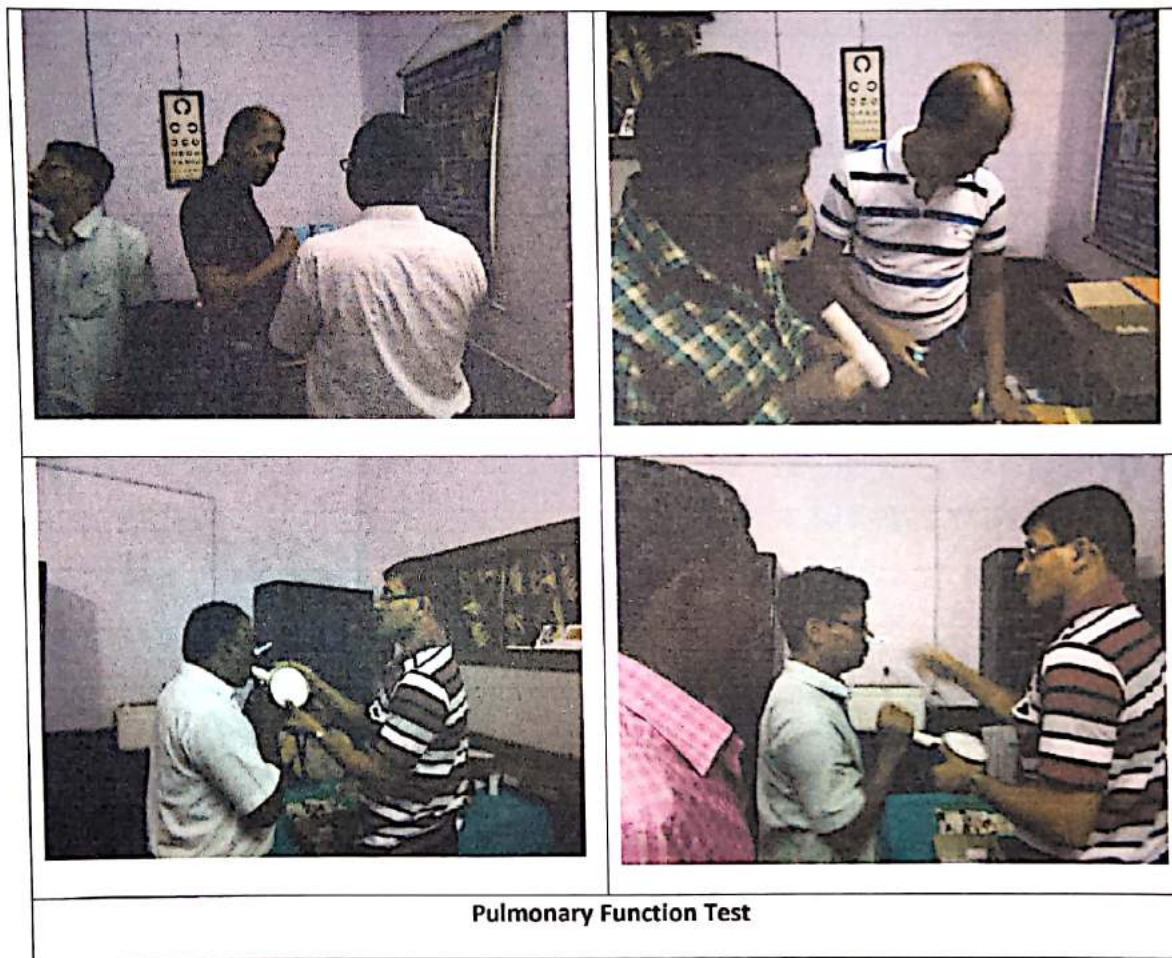
An audiometer was used as the source of pure tone audiometry. It has all the facilities of mask attenuation, frequency setting (125-8000 Hz.), decibel setting of pure tone and pulse setting. It has also a pair of earphone attachment. The audiometer is calibrated periodically as per the specification of International Standards Organization.



Questionnaire survey



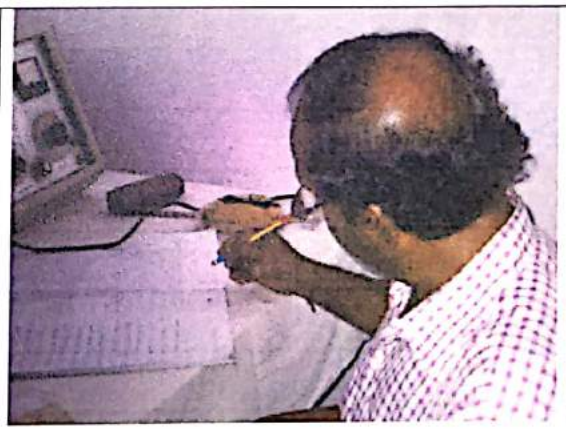
Medical Examination



Pulmonary Function Test



Information- Communication



Audiometry



Haematology & Radiology Examination

RESULT & DISCUSSION (Total subjects)

This study covered 351 subjects from Kustore sector and 140 subjects from Baghmara sector of BCCL Collieries. Among the subjects of Kustore sector 49 were from Kachi Balihari mines, 51 from Bhagabandh mines, 40 from Gopali Chawk mines and 100 from Munidi mines. PB project mines contributed 111 subjects (Table 1). Similarly among the subjects of Baghmara sector, Kharkharee mines and Phularitand mines contributed 75 subjects and 65 subjects respectively. Workers actively involved in mining activity were mainly included in this study. However, about 10% subjects of this study were enrolled from supervisory staffs in order to have a complete and comprehensive understanding of the occupational health condition.

Table 1: Distribution of Supervisory workers and coal miners according to the name of the mine

Sector	Mine Name	Supervisory workers	Coal Miners	Total
		N (%)	N (%)	N (%)
Kustore	10/12 KACHI BALIHARI PITS	8 (2)	41 (12)	49 (14)
	BHAGABANDH COLLIARY	10 (3)	41 (12)	51 (15)
	GOPALI CHAWK COLLIARY	7 (2)	33 (9)	40 (11)
	MUNIDI COLLIARY	17 (5)	83 (24)	100 (29)
	P.B.PROJECT COLLIARY	5 (1)	106 (30)	111 (31)
Total		47 (13)	304 (87)	351
Baghmara	KHARKHAREE COLLIARY	5 (4)	70 (50)	75 (54)
	PHULARITAND COLLIARY	1 (1)	64 (45)	65 (46)
Total		6 (5)	134 (95)	140
Grand Total		53 (10)	438 (90)	491 (100)

Mean age of the workers was 45.9 ± 8.36 years. Most of the workers were between 35-54 years age group. Mean age of supervisory staffs was slightly higher than that of miners. About 98% workers were married. As far as education is concerned majority (56%) had middle school education. Only 4% subjects had graduate level education or higher (Table 2).

Table 2: Demographic characteristics of the study subjects

Demographic characteristics	Supervisory workers	Coal Miners	Total
Age group (in years)	N (%)	N (%)	N (%)
<25	0(0)	4(1)	4(1)
25 - 34	5(1)	34(7)	39(8)
35 - 44	9(2)	148(30)	157(32)
45 - 54	18(4)	175(36)	193(40)
≥55	16(3)	77(16)	93(19)
Mean age (in years)	48.31 ± 9.47	45.55 ± 8.189	45.9 ± 8.36
Marital status			
Single	2(0.5)	6(1.5)	8(2)
Married	46(8.5)	432(89.5)	478(98)
Education status			
Illiterate	0(0)	102(21)	102(21)
Primary schooling	1(0)	15(3)	16(3)
Middle schooling	18(4)	256(53)	274(56)
Secondary schooling	19(4)	56(12)	75(15)
Graduate and above	10(2)	9(2)	19(4)

So far as personal habits are concerned, 86% of subjects were non-smokers, 10% were smokers and 3% were ex-smokers. Tobacco chewing habit was present in 61% subjects and occasional alcohol intake history was found in 39% workers (Table 3).

Table 3: Personal habits of the study subjects

Demographic characteristics	Supervisory workers	Coal Miners	Total
Smoking habits	N (%)	N (%)	N (%)
Non-smoker	38(8)	382(79)	420(86)
Smoker	9(2)	40(8)	49(10)
Ex-smoker	1(0)	16(3)	17(3)
Tobacco chewer			
No	27(6)	160(33)	187(39)
Yes	21(4)	283(57)	304(61)
Alcohol drinking habit			
No	34(7)	264(54)	298(61)
Yes	14(3)	174(36)	188(39)

Mean job experience was 11.72 ± 8.49 years. About 83% workers had job experience of up to 20 years, 3% workers had experience more than 30 years (Table 4). Mean experience was a little higher in supervisory employee group than miners group.

Table 4: Occupational characteristics of Supervisory workers & Coal miners

Demographic characteristics	Supervisory workers	Coal Miners	Total
Duration of job (in years)	N (%)	N (%)	N (%)
<10	23(5)	241(49)	264(54)
10 - 20	12(2)	129(26)	141(29)
21 - 30	13(3)	60(12)	73(15)
>30	0(0)	13(3)	13(3)
Mean duration of job (years)	12.65 ± 9.31	11.61 ± 8.39	11.72 ± 8.49

Most common symptoms complained by study subjects were musculoskeletal pain (34%) (Table 5). Other complaints were Cough, difficulty in breathing, chest pain, loose teeth, and soreness of mouth and colicky pain in abdomen. Headache, sleep disturbance, weakness, tremor in fingers was also experienced by some subjects.

Table 5: Distribution of symptoms among study subjects

Symptoms	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Cough	1 (0.5)	23 (4.5)	24 (5)
Cough with Phlegm	0 (0)	7 (1)	7 (1)
Difficulty in Breathing	2 (0.5)	27 (5.5)	29 (6)
Chest Pain	2 (0.5)	23 (4.5)	25 (5)
Colicky pain	1 (0.5)	14 (2.5)	15 (3)
Loose Teeth	5 (1)	36 (7)	41 (8)
Soreness of mouth/throat	3 (1)	21 (4)	24 (5)
Urinary problems	1 (0.25)	5 (0.75)	6 (1)
Musculoskeletal pain	21 (4)	146 (30)	167 (34)
Headache/sleep difficulty/weakness/dizziness/tremor	6 (2)	46 (9)	52 (11)

Table 8: Pulmonary function impairments among study subjects

Pulmonary function category	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
FVC/PFVC			
<80%	0 (0.0)	15 (3.0)	15 (3.0)
≥80%	53 (11.0)	423 (86.0)	476 (97.0)
FEV₁%			
< 70 %	2 (0.5)	29 (6.0)	31 (6.5)
70- 79.99 %	21 (4.5)	158 (32.0)	179 (36.5)
≥ 80 %	30 (6.0)	251 (51.0)	281 (57.0)
FVC/PFVC <80% + FEV₁% <70%	0 (0.0)	3 (0.6)	3 (0.6)

FVC – Forced Vital Capacity; PFVC – Predicted Forced Vital Capacity; FEV₁ – Forced Expiratory Volume in first second

Table 9: Forced Vital Capacity according to study variables among study subjects

Study variables	Forced Vital Capacity [Mean ± SD (litres)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean ± SD (litres)	Mean ± SD (litres)	Mean ± SD (litres)
< 45	3.85 ± 0.585	3.71 ± 0.646	3.72 ± 0.641
≥ 45	3.53 ± 0.576	3.36 ± 0.64	3.38 ± 0.634
	t = 3.120;df=1;p=0.083	t=30.586;df=1;p=0.00	t=32.016;df=1;p=0.00
Duration of exposure (yrs)			
< 20	3.64 ± 0.562	3.52 ± 0.65	3.53 ± 0.643
≥ 20	3.55 ± 0.672	3.47 ± 0.71	3.48 ± 0.702
	t=0.264;df=1;p=0.610	t=0.430;df=1;p=0.512	t=0.519;df=1;p=0.472
Smoking habit			
Never smoker	3.6 ± 0.587	3.5 ± 0.655	3.51 ± 0.649
Ever smoker	3.76 ± 0.613	3.49 ± 0.616	3.54 ± 0.619
	t=0.210;df=1;p=0.649	t=0.115;df=1;p=0.735	t=0.317;df=1;p=0.574

Similar trend was observed in case of FEV₁ values also (Table 10). Significant difference was observed between subject of less than 45 years and rest of the workers. This difference was more prominent in miners than supervisory staffs. No such remarkable difference was observed when compared in relation to job experience and smoking habit.

Table 10: Forced Expiratory Volume in first second according to study variables among study subjects

Study variables	Forced Expiratory Volume in first second [Mean $\pm$ SD (litres)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)
< 45	3.073 $\pm$ 0.3887	3.028 $\pm$ 0.5229	3.031 $\pm$ 0.5139
$\geq$ 45	2.837 $\pm$ 0.4553	2.685 $\pm$ 0.5597	2.705 $\pm$ 0.5486
	t=2.95;df=1;p=0.092	t=42.02;df=1;p=0.001	t=43.53;df=1;p=0.001
Duration of exposure (yrs)			
< 20	2.945 $\pm$ 0.4025	2.844 $\pm$ 0.5556	2.854 $\pm$ 0.5427
$\geq$ 20	2.791 $\pm$ 0.5426	2.769 $\pm$ 0.6072	2.772 $\pm$ 0.5962
	t=1.259;df=1;p=0.267	t=1.319;df=1;p=0.25	t=1.872;df=1;p=0.172
Smoking habit			
Never smoker	2.886 $\pm$ 0.4428	2.836 $\pm$ 0.5617	2.841 $\pm$ 0.5509
Ever smoker	2.972 $\pm$ 0.5042	2.763 $\pm$ 0.5127	2.805 $\pm$ 0.5129
	t=0.208;df=1;p=0.650	t=0.131;df=1;p=0.72	t=0.018;df=1;p=0.895

Same pattern could be found in case of Peak Expiratory Flow Rate also (Table 11). Significant difference was present in relation to age (more so in miners than supervisor), however, smoking and duration of exposure wise classification did not show any significant difference.

Table 11: Peak Expiratory Flow Rate according to study variables among study subjects

Study variables	Peak Expiratory Flow Rate [Mean $\pm$ SD (litres/minute)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres/minute)	Mean $\pm$ SD (litres/minute)	Mean $\pm$ SD (litres/minute)
< 45	465 $\pm$ 63.579	473.23 $\pm$ 65.358	472.65 $\pm$ 65.113
$\geq$ 45	479.47 $\pm$ 60.402	444.83 $\pm$ 85.172	449.4 $\pm$ 83.078
	t=0.571;df=1;p=0.458	t=14.37;df=1;p=0.00	t=10.97;df=1;p=0.001
Duration of exposure (yrs)			
< 20	474.86 $\pm$ 59.704	458.15 $\pm$ 75.028	459.79 $\pm$ 73.769
$\geq$ 20	477.33 $\pm$ 66.167	450.2 $\pm$ 89.349	453.97 $\pm$ 86.752
	t=0.01;df=1;p=0.896	t=0.785;df=1;p=0.376	t=0.506;df=1;p=0.477
Smoking habit			
Never smoker	475.37 $\pm$ 61.851	456.31 $\pm$ 78.316	458.17 $\pm$ 77.012
Ever smoker	475 $\pm$ 63.64	461.75 $\pm$ 76.691	464.4 $\pm$ 73.849
	t=0.002;df=1;p=0.962	t=0.193;df=1;p=0.661	t=0.301;df=1;p=0.583

So far as chest radiographic findings are concerned, 93% subjects (Table 12) had findings within normal limits. 3% subjects showed findings suggestive of opacities in lung and almost 1.5% had other features on chest X-ray (mostly suggestive of Koch's infection of lung).

Table 12: Chest radiographic findings among the study subjects

Chest X ray findings	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Within normal limit	50 (10)	408 (83)	458 (93)
Pulmonary Opacities	1 (0.5)	12 (2.5)	13 (3)
Koch's infection	0 (0)	7 (1.5)	7 (1.5)
Not Done	2 (0.5)	11(2.0)	13(2.5)
Total	53 (11)	438 (89)	491 (100)

Haematological and biochemical findings of the subjects were mostly within normal limits. Almost 11% workers had random blood sugar level >140 . Mean Hemoglobin level in 13.1 ± 0.8 gm%. Mean ESR was 7.0 ± 2.1 unit. Random Blood sugar, blood urea and creatinine was 114.7 ± 36.4 unit, 22.7 ± 3.6 unit and 0.8 ± 0.1 unit respectively (Table 13).

Table 13: Haematological & Biochemical findings of study subjects

Parameter	Minimum	Maximum	Mean $\pm$ SD
Haemoglobin (g/dL)	10	15	13.15 $\pm$ 0.845
Erythrocyte Sedimentation Rate (mm/h)	3	20	7.046 $\pm$ 2.144
Total Leucocyte Count (mcL)	5500	12600	9064.61 $\pm$ 1167.13
Neutrophil	46	89	61.77 $\pm$ 5.826
Lymphocyte	20	62	31.97 $\pm$ 6.013
Eosinophil	2	13	5.62 $\pm$ 1.77
Monocyte	0	8	0.80 $\pm$ 0.905
Besophil	0	0	0.00
Random Blood Sugar (mg/dL)	55	300	114.74 $\pm$ 36.46
Blood Urea (mg/dL)	14	38	22.75 $\pm$ 3.63
Serum Creatinine (mg/dL)	.30	7.00	0.83 $\pm$ 0.32

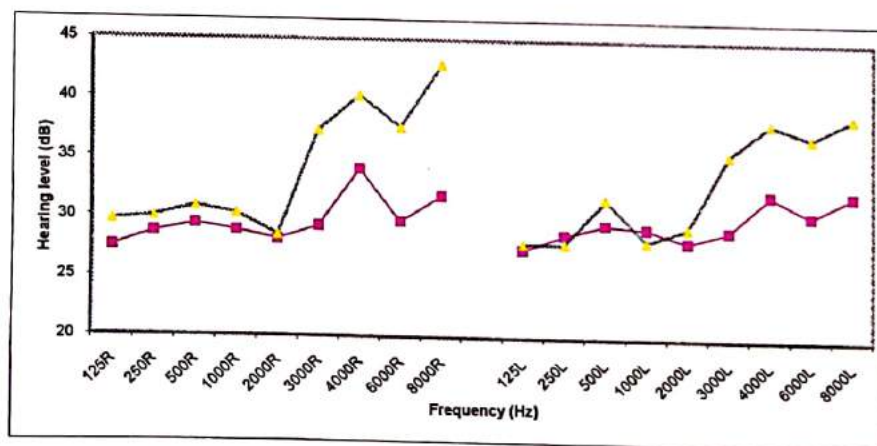
As far as ophthalmological findings are concerned, 5% subjects had uncorrected vision (although using spectacles) and 9% subjects had Cataract in eyes. Colour blindness was also observed in few subjects (Table 14).

Table 14: Ophthalmological findings of study subjects

	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
People having uncorrected vision after correction	1 (0.5)	24 (4.5)	25 (5)
Colour Blindness	0	6 (1)	6 (1)
Cataract	4 (1)	29 (8)	33 (9)
Glaucoma	0 (0)	2 (1)	2 (1)
Muscular Pathology	0	1	1
Pterygium	0	1	1

Figure 1 describes hearing ability of workers examined by audiometry. Two curves depict the median hearing ability of subjects with <10 years (lower curve), and ≥ 10 years (higher curve) of job experience. On preliminary observation, decreased hearing ability at high frequency was observed in some workers. Difference of hearing ability with increasing duration of exposure was also observed at higher frequency; however, this observation also is subject to adjustment for age and other probable factors that can affect hearing ability. Moreover, hearing assessment was done in field condition where despite best efforts ideal experimental chamber condition could not be achieved, which may also be a contributing factor.

Figure 1: Distribution of hearing ability according to job experience



RESULT & DISCUSSION (Kustore area subjects)

This study covered 351 subjects from Kustore sector of BCCL Collieries. Among the subjects of Kustore sector 49 were from Kachi Balihari mines, 51 from Bhagabandh mines, 40 from Gopali Chawk mines and 100 from Munidi mines. PB project mines contributed 111 subjects (Table 15). Workers actively involved in mining activity were mainly included in this study.

Table 15: Distribution of Supervisory workers and coal miners of Kustore area

Sector	Mine Name	Supervisory workers	Coal Miners	Total
		N (%)	N (%)	N (%)
Kustore	10/12 KACHI BALIHARI PITS	8 (2)	41 (12)	49 (14)
	BHAGABANDH COLLIARY	10 (3)	41 (12)	51 (15)
	GOPALI CHAWK COLLIARY	7 (2)	33 (9)	40 (11)
	MUNIDI COLLIARY	17 (5)	83 (24)	100 (29)
	P.B.PROJECT COLLIARY	5 (1)	106 (30)	111 (31)
	Total	47 (13)	304 (87)	351

Mean age of the workers was 46.3 ± 8.36 years. Most of the workers were between 35-54 years age group. Mean age of supervisory staffs was slightly higher than that of miners. About 98% workers were married. As far as education is concerned majority (53%) had middle school education. Only 5% subjects had graduate level education or higher (Table 16).

Table 16: Demographic characteristics of the study subjects of Kustore area

Demographic characteristics	Supervisory workers	Coal Miners	Total
Age group (in years)	N (%)	N (%)	N (%)
< 25	0 (0)	2 (1)	2 (1)
25-34	4 (1)	22 (6)	26 (7)
35-44	8 (2)	104 (30)	112 (32)
45-54	18 (5)	118 (34)	136 (39)
≥ 55	17 (5)	58 (17)	75 (21)
Mean age (in years)	49.06 ± 8.928	48.87 ± 8.21	46.30 ± 8.368
Marital status			
Single	2 (1)	5 (1)	7 (2)
Married	45 (13)	299 (85)	344 (98)
Education status			
Illiterate	0 (0)	72 (20)	72 (20)
Primary schooling	1 (0.5)	12 (3.5)	13 (4)
Middle schooling	17 (5)	169 (48)	186 (53)
Secondary schooling	18 (5)	44 (13)	62 (18)
Graduate and above	11 (3)	7 (2)	18 (5)

So far as personal habits are concerned (Table 17), 83% of subjects were non-smokers, 12% were smokers and 5% were ex-smokers. Tobacco chewing habit was present in 61% subjects and occasional alcohol intake history was found in 38% workers.

Table 17: Personal habits of the study subjects of Kustore area

Demographic characteristics	Supervisory workers	Coal Miners	Total
Smoking habits	N (%)	N (%)	N (%)
Non-smoker	38 (11)	254 (72)	292 (83)
Smoker	8 (2)	34 (10)	42 (12)
Ex-smoker	1 (0.5)	16 (4.5)	17 (5)
Tobacco chewer			
Yes	22 (6)	193 (55)	215 (61)
No	25 (7)	111 (32)	136 (39)
Alcohol drinking habit			
No	35 (10)	183 (52)	218 (62)
Yes	12 (3)	121 (34)	133 (38)

Mean job experience was 12.68 ± 8.9 years. About 78% workers had job experience of up to 20 years, 3% workers had experience more than 30 years. Mean experience was a little higher in supervisory employee group than miners group (Table 18).

Table 18: Occupational characteristics of Supervisory workers & Coal miners of Kustore area

Demographic characteristics	Supervisory workers	Coal Miners	Total
Duration of job (in years)	N (%)	N (%)	N (%)
<10	21 (6)	153 (43)	174 (49)
10 - 20	13 (4)	88 (25)	101 (29)
21 - 30	13 (4)	52 (15)	65 (19)
>30	0 (0)	11 (3)	11 (3)
Mean duration of job (years)	13.48 ± 9.28	12.56 ± 8.85	12.68 ± 8.90

Most common symptoms complained by study subjects were musculoskeletal pain (34%). Other complaints were Cough, difficulty in breathing, and loose teeth. Headache, sleep disturbance, weakness, tremor in fingers was also experienced by some subjects (9%) (Table 19).

Table 19: Distribution of symptoms among study subjects of Kustore area

Symptoms	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Cough	2 (1)	18 (5)	20 (6)
Cough with Phlegm	1 (0.5)	4 (1)	5 (1.5)
Difficulty in Breathing	3 (1)	18 (5)	21 (6)
Chest Pain	2 (1)	12 (3)	14 (4)
Colicky pain	1 (0.5)	10 (2.5)	11 (3)
Loose Teeth	5 (1)	30 (9)	35 (10)
Soreness of mouth/throat	3 (1)	8 (2)	11 (3)
Urinary problems	0 (0)	3 (1)	3 (1)
Musculoskeletal pain	19 (5)	99 (28)	118 (34)
Headache/sleep difficulty/weakness/dizziness/tremor	5 (2)	26 (7)	31 (9)

Mean height was 160.8 ± 6.3 cm and mean weight was 66.1 ± 11.9 kg for miners. Mean height was slightly higher in supervisory staffs whereas mean weight was considerably higher. This may be result of sedentary lifestyle and relative lack of exercise. Mean systolic and diastolic blood pressure of miners was 131.4 ± 19.1 and 85.0 ± 10.6 mm of Mercury (Table 20). About 19% subjects had systolic blood pressure >140 as well as diastolic blood pressure > 90 mm of Mercury. 10% workers had only higher systolic blood pressure and 13% had only higher diastolic blood pressure (Table 21).

Table 20: Distribution of salient clinical findings among study subjects of Kustore area

Clinical examination findings	Supervisory workers	Coal Miners	Total
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Mean Height (cm)	162.53 ± 5.88	160.84 ± 6.37	161.07 ± 6.33
Mean Weight (Kgs)	71.94 ± 9.78	66.19 ± 11.93	66.96 ± 11.81
MSBP (mm Hg)	131.11 ± 15.79	131.42 ± 19.11	131.37 ± 18.68
MDBP (mm Hg)	85.57 ± 8.78	85.02 ± 10.62	85.10 ± 10.38

MSBP - Mean Systolic Blood Pressure; MDBP - Mean Diastolic Blood Pressure

Table 21: Distribution of Blood pressure among study subjects of Kustore area

	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Blood Pressure (mm Hg) >140 & <90	4 (1)	32 (9)	36 (10)
Blood Pressure (mm Hg) <140 & >90	8 (2)	37 (11)	45 (13)
Blood Pressure (mm Hg) <140 & <90	26 (7)	179 (51)	205 (58)
Blood Pressure (mm Hg) >140 & >90	9 (3)	56 (16)	65 (19)

As far as pulmonary functional status of study subjects in concerned, about 3 % subjects had restrictive type of abnormality (FVC/PFVC < 80%) and 0.3% subjects had combined type of abnormality (FVC/PFVC <80 % and FEV_{1%} <70%). A good number of subjects (40.5%) had FEV_{1%} values between 70% and 80% (Table 22).

Table 22: Pulmonary function impairments among study subjects of Kustore area

Pulmonary function category	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
FVC/PFVC			
<80%	0 (0.0)	10 (3.0)	10 (3.0)
≥80%	47 (13.0)	294 (84.0)	341 (97.0)
FEV_{1%}			
< 70 %	2 (0.5)	17 (5.0)	19 (5.5)
70- 79.99 %	17 (5.0)	125 (35.5)	142 (40.5)
≥ 80 %	28 (8.0)	162 (46.0)	190 (54.0)
FVC/PFVC <80% + FEV_{1%} <70%	0 (0.0)	1 (0.3)	1 (0.3)

FVC – Forced Vital Capacity; PFVC – Predicted Forced Vital Capacity; FEV₁ – Forced Expiratory Volume in first second

Mean FVC values were lower among the subjects of age 45 years or above. The difference was significant among the miners but not significant statistically among the supervisory staffs. Such significant difference of FVC values was not observed when compared between higher and lower job experience groups. Similarly difference was not prominent in relation to smoking habit of the subjects (Table 23).

Table 23: Forced Vital Capacity according to study variables among study subjects of Kustore area

Study variables	Forced Vital Capacity [Mean $\pm$ SD (litres)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)
< 45	3.86 $\pm$ 0.60	3.82 $\pm$ 0.66	3.82 $\pm$ 0.65
$\geq$ 45	3.61 $\pm$ 0.55	3.46 $\pm$ 0.67	3.48 $\pm$ 0.65
	t=0.192;df=1;p=0.19	t=21.85;df=1;p= 0.00	t=0.344;df=1;p=0.558
Duration of exposure (yrs)			
< 20	3.69 $\pm$ 0.56	3.63 $\pm$ 0.67	3.64 $\pm$ 0.66
$\geq$ 20	3.64 $\pm$ 0.61	3.52 $\pm$ 0.72	3.54 $\pm$ 0.70
	t=0.071;df=1;p=0.791	t=1.536;df=1;p=0.216	t=1.533;df=1;p=0.217
Smoking habit			
Never smoker	3.67 $\pm$ 0.56	3.63 $\pm$ 0.68	3.63 $\pm$ 0.66
Ever smoker	3.67 $\pm$ 0.65	3.52 $\pm$ 0.75	3.55 $\pm$ 0.73
	t=0.000;df=1;p=0.996	t=0.905;df=1;p=0.342	t=0.768;df=1;p=0.381

Similar trend was observed in case of FEV1 values also (Table 24). Significant difference was observed between subject of less than 45 years and rest of the workers. This difference was more prominent in miners than supervisory staffs. No such remarkable difference was observed when compared in relation to job experience and smoking habit.

Table 24: Forced Expiratory Volume in first second according to study variables among study subjects of Kustore area

Study variables	Forced Expiratory Volume in first second [Mean $\pm$ SD (litres)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)
< 45	3.075 $\pm$ 0.40	3.10 $\pm$ 0.52	3.09 $\pm$ 0.51
$\geq$ 45	2.91 $\pm$ 0.41	2.75 $\pm$ 0.58	2.78 $\pm$ 0.56
	t=1.388;df=1;p=0.245	t=28.214;df=1;p=0.00	t=28.69;df=1;p= 0.00
Duration of exposure (yrs)			
< 20	2.99 $\pm$ 0.37	2.93 $\pm$ 0.56	2.93 $\pm$ 0.54
$\geq$ 20	2.86 $\pm$ 0.48	2.82 $\pm$ 0.63	2.82 $\pm$ 0.60
	t=1.025;df=1;p=0.317	t=2.033;df=1;p=0.155	t=2.64;df=1;p=0.105
Smoking habit			
Never smoker	2.95 $\pm$ 0.40	2.92 $\pm$ 0.57	2.93 $\pm$ 0.55
Ever smoker	2.98 $\pm$ 0.47	2.79 $\pm$ 0.63	2.82 $\pm$ 0.61
	t=0.035;df=1;p=0.853	t=2.156;df=1;p=0.143	t=1.769;df=1;p=0.184

Same pattern could be found in case of Peak Expiratory Flow Rate also (Table 25). Significant difference was present in relation to age (more so in miners than supervisor), however, smoking and duration of exposure wise classification did not show any significant difference.

Table 25: Peak Expiratory Flow Rate according to study variables among study subjects of Kustore area

Study variables	Peak Expiratory Flow Rate [Mean $\pm$ SD (litres/minute)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres/minute)	Mean $\pm$ SD (litres/minute)	Mean $\pm$ SD (litres/minute)
< 45	460 $\pm$ 67.42	474.38 $\pm$ 65.54	473.14 $\pm$ 65.58
$\geq$ 45	486.18 $\pm$ 57.74	447.8 $\pm$ 87.25	454.02 $\pm$ 84.27
	t=1.671;df=1;p=0.20	t=8.416;df=1;p=0.004	t=5.137;df=1;p=0.02
Duration of exposure (yrs)			
< 20	476.56 $\pm$ 61.88	460.98 $\pm$ 74.17	462.93 $\pm$ 72.82
$\geq$ 20	485.71 $\pm$ 59.83	451.31 $\pm$ 92.80	456.49 $\pm$ 89.22
	t=0.217;df=1;p=0.64	t=0.867;df=1;p=0.353	t=0.471;df=1;p=0.493
Smoking habit			
Never smoker	478.92 $\pm$ 60.50	458.56 $\pm$ 79.93	461.15 $\pm$ 77.94
Ever smoker	481.11 $\pm$ 65.47	461.2 $\pm$ 79.94	464.24 $\pm$ 77.73
	t=0.009;df=1;p=0.92	t=0.046;df=1;p=0.83	t=0.077;df=1;p=0.781

So far as chest radiographic findings are concerned, about 94% subjects had findings within normal limits. About 2.5% subjects showed findings suggestive of opacities in lung and almost 1% had other features on chest X-ray (mostly suggestive of Koch's infection of lung) (Table 26).

Table 26: Chest radiographic findings among the study subjects of Kustore area

Chest X ray findings	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Within normal limit	44 (13)	285 (81)	329 (94)
Pulmonary Opacities	1 (0.5)	7 (2.0)	8 (2.5)
Koch's infection	0 (0)	4 (1)	4 (1)
Not Done	2 (0.5)	8 (2.0)	10 (2.5)
Total	47 (14)	304 (86)	351 (100)

Haematological and biochemical findings of the subjects were mostly within normal limits. 9% workers had random blood sugar level >140. Mean Hemoglobin level in 13.4 ± 0.4 gm%. Mean ESR was 7.0 ± 2.1 mm/h. Random Blood sugar, Blood urea and Serum creatinine was 117.6 ± 35.3 mg/dl, 23.5 ± 2.7 mg/dl and 0.9 ± 0.05 mg/dl respectively (Table 27).

Table 27: Haematological & Biochemical findings of study participants of Kustore area

Parameters	Minimum	Maximum	Mean $\pm$ SD
Haemoglobin (g/dL)	12	14	13.47 ± 0.483
Erythrocyte Sedimentation Rate (mm/h)	3	20	7.046 ± 2.14
Total Leucocyte Count (mcL)	6100	12600	9509.86 ± 838.53
Neutrophil	50	72	61.48 ± 5.60
Lymphocyte	23	62	33.072 ± 5.15
Eosinophil	3	9	5.01 ± 0.91
Monocyte	0	2	0.56 ± 0.65
Besophil	0	0	0.00
Random Blood Sugar (mg/dL)	75	270	117.64 ± 35.35
Blood Urea (mg/dL)	18	36	23.57 ± 2.77
Serum Creatinine (mg/dL)	.71	1.00	0.90 ± 0.05

Table 28: Ophthalmological findings of study participants of Kustore area

Findings	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
People having uncorrected vision after correction	1 (0.5)	16 (4.5)	17 (5)
Cataract	4 (1)	29 (8)	33 (9)
Glaucoma	0 (0)	2 (1)	2 (1)
Mascular Pathology	0	1	1
Pterygium	0	1	1

As far as ophthalmological findings are concerned, 5% subjects had uncorrected vision (although using spectacles) and 9% subjects had Cataract in eyes (Table 28).

RESULT
&
DISCUSSION
(Baghmara area subjects)

This study covered 140 subjects from Baghmara sector of BCCL Collieries (Table 29). Among the subjects of Baghmara sector, Kharkharee mines and Phularitand mines contributed 75 subjects and 65 subjects respectively. Workers actively involved in mining activity were mainly included in this study. However, about 5% subjects of this study were enrolled from supervisory staffs in order to have a complete and comprehensive understanding of the occupational health condition.

Table 29: Distribution of Supervisory workers and coal miners of Baghmara area

Sector	Mine Name	Supervisory workers	Coal Miners	Total
		N (%)	N (%)	N (%)
Baghmara	KHARKHAREE COLLIARY	5(4)	70(50)	75(54)
	PHULARITAND COLLIARY	1(1)	64(45)	65(46)
Total		6 (5)	134 (95)	140 (100)

Mean age of the workers was 44.9 ± 8.2 years. Most of the workers were between 35-54 years age group. Mean age of supervisory staffs was slightly higher than that of miners. About 99% workers were married. As far as education is concerned majority (66%) had middle school education. Only 1% subjects had graduate level education or higher (Table 30).

Mean job experience was 9.4 ± 6.8 years. About 93% workers had job experience of up to 20 years. Mean experience was a little higher in supervisory employee group than miners group (Table 32).

Table 32: Occupational characteristics of Supervisory workers & Coal miners of Baghmara area

Demographic characteristics	Supervisory workers	Coal Miners	Total
Duration of job (in years)			
<10	5 (3)	85 (61)	90 (64)
10 - 20	1 (1)	39 (28)	40 (29)
21-30	0 (0)	8 (6)	8 (6)
>30	0 (0)	2 (1)	2 (1)
Mean duration of job (years)	6.17 ± 7.17	9.56 ± 6.83	9.41 ± 6.85

Most common symptoms complained by study subjects were musculoskeletal pain (36%). Other complaints were difficulty in breathing, chest pain and soreness of mouth. Headache, sleep disturbance, weakness, tremor in fingers was also experienced by good number of subjects (15%) (Table 33).

Table 33: Distribution of symptoms among study subjects of Baghmara area

Symptoms	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Cough	0 (0)	5 (4)	5 (4)
Cough with Phlegm	0 (0)	3 (2)	3 (2)
Difficulty in Breathing	0 (0)	9 (6)	9 (6)
Chest Pain	0 (0)	11 (8)	11 (8)
Colicky pain	0 (0)	4 (3)	4 (3)
Loose Teeth	0 (0)	6 (4)	6 (4)
Soreness of mouth/throat	0 (0)	13 (9)	13 (9)
Urinary problems	1 (1)	2 (1)	3 (2)
Musculoskeletal pain	4 (2)	47 (34)	51 (36)
Headache/sleep difficulty/weakness/dizziness/tremor	1 (1)	20 (14)	21 (15)

Mean height was 159.3 ± 6.7 cm and mean weight was 61.9 ± 11.5 kg. Mean systolic and diastolic blood pressure was 130.1 ± 19.2 and 82.9 ± 10.7 mm of Mercury (Table -34).

Table 34: Distribution of salient clinical findings among study subjects of Baghmara area

Clinical examination findings	Supervisory workers	Coal Miners	Total
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Mean Height (cm)	163.67 ± 6.28	159.18 ± 6.72	159.37 ± 6.74
Mean Weight (Kgs)	67.83 ± 11.0	61.70 ± 11.50	61.96 ± 11.51
MSBP (mm Hg)	134.33 ± 19.16	129.97 ± 19.26	130.16 ± 19.21
MDBP (mm Hg)	80.67 ± 9.35	83.01 ± 10.86	82.91 ± 10.78

MSBP – Mean Systolic Blood Pressure; MDBP – Mean Diastolic Blood Pressure

About 23% subjects had systolic blood pressure >140 as well as diastolic blood pressure >90 mm of Mercury. 6% workers had only higher systolic blood pressure and 6% had only higher diastolic blood pressure (Table 35).

Table 35: Distribution of Blood pressure among study subjects of Baghmara area

	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Blood Pressure (mm Hg) >140 & <90	3 (2)	6 (4)	9 (6)
Blood Pressure (mm Hg) <140 & >90	0 (0)	9 (6)	9 (6)
Blood Pressure (mm Hg) <140 & <90	2 (1)	88 (63)	90 (64)
Blood Pressure (mm Hg) >140 & >90	1 (1)	31 (22)	32 (23)

As far as pulmonary functional status of study subjects is concerned, about 3.5 % subjects had restrictive type of abnormality ($FVC/PFVC < 80\%$) and 1.43% subjects had combined type of abnormality ($FVC/PFVC < 80\%$ and $FEV_{1\%} < 70\%$). A good number of subjects (26.5%) had $FEV_{1\%}$ values between 70% and 80% (Table 36).

Table 36: Pulmonary function impairments among study subjects of Baghmara area

Pulmonary function category	Supervisory workers N (%)	Coal Miners N (%)	Total N (%)
FVC/PFVC			
<80%	0 (0.0)	5 (3.5)	5 (3.5)
≥80%	6 (4.5)	129 (92.0)	135 (96.5)
FEV₁%			
< 70 %	0 (0.0)	12 (8.5)	12 (8.5)
70- 79.99 %	4 (3.0)	33 (23.5)	37 (26.5)
≥ 80 %	2 (1.0)	89 (64.0)	91 (65.0)
FVC/PFVC <80% + FEV₁% <70%	0 (0.0)	2 (1.43)	2 (1.43)

FVC – Forced Vital Capacity; PFVC – Predicted Forced Vital Capacity; FEV₁ – Forced Expiratory Volume in first second

Mean FVC values were significantly lower among the subjects of age 45 years or above (Table 37). The difference was more prominent among the miners in comparison to supervisory staffs. Such significant difference of FVC values was not observed when compared between higher and lower job experience groups. Similarly difference was not prominent in relation to smoking habit of the subjects.

Table 37: Forced Vital Capacity according to study variables among study subjects of Baghmara area

Study variables	Forced Vital Capacity [Mean ± SD (litres)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean ± SD (litres)	Mean ± SD (litres)	Mean ± SD (litres)
< 45	3.82 ± 0.68	3.46 ± 0.53	3.47 ± 0.53
≥ 45	2.90 ± 0.41	3.13 ± 0.50	3.12 ± 0.50
	df=1;p=0.098	df=1;p= 0.00	df=1;p= 0.00
Duration of exposure (yrs)			
< 20	3.38 ± 0.55	3.29 ± 0.54	3.29 ± 0.54
≥ 20	2.35	3.14 ± 0.55	3.09 ± 0.56
	df=1;p=0.162	df=1;p=0.316	df=1;p=0.158
Smoking habit			
Never smoker	2.99 ± 0.44	3.26 ± 0.53	3.25 ± 0.53
Ever smoker	3.18 ± 0.74	3.34 ± 0.56	3.42 ± 0.55
	df=1;p=0.138	df=1;p=0.187	df=1;p= 0.099

Similar trend was observed in case of FEV1 values also. Significant difference was observed between subject of less than 45 years and rest of the workers. This difference was prominent in miners and supervisory staffs. No such remarkable difference was observed when compared in relation to job experience and smoking habit (Table 38).

Table 38: Forced Expiratory Volume in first second according to study variables among study subjects of Baghmara area

Study variables	Forced Expiratory Volume in first second [Mean $\pm$ SD (litres)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)	Mean $\pm$ SD (litres)
< 45	3.06 $\pm$ 0.44	2.87 $\pm$ 0.49	2.87 $\pm$ 0.49
$\geq$ 45	2.18 $\pm$ 0.27	2.52 $\pm$ 0.46	2.50 $\pm$ 0.46
	t=9.88;df=1;p=0.035	t=17.48;df=1;p=0.00	t=21.13;df=1;p=0.00
Duration of exposure (yrs)			
< 20	2.614 $\pm$ 0.46	2.69 $\pm$ 0.51	2.69 $\pm$ 0.51
$\geq$ 20	1.780	2.5 $\pm$ 0.41	2.45 $\pm$ 0.43
	t=2.687;df=1;p=0.176	t=1.863;df=1;p=0.175	t=3.03;df=1;p=0.084
Smoking habit			
Never smoker	2.29 $\pm$ 0.40	2.66 $\pm$ 0.50	2.65 $\pm$ 0.50
Ever smoker	2.85 $\pm$ 0.74	2.94 $\pm$ 0.61	2.92 $\pm$ 0.59
	t=1.654;df=1;p=0.268	t=1.77;df=1;p=0.186	t=2.152;df=1;p=0.145

Same pattern could be found in case of Peak Expiratory Flow Rate also (Table 39). Significant difference was present in relation to age (more so in miners than supervisor), however, smoking and duration of exposure wise classification did not show any significant difference.

Table 39: Peak Expiratory Flow Rate according to study variables among study subjects of Baghmara area

Study variables	Peak Expiratory Flow Rate [Mean $\pm$ SD (litres/minute)]		
	Supervisory workers	Coal Miners	Total
Age group (in years)	Mean $\pm$ SD (litres/minute)	Mean $\pm$ SD (litres/minute)	Mean $\pm$ SD (litres/minute)
< 45	495 $\pm$ 21.21	470.69 $\pm$ 65.45	471.5 $\pm$ 64.54
$\geq$ 45	422.5 $\pm$ 59.09	437.77 $\pm$ 80.15	436.99 $\pm$ 78.98
	t=2.566;df=1;p=0.18	t=6.423;df=1;p=0.012	t=7.56;df=1;p=0.007
Duration of exposure (yrs)			
< 20	464 $\pm$ 47.22	453.22 $\pm$ 76.53	453.66 $\pm$ 75.46
$\geq$ 20	360.00	443.93 $\pm$ 69.12	438.33 $\pm$ 70.04
	t=4.042;df=1;p=0.115	t=0.188;df=1;p=0.665	t=0.559;df=1;p=0.456
Smoking habit			
Never smoker	442.5 $\pm$ 74.11	451.79 $\pm$ 75.05	451.5 $\pm$ 74.76
Ever smoker	455 $\pm$ 35.36	461.67 $\pm$ 93.47	460 $\pm$ 80.18
	t=0.047;df=1;p=0.839	t=0.09;df=1;p=0.756	t=0.097;df=1;p=0.756

So far as chest radiographic findings are concerned, about 92% subjects had findings within normal limits. 4% subjects showed findings suggestive of opacities in lung and almost 2% had other features on chest X-ray (mostly suggestive of Koch's infection of lung) (Table 40).

Table 40: Chest radiographic findings among the study participants of Baghmara area

Chest X ray findings	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
Within normal limit	6 (4)	123 (88)	129 (92)
Pulmonary Opacities	0 (0)	5 (4)	5 (4)
Koch's infection	0 (0)	3 (2)	3 (2)
Not Done	0 (0)	3 (2)	3 (2)
Total	6 (4)	134 (96)	140 (100)

Haematological and biochemical findings of the subjects were mostly within normal limits. 15% workers had random blood sugar level >140. Mean hemoglobin level in 11.9 ± 0.8 gm%. Random Blood sugar, blood urea and Serum creatinine was 107.5 ± 38.2 unit, 20.7 ± 4.5 unit and 0.6 ± 0.5 unit respectively (Table 41).

Table 41: Haematological & Biochemical findings of study participants of Baghmara area

Parameters	Minimum	Maximum	Mean
Haemoglobin (g/dL)	10	15	11.98 ± 0.87
Total Leucocyte Count (mcL)	5500	10500	7957.86 ± 1134.57
Neutrophil	46	89	62.49 ± 7.37
Lymphocyte	20	50	29.24 ± 7.06
Eosinophil	2	13	7.13 ± 2.40
Monocyte	0	8	1.38 ± 1.16
Besophil	0	0	0.00
Random Blood Sugar (mg/dL)	55	300	107.51 ± 38.28
Blood Urea (mg/dL)	14	38	20.7 ± 4.57
Serum Creatinine (mg/dL)	.30	7.00	0.64 ± 0.55

As far as ophthalmological findings are concerned, 6% subjects had uncorrected vision (although using spectacles). Colour blindness was also observed in few subjects (Table 42).

Table 42: Ophthalmological findings of study participants of Baghmara area

	Supervisory workers	Coal Miners	Total
	N (%)	N (%)	N (%)
People having uncorrected vision after correction	0 (0)	8 (6)	8 (6)
Colour Blindness	0 (0)	6 (4)	6 (4)

CONCLUSION & RECOMMENDATION

CONCLUSION

- This study covered 351 subjects from Kustore sector and 140 subjects from Baghmara sector of BCCL Collieries. Mean age of the workers was 45.9 ± 8.36 years. Most of the workers were between 35-54 years age. Mean job experience was 11.72 ± 8.49 years.
- Most common symptoms complained by study subjects were musculoskeletal pain (34%). Other complaints were Cough, difficulty in breathing, chest pain, soreness of mouth etc. Headache, sleep disturbance, weakness, tremor in fingers was also experienced by some subjects.
- About 20% subjects had systolic blood pressure >140 as well as diastolic blood pressure >90 mm of Mercury. 9% workers had only higher systolic blood pressure and 11% had only higher diastolic blood pressure.
- As far as pulmonary functional status of study subjects in concerned, about 3% subjects had restrictive type of abnormality ($FVC/PFVC < 80\%$) and 0.6 % subjects had combined type of abnormality ($FVC/PFVC < 80\%$ and $FEV1\% < 70\%$). A good number of subjects (36.5%) had $FEV1\%$ values between 70% and 80%. Mean FVC values were significantly lower among the subjects of age 45 years or above.
- So far as chest radiographic findings are concerned, 93% subjects had findings within normal limits. 3% subjects showed findings suggestive of opacities in lung and almost 1.5% had other features on chest X-ray (mostly suggestive of Koch's infection of lung). Such findings may be due to pneumoconiotic changes in lung, hence these subjects should be properly followed up and necessary medical, ethical, legal, administrative actions may be initiated as necessary.

- Haematological and biochemical findings of the subjects were mostly within normal limits. Almost 11% workers had random blood sugar level more than 140 units. As far as ophthalmological findings are concerned, 5% subjects had uncorrected vision and 9% subjects had Cataract in eyes.
- Decline in hearing ability with increasing duration of exposure was observed more at higher frequency; however, this observation is subject to adjustment for age and other probable factors.
- The subjects for this study are selected from workplaces identified by BCCL, Govt. of India, as required for the purpose of this study. The findings of this study may thus be restricted to the concerned workplaces and may not be generalisable.

RECOMMENDATION

- o Prevalence of musculoskeletal pain during work in a good number of workers reflects that manual work of the work processes might be causing some discomfort for the workers. Training on proper method of manual material handling may prove useful of these workers. On the other hand regular proper exercise should be promoted among workers especially supervisory employees to get rid of ill effects of sedentary activities.
- o Special emphasis should be given to protection of respiratory health, hearing ability. Periodic relevant examination (lung function test, audiometry) at regular interval is recommended.
- o Industrial hygiene survey (periodic monitoring of dust and other environmental hazards) at regular interval should be undertaken including noise level monitoring in different operations.
- o Some prevalent symptoms observed may be representation of nervous system effect due to exposures to toxicants. In order to exclude the possibility of exposure from occupational environment, environmental study should include assessment of exposure to metals.
- o Measures like using protective appliances (e.g. PPEs), pre-placement- and periodic medical examination, for the control and prevention of relevant health hazards, are to be implemented and maintained by all the mining areas to protect the health of the workers.

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EXECUTIVE SUMMARY

BACKGROUND

Although coal remains a major energy resource worldwide, coal mining causes environment problems, whereas the inhaled coal particles at the work place may lead to the development of coal workers' pneumoconiosis (CWP). Typically, coal workers pneumoconiosis takes many years to develop and to be manifested. Further, once initiated the disease is progressive in nature, often leading to lungfunction impairment, disability. The workers' exposure to coal dust generally occurs during mining operations. Coal mining can also increase the risk of developing asthma and chronic obstructive pulmonary disease (COPD), such as emphysema and chronic bronchitis. It is suggested that coal mining operations may also induce noise induced hearing impairment among the workers.

A request was received from Bharat Coking Coal Limited, Dhanbad to assess the health status of their workers involved in the mining activities in Cluster 11 and 15 areas around Dhanbad. About 10% of the subjects involved in mining activities were to be included in this study. The workers were to be assessed for their health status, presence of any occupational disease and hearing impairments. Under this circumstance, in consultation of the scientists of National Institute of Occupational Health (NIOH) and the concerned officers of Bharat Coking Coal Limited, it was decided that an epidemiological study would be carried out involving workers involved in mining activities.

OBJECTIVES

5. To understand health status of workers through questionnaire survey, health examination.
6. To study respiratory health in coal field mining workers.
7. To assess ventilatory functions of coal field mining workers.
8. To analyze hearing ability through audiometric evaluation.

METHODOLOGY

An occupational health study was conducted involving different mines of Cluster 11 and 15 of Bharat coking Coal Limited, Dhanbad. This study was undertaken among the exposed workers mainly from active mining activity. Representative sample from workers working in such occupations is included in this study. Initially the aim of the study was explained to the workers, informed consent was obtained after which they were enrolled for this study. Every individual subject was interviewed with a pre-designed questionnaire to collect information in relation to personal, occupational and morbidity details of the workers. The participants of this study were subjected to following interview/examination/investigations:

- Detailed personal, occupational and medical history.
- Clinical examination with special emphasis on examination of respiratory system.
- Haematological examination.
- Lung function test.
- Audiometry.
- Ophthalmological assessment.

Study design: Cross sectional study

Study subjects: This study covered 351 subjects from Kustore sector and 140 subjects from Bagmara sector of BCCL Collieries. Among the subjects of Kustore sector 49 were from Kachi Balihari mines, 51 from Bhagabandh mines, 40 from Gopali Chawk mines and 100 from Munidi mines. PB project mines contributed 111 subjects. Similarly among the subjects of Bagmara sector, Kharkharee mines and Phularitand mines contributed 75 subjects and 65 subjects respectively. Workers actively involved in mining actively were mainly included in this study. However, few subjects of this study were enrolled from supervisory staffs in order to have a complete and comprehensive understanding of the occupational health condition. These workers were randomly selected from the total workforce in the selected clusters and mines.

Data collection: The information regarding demographic, occupational and clinical history was collected on a pre-designed and pre-tested proforma through interview of subject. This was followed by complete clinical examination, spirometry, audiometry and chest radiography of each subject. The audiometer and spirometer were brought by NIOH team while for chest radiography the facilities at BCCL hospitals were used. The processing of exposed films was done by the technicians at BCCL hospital. The ophthalmological examination and haematological – biochemical estimations were also done using facilities and expertise at BCCL hospitals.

Data analysis: Data entry and analysis were done in standard statistical software. The statistical analysis included calculation of differences, proportions and application of tests of significance etc, to ascertain health effects especially respiratory health conditions.

RESULTS

- This study covered 351 subjects from Kustore sector and 140 subjects from Baghmara sector of BCCL Collieries. Mean age of the workers was 45.9 ± 8.36 years. Most of the workers were between 35-54 years age. Mean job experience was 11.72 ± 8.49 years.
- Most common symptoms complained by study subjects were musculoskeletal pain (34%). Other complaints were Cough, difficulty in breathing, chest pain, soreness of mouth etc. Headache, sleep disturbance, weakness, tremor in fingers was also experienced by some subjects.
- About 20% subjects had systolic blood pressure >140 as well as diastolic blood pressure >90 mm of Mercury. 9% workers had only higher systolic blood pressure and 11% had only higher diastolic blood pressure.

- As far as pulmonary functional status of study subjects is concerned, about 3% subjects had restrictive type of abnormality ($FVC/PFVC < 80\%$) and 0.6 % subjects had combined type of abnormality ($FVC/PFVC < 80\%$ and $FEV1\% < 70\%$). A good number of subjects (36.5%) had $FEV1\%$ values between 70% and 80%. Mean FVC values were significantly lower among the subjects of age 45 years or above.
- So far as chest radiographic findings are concerned, 93% subjects had findings within normal limits. 3% subjects showed findings suggestive of opacities in lung and almost 1.5% had other features on chest X-ray (mostly suggestive of Koch's infection of lung). Such findings may be due to pneumoconiotic changes in lung, hence these subjects should be properly followed up and necessary medical, ethical, legal, administrative actions may be initiated as necessary.
- Haematological and biochemical findings of the subjects were mostly within normal limits. Almost 11% workers had random blood sugar level more than 140 units. As far as ophthalmological findings are concerned, 5% subjects had uncorrected vision and 9% subjects had Cataract in eyes.
- Decline in hearing ability with increasing duration of exposure was observed more at higher frequency; however, this observation is subject to adjustment for age and other probable factors.
- The subjects for this study are selected from workplaces identified by BCCL, Govt. of India, as required for the purpose of this study. The findings of this study may thus be restricted to the concerned workplaces and may not be generalisable.

RECOMMENDATION

- o Prevalence of musculoskeletal pain during work in a good number of workers reflects that manual work of the work processes might be causing some discomfort for the workers. Training on proper method of manual material handling may prove useful of these workers. On the other hand regular proper exercise should be promoted among workers especially supervisory employees to get rid of ill effects of sedentary activities.
- o Special emphasis should be given to protection of respiratory health, hearing ability. Periodic relevant examination (lung function test, audiometry) at regular interval is recommended.
- o Industrial hygiene survey (periodic monitoring of dust and other environmental hazards) at regular interval should be undertaken including noise level monitoring in different operations.
- o Some prevalent symptoms observed may be representation of nervous system effect due to exposures to toxicants. In order to exclude the possibility of exposure from occupational environment, environmental study should include assessment of exposure to metals.
- o Measures like using protective appliances (e.g. PPEs), pre-placement- and periodic medical examination, for the control and prevention of relevant health hazards, are to be implemented and maintained by all the mining areas to protect the health of the workers.

ANNEXURE

(Sample proforma for undertaking
occupational health studies)

Study of occupational diseases and hearing impairments of coalmine workers directly involved in active mining operations

Date: / /

Code No.

PERSONAL AND RESIDENTIAL INFORMATION

Name: _____

Age (completed years): _____ Sex: 1. Male 2. Female

Marital status: 1. Single 2. Married 3. Divorcee 4. Widow(er)

Education: 1) Illiterate 2) 1-4 3) 5-10 4) 11-12 5) College

Number of family members: _____ Mine Name: _____

Residential address: _____

Smoking history: 1) Non-smoker 2) Smoker 3) Past smoker

A. Type of smoking: 1) Beedi 2) Cigarette 3) Other (specify)

B. Frequency (Number per day) C. Duration (years)

Reason from Abstaining From Smoking: 1. Respiratory Problem 2. Any Other Reason

Do You Chew Tobacco: 1. Yes 2. No If Yes, Duration (Yrs.) Frequency: No/day

Do You Drink Alcohol?: 1. Yes 2. No If yes, Duration (Yrs)

Frequency: 1. Regularly 2. Occasionally

OCCUPATIONAL HISTORY

Since how many years you are working in this job

Present Occupational History

No	Designation	Nature of job	Duration (years)
1.			
2.			
3.			

Past Occupational History

No	Designation	Nature of job	Duration (years)
1.			
2.			
3.			

PAST MEDICAL HISTORY:

Have you suffered from any of the following diseases in the past?

PTB ☐ Chronic bronchitis ☐ Recurrent cough and cold ☐ Bronchial asthma ☐ HT ☐ Jaundice ☐ CKD ☐

Any other major illness 1. No

2. Yes ☐ If yes, specify _____

Family history: Has anybody in your family or blood relation suffered from any of the following diseases?
(Also mention the relationship)

PTB ☐ Chronic bronchitis ☐ Recurrent cough and cold ☐ Bronchial asthma ☐ HT ☐ Jaundice ☐ CKD ☐

Any other major illness 1. No

2. Yes ☐ If yes, specify _____

PRESENT MEDICAL HISTORY:

Cough: Do you have cough? 1. No 2. Yes ☐ If 'Yes', Is it Productive ☐ Non productive ☐

If productive go to next symptom

Phlegm: Do you usually bring up phlegm from your chest first thing in the morning? 1. No 2. Yes ☐

(If 'Yes', please go to the next question. If 'No', go to the next symptom)

Do you bring up phlegm like this on most days for as much as 3 months per year? 1. No 2. Yes ☐

If yes since how many years ☐

Have you ever coughed up blood in sputum? 1. No 2. Yes ☐

If 'Yes', when did you have the last haemoptysis (weeks back)? ☐

Dyspnoea: Do you suffer from breathlessness? 1. No 2. Yes ☐ *(If 'Yes', go to next question. If 'No' go to next symptom)*

Are you ever troubled by shortness of breath, while hurrying on the level or walking up a slight hill?

1. No 2. Yes ☐

(If 'No', grade is 1. If 'Yes', proceed to next question)

Do you get short of breath while walking with a person of approximately your age and sex?

1. No 2. Yes ☐

(If 'No', grade is 2. If 'Yes', proceed to next question)

Do you have to stop for breath when walking at your pace on the level?

1. No 2. Yes ☐

(If 'No', grade is 3. If 'Yes', proceed to next question)

Are you short of breath while washing or dressing up or other routine activity? 1. No 2. Yes ☐

(If 'No', grade is 4. If 'Yes', grade is 5)

Final assessment of the grade of dyspnoea (grade 1-5) ☐

Do you have attacks of breathlessness at night? 1. No 2. Yes ☐

Chest pain: Do you have chest pain? 1. No 2. Yes ☐ *(If 'Yes', go to the next question. If 'No', go to next symptom.)*

Is it increased by deep inspiration/Coughing/Sneezing 1. No 2. Yes ☐

Mention the site(s) of chest pain _____

Any other information, specify _____

Do you have following symptoms

Symptom	1.Present/ 2.Absent	Duration (years)	Symptom	1.Present/ 2.Absent	Duration (years)
GENERAL AND SKIN			D. MUSCULOSKELETAL		
Tiredness	☐		Muscle cramps	☐	
Weight loss	☐		Muscle pains	☐	
Recurrent infections	☐		Backache	☐	
Skin rashes	☐				
Itching	☐		E. CENTRAL NERVOUS SYSTEM		
ORAL CAVITY AND G.I. TRACT			Headache	☐	
Excessive salivation	☐		Dizziness	☐	
Loose teeth	☐				
Soreness of throat	☐		Difficulty in hearing	☐	
Soreness of mouth	☐		Difficulty in speech	☐	
			Irritability	☐	
Loss of appetite	☐		Inability to concentrate	☐	
Nausea	☐		Forgetfulness	☐	
Vomiting	☐				
Diarrhoea	☐		Sleep difficulty / disturbances	☐	
Colicky pain in abdomen	☐		Muscular weakness	☐	
RENAL			Tingling in extremities	☐	
Decreased urine	☐		Numbness in extremities	☐	
Hematuria	☐				
Edema over face	☐		Tremors	☐	
			Convulsions	☐	

MEDICAL EXAMINATION

General Examination

Height(cms): _____

Weight (kgs): _____ Pulse/min:

BSA (m²) _____

Pallor: 1. Present 2. Absent ☐

B P: Systolic: _____ mm/Hg Diastolic: _____ mm/Hg

Nails: 1. Normal 2. Abnormal Specify _____

Cyanosis: 1. Present 2. Absent Others(oedema, LNpathy, varicose etc.): 1. Present 2. Absent

Skin: 1. Normal 2. Abnormal ☐ Specify abnormality _____

Mouth and lips: 1. Normal 2. Angular stomatitis 3. Pigmentation 4. Ulceration 5. Blue line over gums

Systemic Examination

Respiratory System

Inspection: 1. Normal 2. Abnormal ☐ Specify abnormality _____

Palpation: 1. Normal 2. Abnormal ☐ Specify abnormality _____

Percussion: 1. Normal 2. Abnormal ☐ Specify abnormality _____

Auscultation: 1. Normal 2. Abnormal ☐ Specify abnormality _____

Intensity: 1. Normal 2. Increased 3. Decreased ☐

Character: 1. Vesicular 2. Broncho-vesicular 3. Bronchial ☐

Added sounds: 1. Fine crepts 2. Coarse crepts 3. Rhonchi 4. Rub ☐

Basal Creptitations: 1. Present 2. Absent ☐

If present, which side: 1. Right 2. Left ☐

Other Systems

Abdomen: Liver: 1. Normal 2. Enlarged ☐ Spleen: 1. Normal 2. Enlarged

CVS: 1. Normal 2. Abnormal ☐ Specify abnormality _____

CNS: Higher functions: 1. Normal 2. Abnormal ☐ Specify abnormality _____

Tremors: 1. Present 2. Absent ☐ If present, specify _____

Motor system abnormality: 1. Present 2. Absent If present, specify _____

Sensory system abnormality: 1. Present 2. Absent If present, specify _____

Abnormal Reflexes: 1. Present 2. Absent If present, specify _____

Any other abnormality: 1. Present 2. Absent If present, specify _____

PULMONARY FUNCTION TESTS

Physical Characteristics:

1. Age: _____ Yrs. 2. Height: _____ Cm 3. Weight: _____ Kg. 4. BSA: _____ m²

Pulmonary Function Test

SVC _____ (l) FVC _____ (l)
FEV 1.0 _____ (l) FEV1.0/FVC _____
FEF0.2 - 1.21 _____ (l/s) FEF 25 - 75 % _____ (l/s)
FEF 75 - 85 % _____ (l/s)
PEFR _____ (l/m)

PFT Diagnosis: 1. Normal 2. Obstructive 3. Restrictive 4. Combined ☐

X Ray findings: _____

Final Diagnosis: _____

ANNEXURE - XII



Moonidih Plantation Site

No. of plants – 600

Variety – Mango, Bamboo, Babul, Jamun, Guava, Kathal, Siris, kachnar, Kaju, neem



Plantatation in Moonidih XV Seam Incline in Vriksharopan Abhiyan, 2021

Planatation Along the mine boundary

ANNEXURE - XIII

STRICTLY RESTRICTED

FOR COMPANY USE ONLY RESTRICTED

The information given in this report is not to be communicated either directly or indirectly to the press or to any person not holding an official position in the CIL / GOVERNMENT.

WATER QUALITY REPORT OF BHARAT COKING COAL LIMITED, CLUSTER – XI

(FOR THE Q.E. JUNE 2021)

E. C. no. J-11015/77/2011-IA.II (M) dated 26.08.2013.



CMPDI

ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

WATER QUALITY

(SURFACE WATER- 17 PARAMETERS)

Name of the Company: **Bharat Coking Coal Limited**

Year : **2021-22**

Name of the Project : **Cluster - XI**

Period: **Q.E. JUNE 2021.**

Stations:

1. Upstream in Jarian Nala SW-23
2. Downstream in Jarian Nala SW-24
3. Upstream in Damodar river SW-25
4. Downstream in Damodar river SW-26

Date of Sampling:

07/06/2021
07/06/2021
07/06/2021
07/06/2021

Sl. No	Parameter	Sampling Stations				IS: 2296	Detection Limit	BIS Standard & Method
		SW23	SW24	SW25	SW26			
1	Arsenic (as As), mg/l, Max	<0.006	<0.006	<0.006	<0.006	0.2	0.006	IS-3025, part 37:1988, R-2019/ APHA 23 rd Edition AAS-VGA
2	BOD (3 days 27°C), mg/l, Max	2.1	2.0	<2.0	<2.0	3.00	2.00	IS 3025 (Part 44) : 1993 Reaffirmed 2019 , 3 day incubation at 27°C
3	Colour	3	2	1	1	1-100.0 Hazen Units	1	APHA, 23 rd Edition , 2120-B-:2017
4	Chlorides (as Cl), mg/l, Max	50	46	24	26	600	2.00	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.2	<0.2	<0.2	<0.2	1.5	0.2	IS 3025/42 : 1992 R : 2019, AAS-Flame
6	Dissolved Oxygen, min.	5.0	4.8	4.9	4.9	4	0.10	IS 3025 (Part 38) : 1989, Reaffirmed 2019 Modified Winkler Azide Method
7	Fluoride (as F) mg/l, Max	0.88	0.81	0.59	0.55	1.5	0.02	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
8	Hexavalent Chromium, mg/l, Max	0.011	0.014	<0.01	<0.01	0.05	0.01	IS 3025 (Part 52) : 2003, Reaffirmed 2019
9	Iron (as Fe), mg/l, Max	<0.2	<0.2	<0.2	<0.2	50	0.2	IS 3025 /53 : 2003, R : 2019 , AAS-Flame Method
10	Lead (as Pb), mg/l, Max	<0.005	<0.005	<0.005	<0.005	0.1	0.005	APHA, 23 rd Edition, AAS-GTA
11	Nitrate (as NO ₃), mg/l, Max	9.42	11.92	5.15	6.31	50	0.50	APHA, 23 rd Edition, P-4-127, 4500 - NO ₃ - B , UV-Spectrophotometric Screening Method
12	pH value	7.58	7.29	7.12	7.35	6.5-8.5	2.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
13	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.002	<0.002	<0.002	<0.002	0.005	0.002	APHA, 22 nd Edition 4-Amino Antipyrine
14	Selenium, mg/l, Max	<0.007	<0.007	<0.007	<0.007	0.05	0.007	IS-3025, part 56:2003, R-2019/ APHA 23 rd Edition, AAS-VGA
15	Sulphate (as SO ₄) mg/l, Max	219	180	66	79	400	10	APHA -23 rd Edition. P-4-199, 4500 SO ₄ ²⁻ E
16	Total Dissolved Solids, mg/l, Max	416	411	225	238	1500	25.00	IS 3025, Part 16: 1984 R 2017 Gravimetric method
17	Zinc (as Zn), mg/l, Max	<0.1	<0.1	<0.1	<0.1	15	0.1	IS 3025/ 49 : 1994, R : 2019, AAS-Flame

All values are expressed in mg/lit unless specified.


 Analysed By
 JSA/SA/SSA


 Checked By
 Lab In Charge
 RI-2, CMPDI, Dhanbad


 Approved By
 HOD(In-charge) Environment
 RI-2, CMPDI, Dhanbad

WATER QUALITY **(DRINKING WATER- 25 PARAMETERS)**

Name of the Company: **Bharat Coking Coal Limited**

Year : **2021-22**

Name of the Project : **Cluster - XI**

Period: **Q.E. JUNE 2021**

Stations:

Date of Sampling:

1. Drinking Water from **Bhagaband DW-11**

31/05/2021

Sl. No	Parameter	Sampling Stations			Detection Limit	IS:10500 Drinking Water Standards	Standard / Test Method
		DW11					
1	Boron (as B), mg/l, Max	<0.2			0.2	0.5	APHA, 23 rd Edition ,Carminc
2	Colour,in Hazen Units	3			1	5	APHA, 23 rd Edition ,Pt.-Co. Method
3	Calcium (as Ca), mg/l, Max	96			1.6	75	IS 3025, Part 40: 1991 R 2019 EDTA Method
4	Chloride (as Cl), mg/l, Max	103			2	250	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.03			0.03	0.05	IS 3025 Part 42 : 1992 R : 2019, AAS-Flame APHA,23 rd Edition, AAS-GTA
6	Fluoride (as F) mg/l, Max	0.82			0.2	1.0	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
7	Free Residual Chlorine, mg/l, Min	<0.04			0.04	0.2	APHA, 23 rd Edition, , 4500-Cl ⁺ B. (Iodometric Method-I)
8	Iron (as Fe), mg/l, Max	0.59			0.2	1.0	IS 3025 Part 53 : 2003, R : 2019 , AAS-Flame Method
9	Lead (as Pb), mg/l, Max	<0.005			0.005	0.01	IS:3025(Part 47):1994 (Reaffirmed 2019) APHA, 23 rd Edition, AAS-GTA
10	Manganese (as Mn), mg/l, Max	0.02			0.02	0.1	APHA, 23 rd Edition, 3111B, Direct Air Acetylene Flame AAS-Flame
11	Nitrate (as NO ₃), mg/l, Max	0.84			0.5	45	APHA, 23 rd Edition, P-4-127, 4500 - NO ₃ - B , UV-Spectrophotometric Screening Method
12	Odour	Agreeable			Qualitative	Agreeable	APHA, 23 rd Edition, , 2150-C
13	pH value	7.42			0.2	6.5-8.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
14	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.001			0.001	0.002	APHA, 22 nd Edition,4-Amino Autipyrine
15	Selenium, mg/l, Max	<0.007			0.007	0.01	IS -3025,part 56:2003,R-2019/APHA 23 rd Edition, AAS-VGA
16	Sulphate (as SO ₄) mg/l, Max	202			10	200	APHA -23 rd Edition, P-4-199, 4500 SO ₄ ²⁻ E
17	Taste	Acceptable			Qualitative	Acceptable	APHA,23 rd Edition, 2160-C Flavour Rating Assesment
18	Total Alkalinity (c _a co ₃),, mg/l, Max	198			4	200	IS 3025, Part 23: 1986 R 2019 Titration Method
19	Total Arsenic (as As), mg/l,Max	<0.006			0.006	0.01	IS-3025, part 37:1988,R-2019/APHA23 rd Edition AAS-VGA
20	Total Chromium (as Cr), mg/l, Max	<0.04			0.04	0.05	IS-3025 Part 52:2003, R:2019,AAS-Flame APHA, 23 rd Edition, AAS-GTA
21	Total Dissolved Solids, mg/l, Max	826			25	500	IS 3025, Part 16: 1984 R 2017 Gravimetric method
22	Total Hardness (c _a co ₃), mg/l, Max	612			4	200	IS 3025, Part 21, 2009 R 2019 EDTA Method
23	Turbidity, NTU, Max	3			1	5	IS 3025, Part 10 : 1984 R 2017 Nephelometric Method
24	Zinc (as Zn), mg/l, Max	1.16			0.1	5	IS 3025 Part 49 : 1994,R : 2019, AAS-Flame
25	Nickel as Ni, mg/l Max	<0.01			0.01	0.02	IS 3025 Pat 54 : 2003,R : 2019, AAS-Flame APHA 23 rd Edition, AAS-GTA

All values are expressed in mg/lit unless specified.

अनुमान रंजु राहुल

Analysed By
JSA/SA/SSA

✓

Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

अतिर

Approved By
HOD(In-charge) Environment
RI-2, CMPDI, Dhanbad

WATER QUALITY

(Mine WATER- 17 PARAMETERS)

Name of the Company: **Bharat Coking Coal Limited**

Year : **2021-22.**

Name of the Project : **Cluster - XI**

Period: **Q.E. JUNE 2021.**

Effluent water of BCCL Mines					Date of Sampling:
Sample Code :MW 11					07.06.2021
Sl.No.	Parameter	MW-11	Detection Limit	MOEF -SCH-VI STANDARDS Class 'A'	BIS Standard & Method
1	Ammonical Nitrogen, mg/l, Max	<0.02	0.02	50.0	IS 3025/34:1988, R : 2009, Nessler's
2	Arsenic (as As), mg/l, Max	<0.006	0.006	0.2	IS 3025, part 37:1988, R-2019/ APHA 23 rd Edition AAS-VGA
3	B.O.D (3 days 27°C), mg/l, Max	<2.0	2.00	30.0	IS 3025 /44:1993,R:2003 3 day incubation at 27°C
4	Colour	<1	Quantitative	Quantitative	APHA 23 rd Edition, 2120B 2017
5	COD, mg/l, Max	28	4.00	250.0	APHA 23 rd Edition 5220 C Titrimetric Method
6	Copper (as Cu), mg/l, Max	<0.2	0.2	3.0	IS 3025(Part42): 1992 R : 2019, AAS-Flame
7	Dissolved Phosphate (as P), mg/l, Max	<0.1	0.10	5.0	IS 3025/ 31, 1988 R 2019
8	Fluoride (as F) mg/l, Max	0.56	0.2	2.0	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
9	Free Ammonia, mg/l, Max	<0.01	0.01	5.0	IS:3025/34:1988, Nessler's
10	Hexavalent Chromium, mg/l, Max	<0.01	0.01	0.1	IS 3025 (Part 52) : 2003,Reaffirmed 2019
11	Iron (as Fe), mg/l, Max	<0.2	0.2	3.0	IS 3025 (Part 53) : 2003, R : 2019 , AAS-Flame
12	Lead (as Pb), mg/l, Max	<0.005	0.005	0.1	APHA, 23 rd Edition, AAS-GTA
13	Manganese(as Mn), mg/l, Max	<0.2	0.2	2.0	IS-3025(Part 59):2006, R 2017 AAS-Flame /APHA, 23 rd Edition, 3111B, AAS-Flame
14	Nickel (as Ni), mg/l, Max	<0.1	0.1	3.0	IS-3025(Part 54):2003, R:2019 AAS-Flame
15	Nitrate Nitrogen, mg/l, Max	0.59	0.50	10.0	APHA, 23 rd Edition,UV-Spectrophotometric
16	Oil & Grease, mg/l, Max	<2.0	2.00	10.0	IS 3025/39:1991, R : 2019, Partition Gravimetric
17	pH value	7.81	2.5	5.5 to 9.0	IS-3025/11:1983, R-2017, Electrometric
18	Phenolic compounds (as C ₆ H ₅ OH),mg/l, Max	<0.002	0.002	1.0	APHA, 23 rd Edition 4-Amino Antipyrine
19	Selenium, mg/l, Max	<0.007	0.007	0.05	IS 3025, part 56:2003, R-2019/APHA 23 rd Edition, AAS-VGA
20	Sulphide (as S ²⁻) mg/l Max.	<0.005	0.005	2.0	APHA 23 rd Edition Methylene Blue Method
21	Temperature (°C)	32.1	Shall not exceed 5° C above the receiving temp.		IS-3025/09:1984, Thermometric
22	Total Chromium (as Cr), mg/l, Max	<0.1	0.1	2.0	IS-3025(Part 52):2003, R:2019 AAS-Flame
23	Total Kjeldahl Nitrogen, mg/l, Max	<1.0	1.00	100.0	IS:3025/34:1988, Nessler's
24	Total Residual Chlorine, mg/l, Max	<0.04	0.04	1.0	APHA, 23 rd Edition, , 4500-Cl B. (Iodometric Method-I)
25	Total Suspended Solids, mg/l, Max	42	10.00	100.0	IS 3025/17:1984, R :2017, Gravimetric
26	Zinc (as Zn), mg/l, Max	<0.1	0.1	5.0	IS 3025 /49 : 1994, R : 2019, AAS-Flame
27	Odour	Agreeable	Agreeable	Qualitative	APHA, 23 rd Edition, , 2150-C

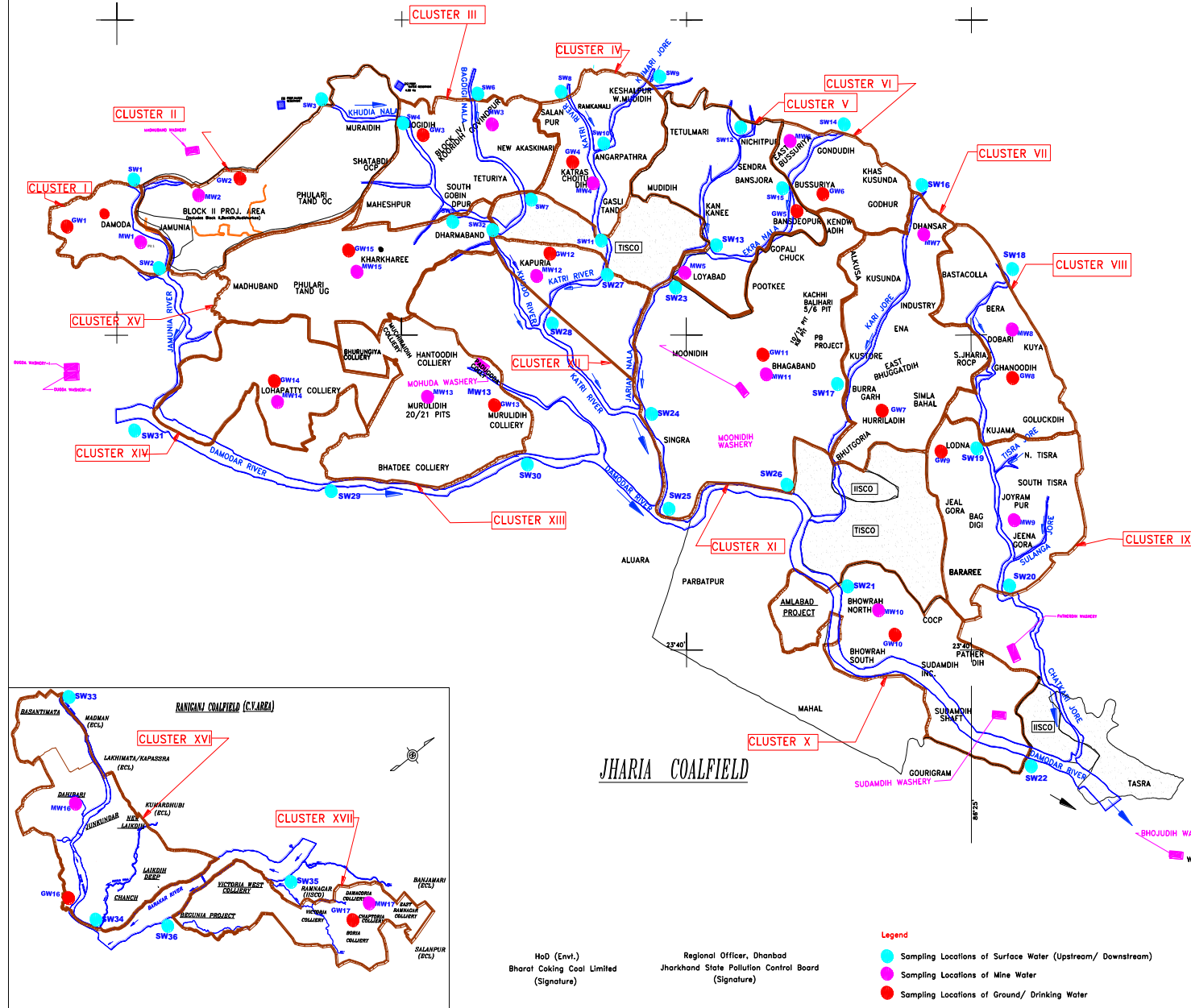
All values are expressed in mg/lit unless specified.


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 RI-2, CMPDI, Dhanbad


 Approved By
 HOD(In-charge) Environment
 RI-2, CMPDI, Dhanbad

Water Sampling Locations in BCCL



INDEX

Cluster	Surface Water (US, DS)	Name of River/ Nala/ Jore	Minel Effluent Water	Sampling Location	Ground Water	Sampling Location
I	SW1, SW2	Jamunia River	MW1	Damoda Area	GW1	Chowdhury Village
II	SW3, SW4	Khudia Nala	MW2	Block II OCP	GW2	Joyrampur Village
III	SW4, SW5, SW6, SW7	Khudia Nala, Bagdigi Nala	MW3	Govindpur Colliery	GW3	Jogdih Village
IV	SW8, SW11, SW9, SW10	Kain River, Kurnari Jore	MW4	Chotudih	GW4	Kankanee Village
V	SW12, SW13, SW15	Jarian Nala, Ekra Nala	MW5	Mudidi	GW5	Nichitpur
VI	SW14, SW15	Ekra Nala	MW6	East Bassuria UGP	GW6	Bansira Borewell
VII	SW16, SW17	Kan Jore	MW7	Dhansar UGP	GW7	Humliadih
VIII	SW18, SW19	Kashi Jore	MW8	Doban UGP	GW8	Gharudih
IX	SW19, SW20	Kashi Jore	MW9	Jeenagora	GW9	Lodna
X	SW21, SW22	Damodar River	MW10	Bhowrah North	GW10	Bhowrah South
XI	SW23, SW24, SW25, SW26	Damodar River	MW11	Bhagaband UGP	GW11	Bhagaband
XII	SW27, SW28	Kan River	MW12	Kapuria	GW12	Kapuria
XIII	SW29, SW30	Damodar River	MW13	Murudih (20/21)	GW13	Murudih
XIV	SW31, SW29	Damodar River	MW14	Lohapatti	GW14	Lohapatti
XV	SW5, SW32	Khudia Nala	MW15	Kharkharee UGP	GW15	Kharkharee
XVI	SW33, SW34	Khudia River	MW16	Dahbani OCP	GW16	Patlabari Village
XVII	SW35, SW36	Batakal River	MW17	Damagoria Colliery	GW17	Chaptoria

Legend

- Sampling Locations of Surface Water (Upstream/ Downstream)
- Sampling Locations of Mine Water
- Sampling Locations of Ground/ Drinking Water

HoD (Env.)
Bharat Coking Coal Limited
(Signature)

Regional Officer, Dhanbad
Jharkhand State Pollution Control Board
(Signature)



**GROUNDWATER LEVEL & QUALITY REPORT
FOR CLUSTER OF MINES, BCCL**

(Assessment year – 2020-21)

[CLUSTER – I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XIII, XIV, XV & XVI of Mines, BCCL]

JHARIA COALFIELD AND RANIGANJ COALFIELD (PART)

**For
(BHARAT COKING COAL LIMITED)**

(A Subsidiary of Coal India Limited)

KOYLA BHAWAN (DHANBAD)

**Prepared by
Hydrogeology Department
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MARCH – 2021

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(Accredited by NABL, valid upto: 2022)

(Accredited as a FAE in (HG) by QCI-NABET, valid upto: Aug'2021)

CONTENT

Sl. No	Contents	Page No
1	Annexure-I Details of The Report	1
2	Annexure-II Groundwater Level and Quality Report for Cluster of Mines of BCCL	2-88
3	Chapter-1.0 Introduction	2-6
4	1.1 Location details and brief about the report	2
5	1.2 Objective of the study	2
6	1.3 Scope of the report	2-3
7	1.4 Topography and Drainage	4
8	1.5 Details regarding Wetland	4
9	1.6 Climate & Rainfall	5-6
10	Chapter-2.0 Geology & Hydrogeological Set-up of the Area	7-10
11	2.1 Regional Geology of the Coalfield	7
12	2.2 Hydrogeological setup	8
13	2.3 Aquifers Description	8-9
14	2.4 General Aquifer Parameters	9-10
15	Chapter-3.0 Ground Water Level data of the Cluster of Mines of BCCL	10-
16	3.1 Historical groundwater level	11
17	3.2 Groundwater level scenario (mining/non-mining)	12
18	3.3 Quarterly groundwater level, Cluster of mines during 2020-21	13
	A. Ground Water Levels of Cluster-I	13-14
	B. Ground Water Levels of Cluster-II	15-16
	C. Ground Water Levels of Cluster-III	17-18
	D. Ground Water Levels of Cluster-IV	19-20
	E. Ground Water Levels of Cluster-V	21-22
	F. Ground Water Levels of Cluster-VI	23-24
	G. Ground Water Levels of Cluster-VII	25-26
	H. Ground Water Levels of Cluster-VIII	27-28
	I. Ground Water Levels of Cluster-IX	29-30
	J. Ground Water Levels of Cluster-X	31-32
	K. Ground Water Levels of Cluster-XI	33-34
	L. Ground Water Levels of Cluster-XIII	35-36
	M. Ground Water Levels of Cluster-XIV	37-38

	N. Ground Water Levels of Cluster-XV	39-40
	O. Ground Water Levels of Cluster-XVI	41-42
19	Chapter-4.0 Ground water level scenario	43
20	Chapter-5.0 Groundwater Quality	44
21	Chapter-6.0 Stage of Groundwater extraction	45
22	Chapter-7.0 Impact of Mining on Ground Water Regime	46-
23	7.1 General consequences of Coal Mines on ambient Hydrogeological Regime	46
24	7.2 Potential consequences of OC & UG coal mines on Hydrogeological Regime	47
25	7.3 Estimation of Radius of Mine Influence zone	47
26	Chapter-8.0 Conservation measures & future strategy	48
27	Chapter-9.0 Existing / Proposed Rainwater harvesting structures in BCCL coal mines	50-56
28	Annexure-III List of RAMSAR Wetlands as given on official website of MoEF & CC	57
29	Annexure-IV Rainfall Data	58
30	Annexure-V Ground Water Level Monitoring Data	60-64
31	Annexure-VI Ground Water Level Hydrographs	65-81
32	Annexure-VII Ground Water Quality analysis data	82-87
33	Abbreviations	88

LIST OF TABLES

Fig No	Contents	Page No
1	Regional Geological Succession of JCF	7
2	Generalized Hydrogeological Units developed in the study Area	9
3	Aquifer parameters considered for the study Area	10
4	Historical Groundwater Level	11
5	Depth to water table	12
6	Average hydraulic gradient	12
7	GW level data Cluster wise	43
8A, B	Block / Cluster wise GW Development scenario	45

LIST OF PLATES

Sl No	Plate No	Contents	Scale
1	I	Location Map of Groundwater Level Monitoring stations	1:50000
2	II	Location Map of Groundwater Quality Monitoring stations	1:50000
3	III	Location Map of Proposed Piezometers	1:50000
4	IV	Water table Contour Map of JCF	1:50000
5	V	Depth to Groundwater Level map of JCF	1:50000

LIST OF FIGURES

Table No	Contents	Page No
1 & 2	Historical Rainfall trend at Jharkhand	6
3 to 15	Existing / Proposed Rainwater Harvesting Structure	50-56

DETAILS OF THE REPORT

SI No.	ITEMS	INFORMATIONS
1	Geographical Area	Jharia Coalfield (JCF): 453 sq. km. Raniganj Coalfield (RCF part): 19.64 sq. km. (Cluster-XVI area only)
2	Major Physiographic Units	Dissected Pediplain with surface Reduced Level (RL) varies from 160 m to 220 m above mean sea level (AMSL) in JCF and 100 m to 140 m AMSL in RCF.
3	Drainage System	Damodar River is the master drainage flowing along western boundary of the JCF. Jamunia River, Khudia River, Katri River, Jarian Nala, Ekra Jore, Kari Jore, Kashi Jore, Chatkari Jore and their tributaries are flowing through the JCF area. Damodar River, Barakar River is the master drainage of the part of RCF area (CV Area).
4	Annual Rainfall (IMD-report)	Jharkhand State: 1264.10 mm Rainfall data given in Annexure-IV .
5	Geological Formations	Gondwana Formation (Talchir Formation, Barakar Formation, Barren Measure Formation & Raniganj Formation)
6	Aquifer System	Unconfined/Phreatic Aquifer – thickness 25 m (Avg.) Semi-confined to confined Aquifer – thickness from 25 m upto 650 m
7	Hydrogeological properties (Aquifer Pump Test)	Unconfined Aquifer (Damoda BJ Section & Block-II): Hydraulic Conductivity – upto 0.50 m/day Transmissivity – 10 - 42 m ² /day Semi-confined to confined Aquifer (Sitnala & Kumari Block): Hydraulic Conductivity – 0.0006-1.44 & 0.05-0.0027 m/day Transmissivity – 0.06 – 0.573 m ² /day
8	Groundwater Level Monitoring Network	Out of total 252 nos. of monitoring stations 64 nos located within core mining area and rest comes within Buffers zone. 60 Nos. of Groundwater monitoring well (Dug Wells) network established by CMPDI to record groundwater level data in and around the Core Zone of JCF and 4 Nos. of Groundwater monitoring well (Dug Wells) in RCF (CV Area).
9	Groundwater Levels Below Ground Level (bgl)	JCF area: Pre-monsoon – 0.80 to 16.25 m (Avg. 4.95 m bgl) in '2020 Post-monsoon – 0.75 to 10.10 m (Avg. 3.26 m bgl) in '2020 RCF area (part): Pre-monsoon – 2.30 to 9.70 m (Avg. 4.30 m bgl) in '2020 Post-monsoon – 1.75 to 5.50 m (Avg. 2.70 m bgl) in '2020
10	Groundwater Quality	Potable as per GEC-2015 Norms (Annexure- VIII)
11	Proposed Piezometers	Proposed piezometers (23 nos.) to monitor impact of coal mining on groundwater regime within the coalfield area (JCF & part of RCF) for maximum depth upto 290 m.
12	Stage of Groundwater Development (CGWB)	Dhanbad District-76.30% (GWRE-2017)

GROUNDWATER LEVEL & QUALITY REPORT FOR CLUSTER OF MINES OF BCCL

1.0 INTRODUCTION

1.1 LOCATION DETAILS AND BRIEF ABOUT THE PROJECT

The 15 nos. Cluster of mines (Cluster-I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XIII, XIV, XV and XVI) of BCCL is located in the Jharia coalfield in Bokaro district of and Dhanbad district of Jharkhand and part of Raniganj coalfield of Dhanbad district of Jharkhand.

The area of Jharia Coalfield (JCF) is 453 sq. km. and Raniganj Coalfield (RCF part) is 19.64 sq. km. (Cluster-XVI area only). Located about 3.0 km south-west of Dhanbad town and 10.0 km north-east of Bokaro town. The coalfield bounded by Jamunia River in the west, Damodar river in the south, and metamorphics (hard rock) in the north and east side. **(Plate-I)**.

1.2 OBJECTIVE OF THE STUDY:

The objective of the report is to conducting hydrogeological study by quarterly monitoring of groundwater level and quality of the Jharia coalfield and Raniganj coalfield (part) within BCCL command area for 15 nos. Cluster of mines of BCCL. The data collected shall submitted to the MoEF&CC, CPCB & SPCB within stipulated timeframe. The work being done yearly and require d to be continued as per the specific condition mentioned invariably in Environmental Condition (EC) for all of the Clusters of BCCL.

1.3 SCOPE OF THE STUDY:

The following scope has taken into account for hydro-geological investigation of the study area.

- i) The monitoring of the groundwater levels done four times/year during (May, August, Nov and Jan).
- ii) The monitoring of the groundwater quality done during May including Arsenic and Fluoride.
- iii) To evaluate the status of ground water level condition in the area.
- iv) To study the ground water flow direction in the mining areas.
- v) To study the depth to ground water level condition in the mining areas.
- vi) To study the ground water quality data and interpretation in the mining areas.

File No. 08HBDD/JRRI/BCCL/ENV/0003/2018-BD Divn.-CMPDI (Computer No. 68378)
Receipt No : 188686/2018/O/e HEAD OF BUSINESS DEVELOPMENT, CMPDI HQ
भारत कोकिंग कोल लिमिटेड

एक मिनी रत्न कंपनी
(कोल इंडिया लिमिटेड का एक अंग)
कोयलाभवन, कोयलानगर, धनबाद -826005



Bharat Coking Coal Limited
A Mini Ratna Company
(A Subsidiary of Coal India Limited)
Regd.Off: Koyla Bhawan, Koyla Nagar

CIN: U10101JH1972GOI000918
Environment Department

पत्र संख्या भाकोकोलि/उप महाप्रबंधक(पर्या0)/संचिका-18/1086- दिनांक : 14.06.2018
1088/14)

सेवा में,
महाप्रबंधक
व्यापार विकास

सीएमपीडीआई - कांके रोड रांची ८३४०३१-

Sub: For work of Ground water level and quality monitoring

महोदय,

This is with reference to earlier letter ref no. BCCL/HOD(Env)/F-Env/13/161 dated 11.02.2014 regarding conducting hydrological study by quarterly monitoring of groundwater level and quality of the study to be carried out by establishing a network of existing wells. The monitoring for quantity shall be done four times a year in pre-monsoon (May), monsoon (August), post-monsoon (November) and winter (January) season and for quality including Arsenic and Fluoride during month of May. Data thus collected shall be submitted to the Ministry of Environment & Forest and to Central Pollution Control Board/SPCB quarterly within one month of monitoring.

The above work is being done yearly and required to be continued as per the specific condition mentioned invariably in Environment Clearance order of all clusters of BCCL.

This is for your kind information and further necessary action

भवदीय

14/6/18
उप-महाप्रबंधक (पर्यावरण)

Copy To:

१ महाप्रबंधक (गवेषण), कांके रोड रांची ८३४०३१-

1.4 TOPOGRAPHY AND DRAINAGE

Northern part of the JCF area covered with hills and thin forest. In general, the altitude varies from 220 m AMSL in Barora area (Cluster-I) to 160 m above mean sea level (AMSL) in Sudamdih area (Cluster-X). Pediplains developed over sedimentary rocks or Gondwana formation consisting of Sandstone, Shale, coal, etc. Dissected pediplains developed over Gondwana formations found in Jharia, Baghmara, Katras areas etc. However, in RCF (part) areas the altitude varies from 100 m to 140 m AMSL (Cluster-XVI). The general slope of the topography is towards south, i.e. Damodar River.

The drainage pattern of the area is dendritic in nature. The drainage system of the area is the part of Damodar sub-basin. All the rivers that originate or flow through the coalfield area have an easterly or southeast course and ultimately joins Damodar River, the master drainage. The drainage of the JCF is mainly controlled by Jamuniya River (5th order), Khudia nala (3rd order), Katri River (4th) and Chatkari nala (3rd order) flowing from north to south and joins Damodar River. Whereas, Barakar River and Khudia River are controlling the drainage pattern of RCF (part) and joins Damodar River in the south. Damodar River is the main drainage channel and flows from west to east along the southern boundary of JCF and RCF.

The drainage map of the JCF and part of RCF has been prepared on topographic map of scale 1:50,000 (**Plate-II**). The watershed of all tributary rivers (Jamuniya River to Barakar River) falls within the north-western part of Damodar sub-basin which comes under Lower Ganga Basin.

Besides, a large number of ponds/tanks distributed in and around JCF, out of which one prominent lake is located at Topchanchi in the north-west part. Two reservoirs, Maithon dam in Barakar River and Panchet dam in Damodar River near to Chanch Victoria Area of BCCL (part of RCF) are the main source of water supply to the nearby area. Jharia Water Board, Damodar Water Supply Scheme and Mineral Area Development Authority (MADA) are supplying water.

1.5 DETAILS REGARDING WETLANDS

A **wetland** is a distinct ecosystem that flooded by water, either permanently or seasonally. The primary factor that distinguishes **wetlands** from other landform or water bodies is the characteristic vegetation of aquatic plants. Wetland are protective ecosystem as per new guidelines of CGWA & MoEF&CC. There are no Wetlands in and around the area (Jharia coalfield and Raniganj coalfield) as per the list given on official website of MoEF&CC, Govt. of India. The list enclosed as **Annexure-III**.

1.6 CLIMATE & RAINFALL

The Jharia Coalfield (JCF) and part of Raniganj Coalfield (RCF) area in Dhanbad District belongs to sub-humid tropical climatic region. The maximum temperature during summer shoots upto 45° C and falls between 10° C to 5° C in winter. The maximum rainfall occurs during the period between June and September. Rainfall data of IMD Dhanbad and Mine Rescue Station Dhanbad given in **Annexure-IV**.

In Jharkhand state, Daily Rainfall data from 1989 to 2018 considered for analysis of trend variability and mean rainfall patterns. From the daily rainfall data, monthly rainfall series of each stations computed and then monthly district rainfall series has constructed by considering arithmetic average of all the station rainfall values within the district. The monthly rainfall series of the state has computed by using area weighted rainfall values of all the districts within the state. The objective of the analysis is to:

1. Identify the spatial pattern of the mean rainfall
2. Understand district wise observed rainfall trend and variability in annual and SW monsoon season (June, July, august and September).

Daily station rainfall data utilized for identification of the mean spatial patterns and rainfall intensity trends. From mean and standard deviation (SD), the coefficient of variation (CV) calculated as follows: Coefficient of variation (CV) = [Standard Deviation / Mean] × 100

The analysis has done in two parts. For identification of the spatial pattern mean rainfall and variability and observed trends we have used district rainfall series and results have been brought out for four southwest monsoon months viz. June, July, August, September, for the southwest monsoon season and also for annual.

Table shows the mean rainfall (mm) and coefficient of variation of the state for the monsoon months, southwest monsoon season and annual during the period 1989-2018. It can see that the state gets highest rainfall (31%) of southwest monsoon rainfall in July month while the August month get 28% of the southwest monsoon rainfall. June and September receive 19% and 22% of southwest monsoon rainfall. Also more than 84% of annual rainfall receives during the southwest monsoon season only. The variability of monsoon or annual rainfall is also very less.

Jharkhand State

	June	July	August	September	Sub-total	Annual
Mean	190.3	313.9	289.2	225.7	1019.1	1211.4
CV	44.4	29.0	24.8	37.0	18.7	16.9

Dhanbad District

	June	July	August	September	Sub-total	Annual
Mean	203.9	327.7	302.5	271.5	1105.6	1332.2
CV	41.0	35.0	33.5	48.7	20.8	19.4

Fig. 1 and 2 show the time series of rainfall in mm for the months of June, July, August, September and southwest monsoon season, annual respectively. The trend lines displayed for each of the series. Neither monthly rainfall nor seasonal rainfall shows any significant increasing/decreasing trend while annual rainfall shows significant decreasing trend. In the monthly rainfall June, July, August, September and seasonal rainfall shows decreasing trend. During the last 30 years highest rainfall of 390.3 mm received in June in the year 1994, 492.1 mm received in June in the year 2017, 431.5 mm received in August in the year 1997, while highest rainfall of 395.2 in September received in the year 1995. Highest annual rainfall of 1587.9 mm received in the year 1999 and highest southwest monsoon rainfall of 1364.6 mm received in the year 1994 (Climate Research and Services, IMD, Ministry of Earth Sciences, Pune, Jan'2020).

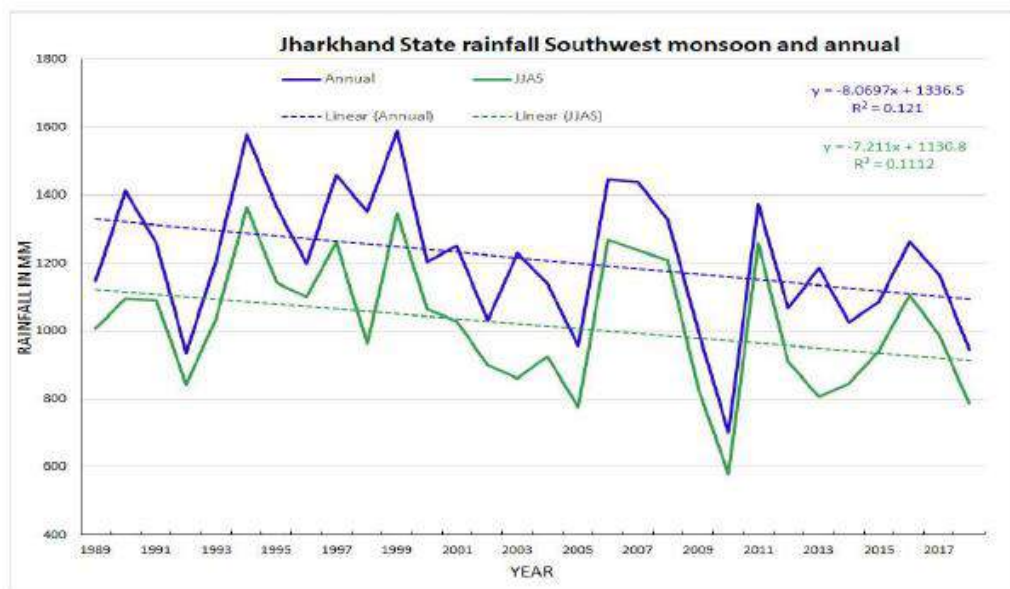


Fig-1.

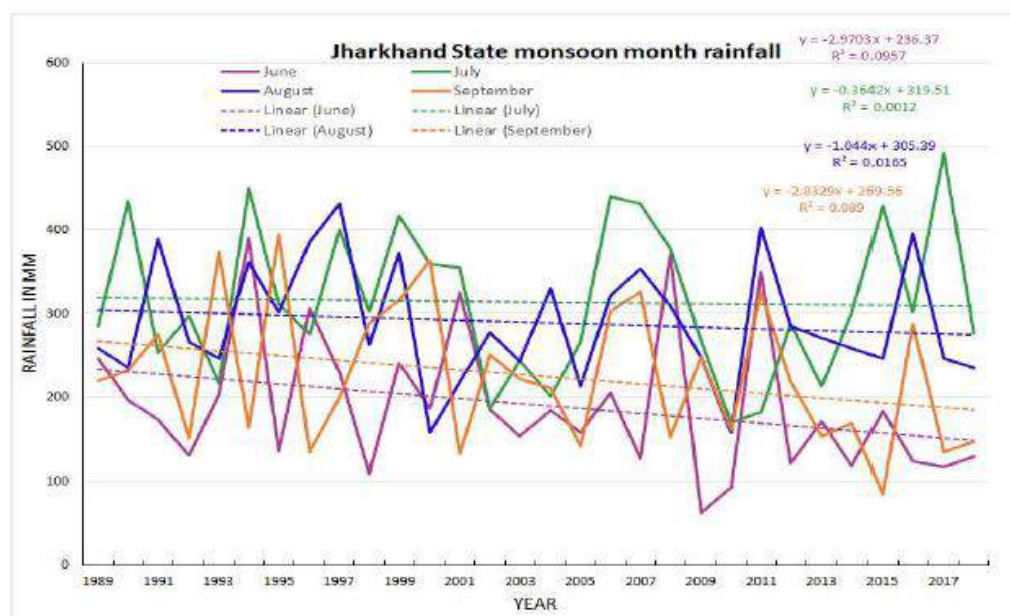


Fig-2.

2.0 GEOLOGY AND HYDROGEOLOGICAL SETUP OF THE AREA

2.1 REGIONAL GEOLOGY

The Jharia Coalfield covers an area of 453 sq. km. located in Dhanbad District, Jharkhand. The non-coal bearing Talchir Formation exposed in patches along the northern fringe of the Coalfield. The Barakar Formation overlies the Talchir is covering the most part of the Jharia Coalfield and having an area of 218 sq. km. This successively overlain by the non-coal bearing Barren Formation mainly exposed in the central part of the Coalfield. This, in turn, overlain by the Raniganj formation (Coal Bearing horizon) in the south-west part of the Coalfield and covers an area of 54 sq. km.

Chanch-Victoria Area is located in the western part of Raniganj Coalfield. The Raniganj coalfield represents the eastern most coal basin in the Damodar Valley Region, located in the border of Dhanbad District of Jharkhand and Bardhaman District of West Bengal. The Coalfield is almost elliptical in shape and covers an area of about 1530 sq. km. out of which only 35 sq. km. comes under leasehold area of BCCL out of which 19.64 sq. km is the study area (Cluster-XVI only). The coal bearing formations of the area belongs to Barakar Formation of the Lower Gondwana in **Table-1**.

Table – 1: Regional Geological Succession of Jharia Coalfield in the area

Geological Formations		Age
Quaternary/Recent	Soil cover/Weathered mantle	Recent
Post-Gondwana	Dolerite	Upper Cretaceous
	Lamprophyres	Jurassic
Damoda Group	Raniganj Formation	Upper Permian
	Barren Measures Formation	Middle Permian
	Barakar Formation	Lower Permian
	Karharbari	
	Talchir Formaton	Upper Carboniferous
-----Unconformity-----		
Metamorphics		Proterozoic

2.2 HYDROGEOLOGICAL SET- UP

The permeable formations mainly composed of sandstone behave as aquifer units. The coal seam and shales developed in the area act as impermeable beds i.e. aquiclude. The aquifer materials of Gondwana Formation constituted of fine to coarse grain sandstone having primary porosity of intergranular void space. The secondary porosity formed due to presence of faults, fracture, joints, etc. Sandstone of Gondwana formations in JCF and RCF are very hard, compact and cemented sandstone and forming less potential aquifer, particularly the deeper aquifer system. The secondary porosity along with primary porosity forms a conduit system making these formations good aquifers for movement and storage of ground water.

2.3 AQUIFERS DESCRIPTION

The aquifer system for shallow and deeper aquifer has established through hydrogeological studies, exploration, surface and subsurface geophysical studies in the JCF and RCF (part) covering all geological formations. The aquifer can be divided into two zones – Un-confined/Phreatic (shallow) and Semi-confined to confined (deeper) aquifer.

PHREATIC/UN-CONFINED AQUIFER

The top aquifer occurred above the top most coal seam/shale bed called un-confined or water table aquifer and it consists of relatively permeable formation such as weathered sandstone and loose soil. The thickness of the un-confined aquifer is varying from few meters to 50 m. This un-confined aquifer is potential than semi-confined to confined aquifer.

SEMI-CONFINED TO CONFINED AQUIFER

The semi-confined to confined aquifer consisting of sandstone bed is sandwiched with coal seams/shale beds and multiple aquifer system developed due to presence of multiple numbers of coal seams/shale beds. With the presence of intercalated shale and carbonaceous shale beds and reduction in permeability with depth, the lower aquifers are poor in potential.

Table –2 Generalized Hydrogeological Units developed in the study Area

Sl. No.	Type of Aquifer	Depth range (m)	Core zone (within 3 km)	Buffer zone (within 10 km)
1.	Unconfined	0 – 25 (Avg.)	Alluvium, weathered sandstone	Alluvium, weathered sandstone
2.	Semiconfined/ confined	Beyond 25 upto 650 m	Multiple Sandstone horizons in Barakar formation	Multiple Barakar, sandstone, Barren Measure, Raniganj sandstone and Talchir shale

2.4 GENERAL AQUIFER PARAMETERS

PHREATIC/UN-CONFINED AQUIFER

The wells tested by CMPDI for determination of aquifer parameters in Damuda (BJ Section) and Block-III area of JCF. The hydraulic conductivity of the un-confined aquifer is 0.50 m/day as computed from pumping tests on the wells. The transmissivity of the unconfined aquifer ranges from 10.68 m² /day to 41.48 m² /day.

SEMI-CONFINED TO CONFINED AQUIFER

The un-confined aquifer, the sandstone partings in-between impervious layers of shale and coal seams designated as semi-confined / confined aquifers. The sandstones in these aquifers are fine to coarse grained, hard and compact with very low porosity. Mostly groundwater occurs in the weak zones formed due to weathering, fracture, faults, which create the secondary porosity. The hydrogeological parameter has determined by CMPDI in Sitanala Block by conducting aquifer performance test (APT). The hydraulic conductivity (K) of semi-confined aquifer in Barakar Formation ranges from 0.0006 m/day to 1.44 m/day. The hydrogeological parameter has also been determined at Kumari OCP Block in the central JCF by conducting aquifer performance test. The hydraulic conductivity (K) of semi-confined aquifer in Barakar Formation in this area ranges from 0.0027 m/day to 0.05 m/day.

Table – 3: Aquifer parameters considered for the study Area

Hydraulic Parameter	Unconfined aquifer Site: Damuda (BJ Section) and Block-III area	Semi-confined aquifer Site: (1): Sitanala Block (2): Kumari Block
Transmissivity (m ² /d)	10.68 – 41.48	0.0621 – 0.573
Hydraulic conductivity (m/d)	0.5	0.05 – 0.0027
Specific yield	0.03 to 0.04 (as per GEC recommended values)	

3.0 GROUND WATER LEVEL MONITORING

To collect the representative groundwater levels in the study area, CMPDI has established a monitoring network of total 252 monitoring stations out of which 64 located within core zone and rest comes within Buffer zone. Total 60 nos. dug well within JCF and 04 nos. dug well within RCF (part) area (Details of the Hydrograph stations & water level given in **Annexure-V, VA & VB**) spread over the entire BCCL leasehold area, **Plate-II**. Water level monitoring in all hydrograph stations has been done in pre-monsoon as well as in post monsoon whereas in 64 stations monitoring done in quarterly (May'20, Aug'20, Nov'20 and Jan'21) basis.

Depth to water level of the water table depict the inequalities in the position of water table with respect to ground surface and is useful in delineating recharge / discharge areas, planning of artificial recharge structure and shows the overall status of the groundwater level in the area. Historical groundwater level (GWL) of entire JCF and part of RCF with fluctuation, GWL of Non-mining / Mining areas and GWL of the Cluster of Mines of BCCL are shown in this report to assess the effect of Coal mining activity in the groundwater regime in and around the Coalfield area.

Mining is a dynamic phenomenon. The mining activity creates dis-equilibrium in environmental scenario of the area and disturbs the groundwater conditions/regime in particular. The impact on shallow water regime due to mining activity can broadly viewed as under:

- Historical GWL with annual fluctuation over the years
- GWL scenario in Non-mining and Mining area (OC/UG mines)
- GWL scenario of Cluster of mines of BCCL

3.1 HISTORICAL GROUNDWATER LEVEL (GWL)

Historical GWL of JCF and part of RCF given from 2005 to 2020 of CMPDI monitoring stations (total 64 stations within Coalfield area). Pre-monsoon and Post-monsoon GWL with Fluctuation has been mentioned below in the table.

Table – 4: Historical Groundwater Level

Period		(Water level in metre below ground level)								
		Pre-Monsoon (April/May)			Post-Monsoon (Nov/Dec)			Fluctuation		
		From	To	Average	From	To	Average	From	To	Average
JCF	2005	0.07	19.08	6.29	0.84	12.13	3.20	0.12	12.45	3.21
	2007	0.40	19.27	5.66	0.35	8.21	2.87	0.02	16.15	2.96
	2008	0.45	18.35	5.42	0.35	14.20	3.62	0.03	9.22	2.45
	2010	0.85	14.47	5.24	0.10	15.88	4.48	0.02	5.55	1.54
	2012	1.27	18.68	5.58	0.15	7.80	2.72	0.08	13.45	2.96
	2013	0.70	19.20	5.65	0.45	8.35	2.77	0.29	15.88	3.17
	2014	0.70	16.28	4.92	0.75	14.98	3.27	0.25	10.15	2.17
	2015	1.38	17.20	6.00	0.45	14.58	3.92	0.28	7.62	2.15
	2016	0.78	16.73	5.64	0.30	12.43	3.19	0.23	6.35	2.88
	2017	0.67	16.28	5.61	0.15	6.97	2.41	0.10	12.10	3.25
	2018	1.20	14.58	5.55	0.40	7.17	2.83	0.20	9.45	2.68
	2019	0.95	15.88	5.46	0.45	5.95	2.34	0.20	13.40	3.05
	2020	0.80	16.25	4.95	0.75	10.10	3.26	0.25	11.05	2.15
RCF (part)	2008	5.02	10.50	7.59	2.85	4.90	3.71	1.82	6.60	3.87
	2010	2.20	8.85	4.74	2.78	9.58	4.63	0.68	1.10	0.89
	2011	3.57	8.02	4.98	2.50	6.21	3.75	0.55	1.90	1.23
	2012	3.10	7.34	4.59	1.55	7.00	3.66	0.05	2.78	0.94
	2013	1.70	9.87	6.54	2.90	8.85	4.71	1.02	5.54	2.84
	2014	3.27	6.48	4.57	2.13	3.03	2.63	0.54	3.45	1.94
	2015	3.38	9.52	5.33	2.68	8.20	5.11	1.06	1.32	1.81
	2016	3.61	10.65	6.24	0.90	6.50	3.18	1.63	4.40	3.06
	2017	1.93	5.80	3.25	1.63	3.78	2.47	1.63	3.78	0.78
	2018	2.34	8.70	4.35	1.75	5.70	2.75	0.41	2.55	1.59
	2019	1.60	9.35	5.29	0.80	3.88	2.10	0.80	5.47	3.20
	2020	2.30	9.70	4.30	1.75	5.50	2.70	0.40	2.75	1.60

3.2 GROUNDWATER LEVEL SCENARIO IN NON-MINING/MINING AREA

Depth to water level (DTW) range in different formations with respect of mining and non-mining areas summarized in the Table-5.

Table – 5: Depth to water table

Formation	Area		DTW (bgl, m) [Year-2020]		Average GWL (m)	
			Pre-monsoon (Apr/May)	Post-monsoon (Nov/Dec)	Pre-monsoon	Post-monsoon
Sedimentary (Gondwana)	Non-mining		1.40-11.35	0.75-4.60	5.45	2.55
	Mining	OC	0.90-12.50	0.55-5.85	5.15	2.24
		UG	1.20-16.25	0.55-4.75	5.85	2.75
Metamorphics (Hard rock)	Peripheral part of the Coalfield		0.45-15.10	0.45-9.50	7.25	3.85

The study revealed that water table is in shallow depth and there is no significant stress in the water table due to coal mining activity. Mining and Non-mining areas shows barely any difference in water table condition in the JCF and RCF (part) area. The average hydraulic gradient of the water table within mining and non-mining areas given in Table-6. There is no significant change in hydraulic gradient observed. Relatively steep gradient near active opencast mining areas w.r.t., Non-Mining, Underground mines and Metamorphics areas observed.

Table – 6: Average hydraulic gradient

Sl. No	Formation	Area		Average hydraulic gradient
1	Sedimentary (Gondwana)	Non-Mining		1.0×10^{-3} to 3.0×10^{-3}
		Mining	OC	3.0×10^{-2} to 6.0×10^{-3}
			UG	2.0×10^{-2} to 4.0×10^{-3}
2	Metamorphics (Hard rock)	Peripheral part of the Coalfield		1.0×10^{-3} to 3.0×10^{-3}

3.3 GROUND WATER LEVEL DATA OF THE CLUSTER OF MINES OF BCCL

A GROUND WATER LEVEL OF CLUSTER-I

Cluster-I (Damuda Group of Mines) consisting of (Cluster-I consisting of Damoda UG, Albion OCP, Proposed BJ Section OCP and Abandoned Gutway OCP) of Barora area, BCCL is located in the western most part of Jharia coalfield in Bokaro district of Jharkhand. The life of the project works out upto 15 years considering annual target production of 1.17 MTPA. It is located in the extreme western part of JCF in Bokaro district of Jharkhand (Toposheet no – 73 I/1).

The present leasehold area of Cluster-I is 575.0 Ha. The Damoda block area marked by more or less flat and gently undulating topography. The RL varies from 179 m to 208 m AMSL and the general slope of topography is towards east. Jamuniya River, Kari Jore, Podo Jore and its tributaries are controlling the drainage system of the area. The area comes under the watershed of Jamuniya River.

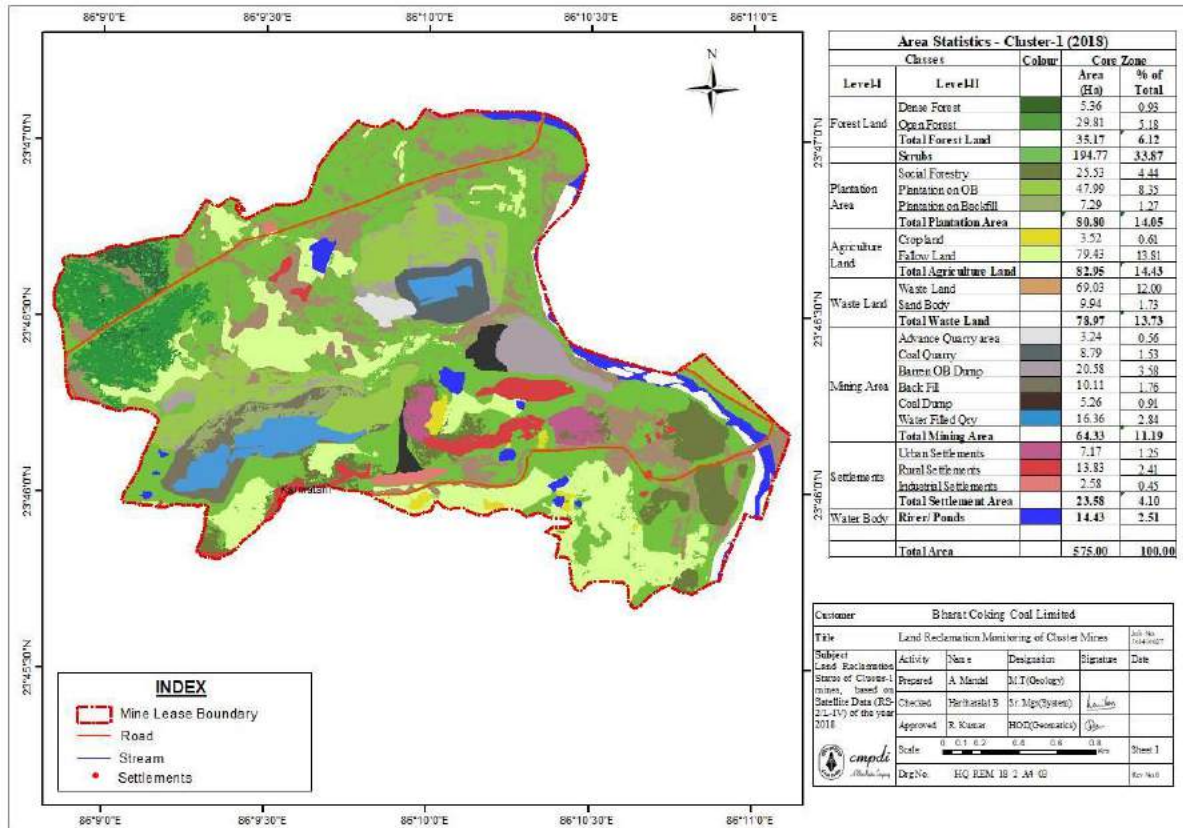
Monitoring stations (**B-15, B-21A, B51 and B-53**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	B-15	Bera Basti	3.70	0.15	1.47	1.70	1.90	0.45	1.65	2.65	1.56	1.85	0.75	0.85
2	B21A	Dugdha	10.00	4.15	5.80	6.70	9.45	1.90	-	-	6.73	9.65	3.45	2.65
3	B-51	Taranga	5.00	0.88	2.10	3.00	5.10	1.10	2.70	2.90	3.00	5.02	2.25	2.42
4	B-53	Karmatanr	3.12	1.07	1.40	1.92	3.22	0.97	1.42	2.12	2.52	3.92	1.62	1.42
Average WL (bgl)			5.46	1.56	2.69	3.33	4.92	1.11	1.92	2.56	3.45	5.11	2.02	1.84

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.85 m Max – 10.00 m
Post-monsoon GW Level (m): Min – 0.85 m Max – 5.80 m

LAND USE / LAND COVER MAP OF THE CLUSTER-I MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	393.69 x 10 ⁴	393.69 x 10 ⁴	393.69 x 10 ⁴
2	Open Land	204.89 x 10 ⁴	204.89 x 10 ⁴	204.89 x 10 ⁴
3	Road/ Paved Area	09.0 x 10 ⁴	09.0 x 10 ⁴	09.0 x 10 ⁴
4	Rooftop area of building/ sheds	14.58 x 10 ⁴	14.58 x 10 ⁴	14.58 x 10 ⁴
5	Total	575.00 x 10 ⁴	575.00 x 10 ⁴	575.00 x 10 ⁴

B. GROUND WATER LEVEL OF CLUSTER-II

Cluster-II consists of seven mines namely; (Block II Mixed mines (OCP & UGP), Jamunia OCP, Shatabdi OCP, Muraidih Mixed mines (OCP & UGP), and Phularitand OCP of BCCL is located in the western most part of Jharia coalfield in Bokaro district and Dhanbad district of Jharkhand. The life of the project works out upto 30 years considering annual target production of 20.215 MTPA. It is located in the extreme western part of Jharia Coalfield in Dhanbad district of Jharkhand (Toposheet no- 73 I/1 and I/5).

The present leasehold area of Cluster-II is 2260.54 Ha. The Damoda block area marked by more or less flat and gently undulating topography. The RL varies from 176 m to 235 m AMSL. Jamuniya River, Khudia River and its tributaries are controlling the drainage system of the area. The area comes under the watershed of Jamuniya River and Khudia River.

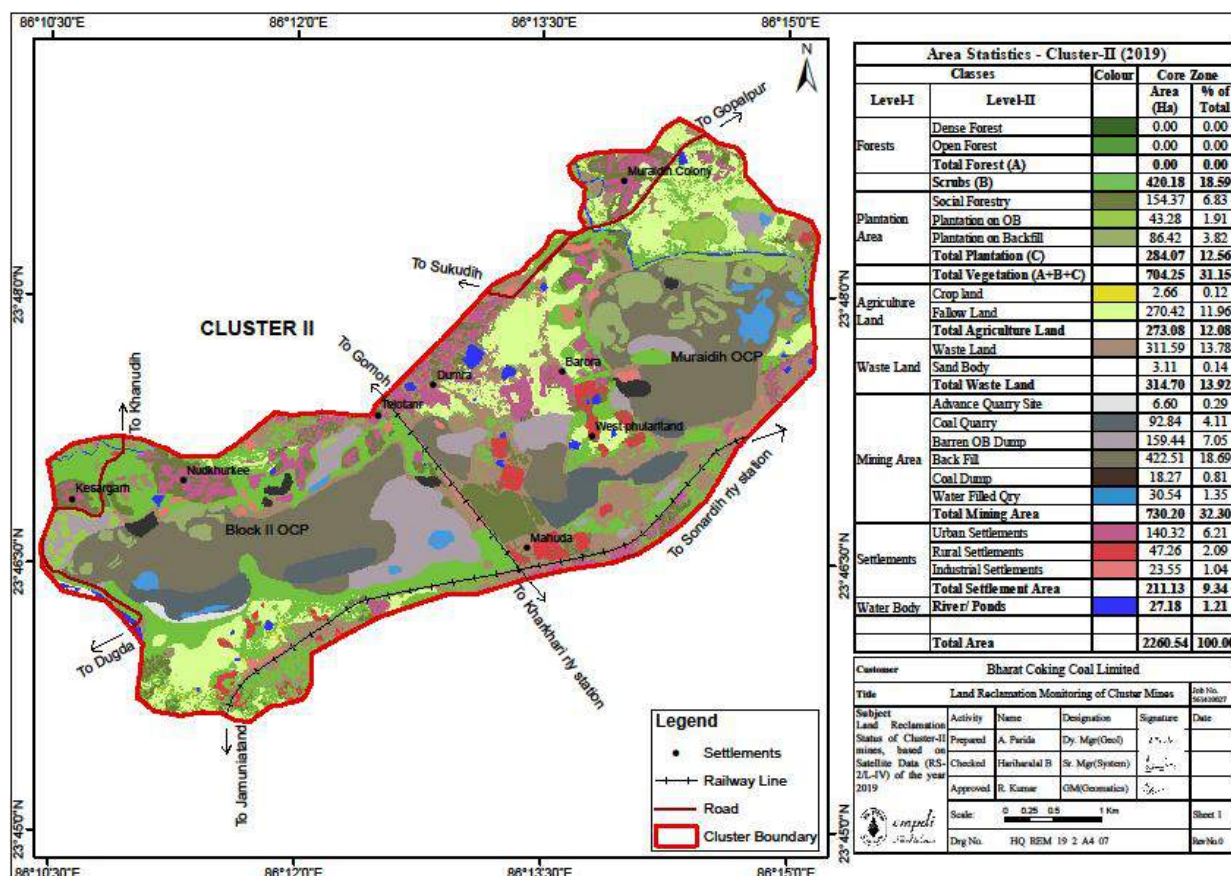
Monitoring stations (**B-1, B-59, B-60, B-61A and B-62A**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	B-1	Muraidih	3.28	0.73	1.63	1.73	3.18	1.33	1.73	1.98	1.68	2.88	1.48	2.08
2	B-59	Khodovaly	5.25	0.67	1.40	2.10	6.20	0.80	0.90	1.20	1.38	5.47	0.90	1.10
3	B-60	Bahiyardih	10.33	0.91	3.21	6.13	8.13	1.23	3.23	4.93	8.21	13.68	3.13	4.23
4	B61A	Kesargora	3.32	0.85	1.60	2.07	3.32	1.39	0.52	1.12	1.27	2.57	2.62	2.02
5	B62A	Sadiyardih	6.95	2.77	3.00	4.95	7.55	2.80	3.25	4.95	5.87	8.27	4.00	4.78
Average WL (bgl)			5.83	1.19	2.17	3.40	5.68	1.51	1.93	2.84	3.68	6.57	2.43	2.84

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 2.57 m Max – 13.68 m
Post-monsoon GW Level (m): Min – 0.52 m Max – 4.78 m

LAND USE / LAND COVER MAP OF THE CLUSTER-II MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	977.33 x 10 ⁴	977.33 x 10 ⁴	977.33 x 10 ⁴
2	Open Land	1072.08 x 10 ⁴	1072.08 x 10 ⁴	1072.08 x 10 ⁴
3	Road/ Paved Area	140.32 x 10 ⁴	140.32 x 10 ⁴	140.32 x 10 ⁴
4	Rooftop area of building/ sheds	70.81 x 10 ⁴	70.81 x 10 ⁴	70.81 x 10 ⁴
5	Total	2260.54 x 10 ⁴	2260.54 x 10 ⁴	2260.54 x 10 ⁴

C. GROUND WATER LEVEL OF CLUSTER-III

Cluster-III consists of nine mines namely, Jogidih UG, Govindpur UG, Maheshpur UG, Kooridih/Block-IV Mixed Mine, New Akashkinaree Mixed Mine, South Govindpur UG (closed), and Teturiya UG (closed) mines. It is located in the western most part of Jharia coalfield in Dhanbad district of Jharkhand. The life of the project works out upto 60 years considering annual target production of 3.60 MTPA. This Cluster of mines is located in western part of Jharia Coalfield in Dhanbad district of Jharkhand (Toposheet no – 73 I/5).

The present leasehold area of Cluster-III is 1552.53 Ha. The area is plain with gentle undulation with RL varies from 160 m to 208.80 m AMSL. The general slope of the area is towards south. Khudia River, Baghdihi Jore, Katri River and its tributaries are controlling the drainage system of the area. The area comes under the watershed of Khudia River.

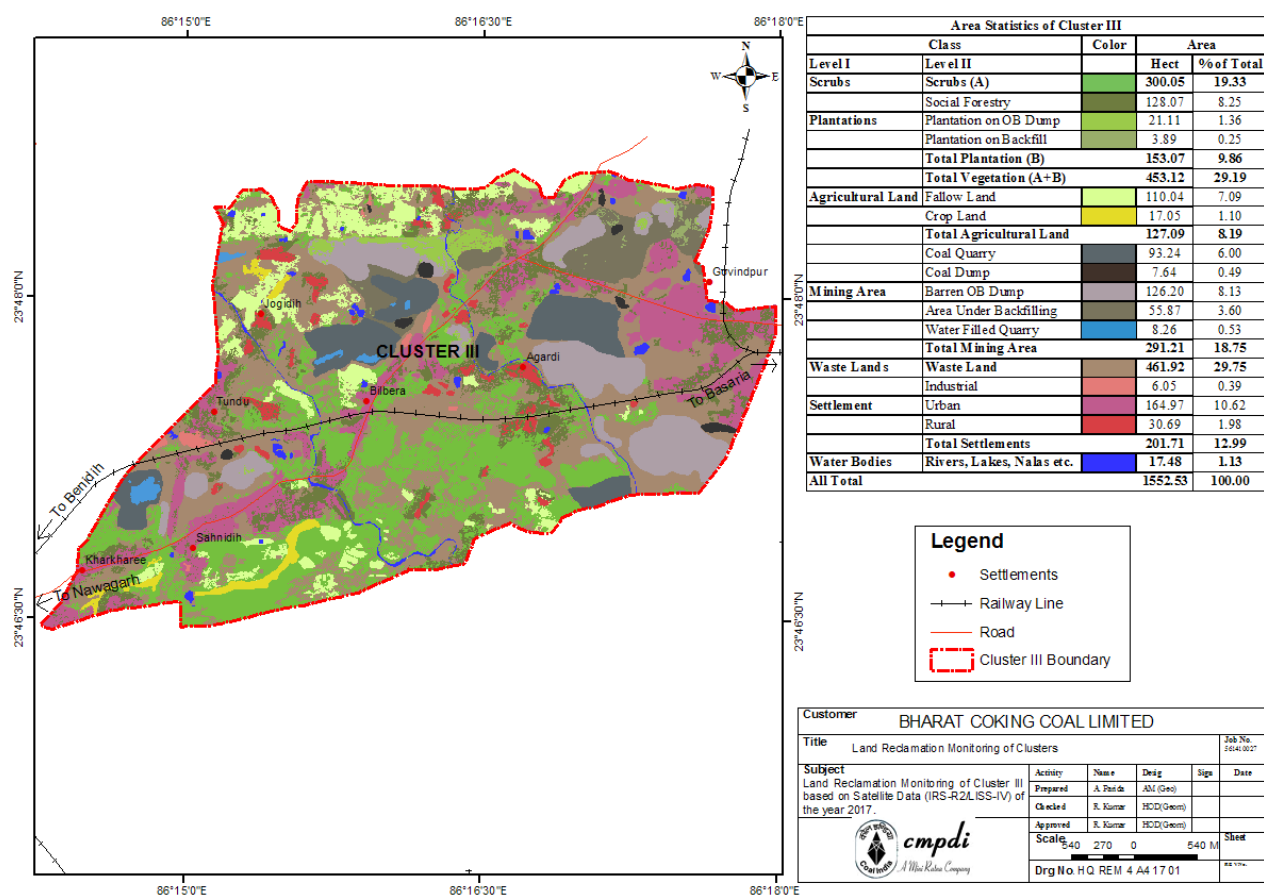
Monitoring stations (**A-12, A-25, A-29, B-14 and B-60**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A12	Jamua	2.60	0.32	0.50	1.20	2.10	0.29	0.45	0.75	1.20	2.80	0.40	1.0
2	A25	Sinidih	2.98	1.30	1.83	2.53	6.08	1.43	1.93	2.48	4.88	6.63	2.88	3.13
3	A29	Dharmaband	6.20	1.21	3.20	3.25	4.85	1.20	3.40	3.65	3.25	6.45	2.86	2.10
4	B14	Mathadih	2.44	0.32	1.04	1.69	2.24	0.54	0.94	2.04	1.69	3.64	1.22	2.84
5	B60	Sonardih	10.33	0.91	3.21	6.13	8.13	1.23	3.23	4.93	8.21	13.68	3.13	4.23
Average WL (bgl)			4.91	0.81	1.96	2.96	4.68	0.94	1.99	2.77	3.85	6.64	2.12	2.64

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 2.10 m Max – 13.68 m
Post-monsoon GW Level (m): Min – 0.45 m Max – 4.23 m

LAND USE / LAND COVER MAP OF THE CLUSTER-III MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	580.21 x 10 ⁴	580.21 x 10 ⁴	580.21 x 10 ⁴
2	Open Land	770.61 x 10 ⁴	770.61 x 10 ⁴	770.61 x 10 ⁴
3	Road/ Paved Area	164.97 x 10 ⁴	164.97 x 10 ⁴	164.97 x 10 ⁴
4	Rooftop area of building/ sheds	36.74 x 10 ⁴	36.74 x 10 ⁴	36.74 x 10 ⁴
5	Total	1552.53 x 10 ⁴	1552.53 x 10 ⁴	1552.53 x 10 ⁴

D. GROUND WATER LEVEL OF CLUSTER-IV

Cluster-IV consists of six mines namely, Amalgamated Keshalpur & West Mudidih colliery, Amalgamated Angarpathra & Ramkanali colliery, Katras-Choitudih Colliery, Salanpur colliery and Gaslitand colliery of Katras area, BCCL. It is located in the north-central part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out more than 30 years considering annual target production of 9.55 MTPA (Toposheet no – 73 I/5).

The present leasehold area of Cluster-IV is 1123.79 Ha. The area has a general undulating topography, with an overall gentle south-westerly slope. The RL varies from 182 m to 216 m AMSL. Katri River, Kumari Jore and its tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Katri River.

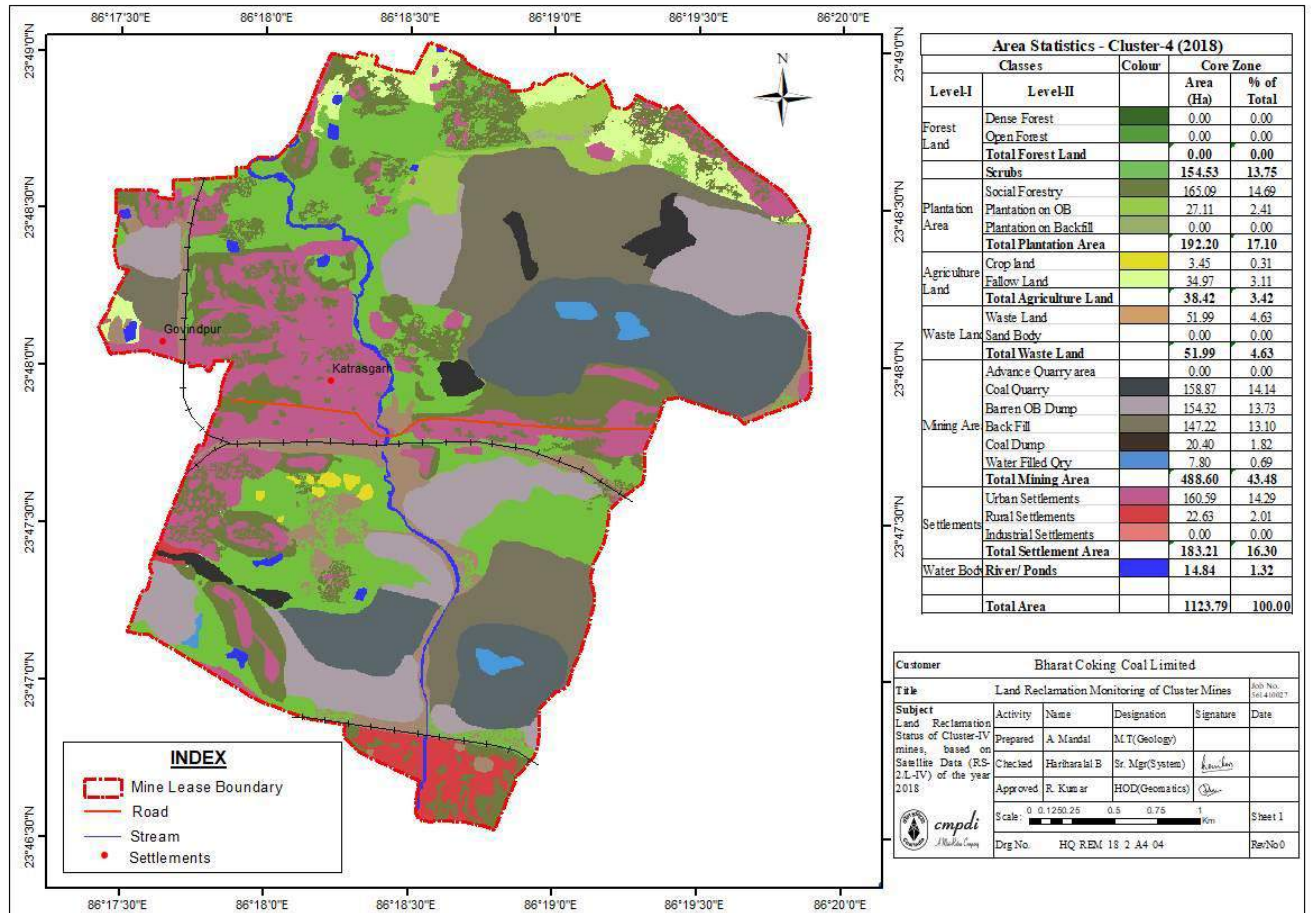
Monitoring stations (**A-26, A28A, B-64 and B-65A**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

SI No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A-26	Malkhera	6.98	2.69	3.18	4.78	6.58	2.23	3.33	3.83	4.75	6.23	3.58	3.88
2	A28A	Lakarka	4.00	1.33	3.03	3.35	2.45	1.25	3.15	3.60	2.22	4.15	2.00	2.51
3	B-64	Keshalpur	1.85	0.93	0.50	1.37	0.95	0.30	0.45	1.20	1.42	2.15	0.55	1.85
4	B65A	Jhinjipahari	9.25	0.03	2.30	4.10	11.05	1.85	0.95	2.95	4.18	10.03	2.10	2.40
Average WL (bgl)			5.52	1.25	2.25	3.40	5.26	1.41	1.97	2.90	3.14	5.64	2.16	2.66

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 0.95 m Max – 11.05 m
Post-monsoon GW Level (m): Min – 0.45 m Max – 3.88 m

LAND USE / LAND COVER MAP OF THE CLUSTER-IV MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	385.15 x 10 ⁴	385.15 x 10 ⁴	385.15 x 10 ⁴
2	Open Land	555.43 x 10 ⁴	555.43 x 10 ⁴	555.43 x 10 ⁴
3	Road/ Paved Area	160.59 x 10 ⁴	160.59 x 10 ⁴	160.59 x 10 ⁴
4	Rooftop area of building/ sheds	22.63 x 10 ⁴	22.63 x 10 ⁴	22.63 x 10 ⁴
5	Total	1123.79 x 10 ⁴	1123.79 x 10 ⁴	1123.79 x 10 ⁴

E. GROUND WATER LEVEL OF CLUSTER-V

Cluster-V consists of twelve mines namely; Tetulmari OC & UG mines, Mudidih OC & UG mines, Nichitpur OC mine, Sendra Bansjore OC & UG mines, Bansdeopur OCP (proposed) & UG Mines, Kankanee OC & UG mines and Loyabad UG mine (closed) of Sijua area, BCCL. This Cluster of mines is located in northern part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out more than 30 years considering annual target production of 6.311 MTPA (Toposheet no – 73 I/6).

The present leasehold area of Cluster-V is 1724.52 Ha. The area has a general undulating topography, with an overall gentle south westerly slope. The RL varies from 210 m to 170 m AMSL. Jarian Nala, Nagri Jore, Ekra Jore and its tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Jarian Nala and Ekra Jore.

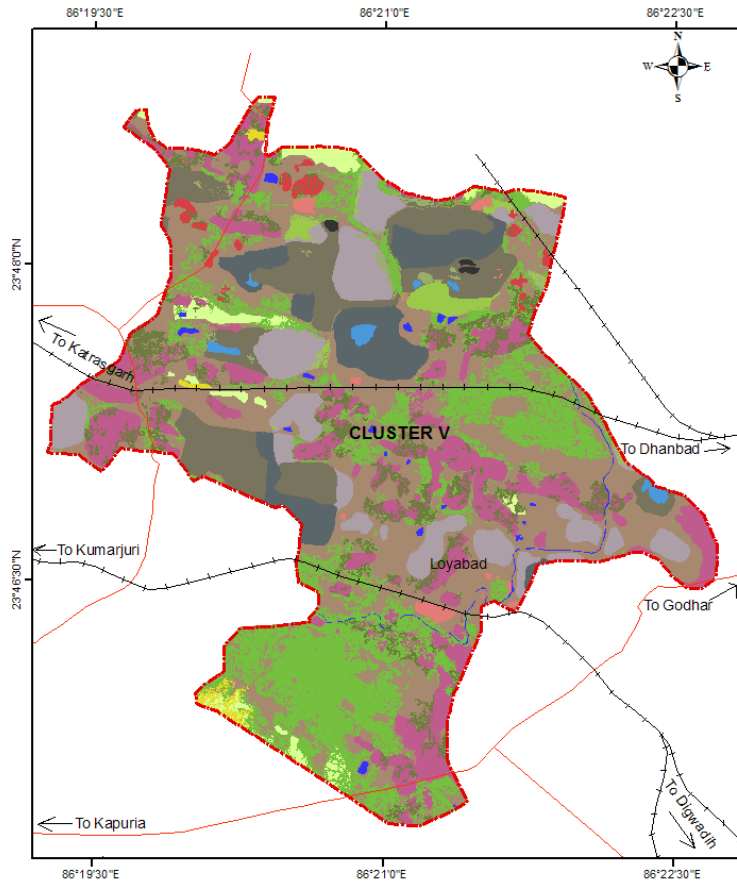
Monitoring stations (**A-3, A-16, A-27 and D-23**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A-3	Sijua	1.57	0.02	0.47	0.77	3.47	0.32	0.47	0.62	0.77	1.27	0.37	0.47
2	A-16	Ekra	7.15	1.34	1.75	3.20	5.45	1.65	1.95	4.55	2.60	4.30	2.05	3.65
3	A-27	Tetulmari	2.40	0.03	1.10	1.90	2.40	0.15	0.92	1.30	1.90	2.90	1.49	1.00
4	D-23	Jogta	5.60	1.69	3.35	3.70	4.70	1.65	1.40	1.50	2.70	4.40	2.60	3.40
Average WL (bgl)			4.18	0.77	1.67	2.39	4.01	0.94	1.19	1.99	1.99	3.22	1.63	2.13

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.27 m Max – 5.60 m
Post-monsoon GW Level (m): Min – 0.47 m Max – 3.65 m

LAND USE / LAND COVER MAP OF THE CLUSTER-V MINES, BCCL



Area Statistics of Cluster V				
Level I	Level II	Color	Hect	% of Total
Scrubs	Scrubs (A)		344.78	19.99
	Social Forestry		105.29	6.10
Plantations	Plantation on OB Dump		23.85	1.38
	Plantation on Backfill		7.19	0.42
	Total Plantation (B)		136.33	7.90
	Total Vegetation (A+B)		481.11	27.89
Agricultural Land	Crop Land		8.41	0.49
	Fallow Land		37.74	2.19
	Total Agricultural Land		46.15	2.68
Mining Area	Coal Quarry		102.79	5.96
	Coal Dump		2.55	0.15
	Barren OB Dump		151.20	8.77
	Area Under Backfilling		162.09	9.40
	Water Filled Quarry		9.45	0.55
	Total Mining Area		428.08	24.83
Waste Lands	Waste Land		517.23	29.99
	Industrial		10.46	0.61
Settlement	Rural		13.78	0.80
	Urban		217.50	12.61
	Total Settlements		241.74	14.02
Water Bodies	Rivers, Lakes, Nalas etc.		10.21	0.59
All Total			1724.52	100.00

Legend	
	Road
	Railway Line
	Cluster V Boundary

Customer		BHARAT COKING COAL LIMITED				
Title		Land Reclamation Monitoring of Clusters				Job No. 260419012
Subject Land Reclamation Status of Cluster V based on Satellite Data (IRS-R2/LISS-IV) of the year 2017.	Activity	Name	Design	Sign	Date	
	Prepared	A. Panda	AM (Geo)			
	Checked	S. Kumar	HOD(Geom)			
	Approved	S. Kumar	HOD(Geom)			
	Scale	400 230 0 400 Meters			Sheet	
Drg No. HQ REM 4 A4 17 01					REVISION	

Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	527.26 x 10 ⁴	527.26 x 10 ⁴	527.26 x 10 ⁴
2	Open Land	973.52 x 10 ⁴	973.52 x 10 ⁴	973.52 x 10 ⁴
3	Road/ Paved Area	217.50 x 10 ⁴	217.50 x 10 ⁴	217.50 x 10 ⁴
4	Rooftop area of building/ sheds	24.24 x 10 ⁴	24.24 x 10 ⁴	24.24 x 10 ⁴
5	Total	1724.52 x 10 ⁴	1724.52 x 10 ⁴	1724.52 x 10 ⁴

F. GROUND WATER LEVEL OF CLUSTER-VI

Cluster-VI consists of four coal mines; East Bassuriya opencast (OC), Bassuriya underground (UG), Gondudih Khas-Kusunda OC and Godhur Mixed Mines (OC and UG) of BCCL. This Cluster of mines is located in central part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out more than 30 years considering annual target production of 7.631 MTPA (Toposheet no – 73 I/6).

The present leasehold area of Cluster-VI is 831.83 Ha. The area has a general undulating topography with general slope towards south. The RL varies from 180 m to 240 m AMSL. Ekra Jore, Kari Jore and their tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Ekra Jore and Kari Jore.

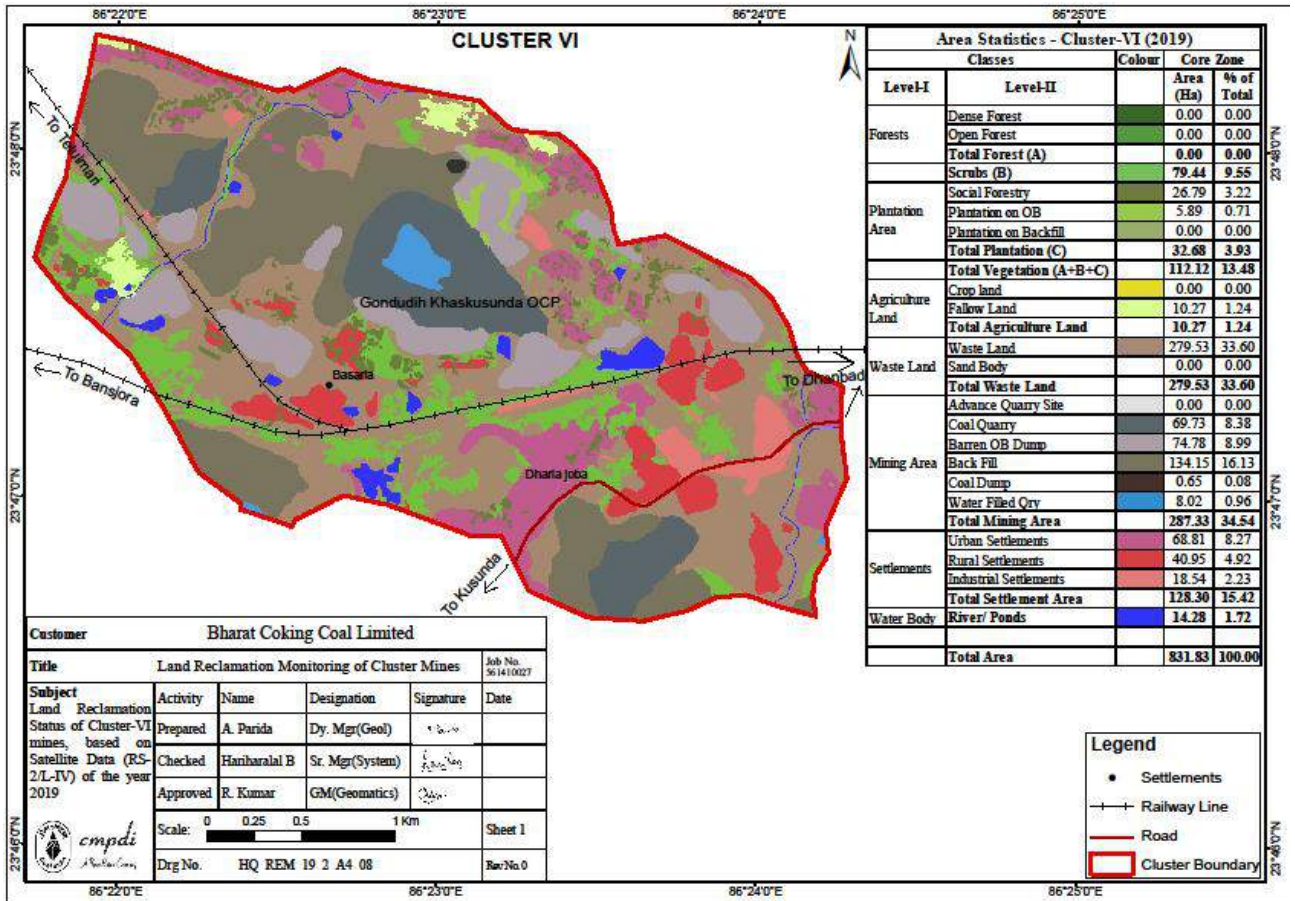
Monitoring stations (**D-25 and D-30**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	D25	Godhur	10.50	2.28	5.62	6.40	9.90	4.35	5.38	5.50	0.50	2.60	0.60	2.40
2	D30	Borkiboa	4.50	1.65	1.35	2.40	4.60	0.38	0.75	1.95	2.60	4.58	1.00	1.10
Average WL (bgl)			7.50	1.97	3.49	4.40	7.25	2.37	3.07	3.73	1.55	3.59	0.80	1.75

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 2.60 m Max – 10.50 m
Post-monsoon GW Level (m): Min – 0.75 m Max – 5.62 m

LAND USE / LAND COVER MAP OF THE CLUSTER-VI MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	122.39 X 10 ⁴	122.39 X 10 ⁴	122.39 X 10 ⁴
2	Open Land	581.14 X 10 ⁴	581.14 X 10 ⁴	581.14 X 10 ⁴
3	Road/ Paved Area	68.81 X 10 ⁴	68.81 X 10 ⁴	68.81 X 10 ⁴
4	Rooftop area of building/ sheds	59.49 X 10 ⁴	59.49 X 10 ⁴	59.49 X 10 ⁴
5	Total	831.83 X 10 ⁴	831.83 X 10 ⁴	831.83 X 10 ⁴

G. GROUND WATER LEVEL OF CLUSTER-VII

Cluster-VII consists of fourteen mines namely; Kusunda Area, Bastacolla Area and PB Area B.C.C.L (Jharia Coalfield) is located in Dhanbad district of Jharkhand. Cluster-VII consists of coal mines; Dhansar UG, Dhansar OCP, Kusunda OCP and Viswakarma OCP (proposed) are under the administrative control of Kusunda Area and Industry UG (closed), Alkusa UG, Ena OCP, S.Jharia/Rajapur OCP, Burragarh UG, Simlabahal UG, Huriladih UG, Bhutgoria UG (Re-opening), Kustore UG (closed) and E.Bhuggatdih UG (closed) are under Bastacolla and PB Area of BCCL. This Cluster of mines is located in east central part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out more than 30 years considering annual target production of 8.226 MTPA (Toposheet no – 73 I/6).

The present leasehold area of Cluster-VII is 2127.70 Ha. The area has a general undulating topography with general slope towards south. The RL varies from 172 m to 221 m above M.S.L. Kari Jore, Chatkari Jore and its tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Kari Jore and Chatkari Jore.

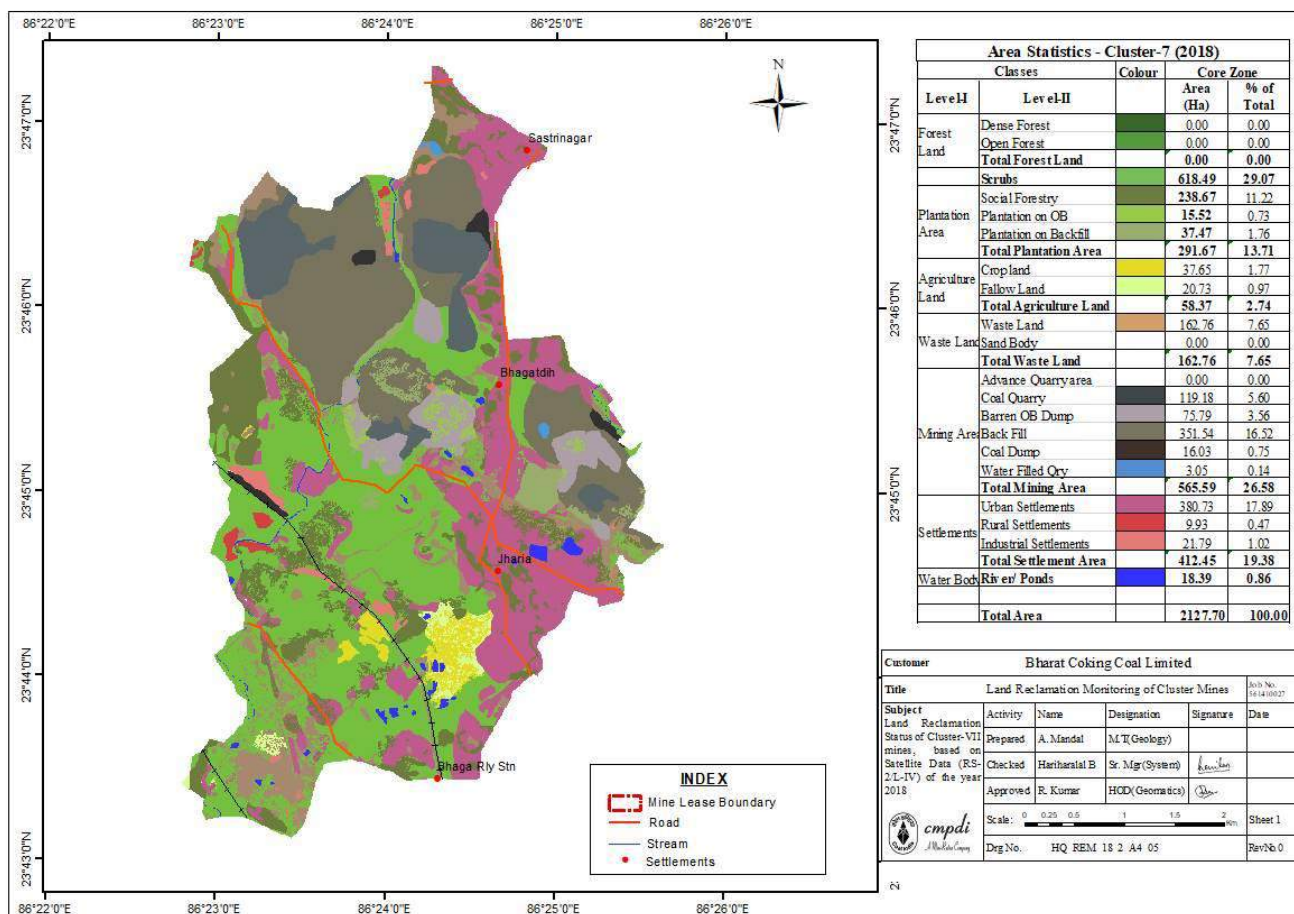
Monitoring stations (**D-3, D-4, D-33, D-34, D-47, D-55 and D-80**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	D-3	Dhansar	5.40	0.56	1.38	1.90	1.75	1.05	1.30	1.45	1.65	3.43	1.50	2.45
2	D-4	Jharia	3.41	0.51	1.41	2.26	2.81	1.16	1.71	2.16	1.21	1.91	0.91	1.56
3	D33	Kustore	3.65	0.48	1.45	1.80	2.35	0.25	1.65	2.35	0.55	2.85	0.55	0.95
4	D34	Kusunda	3.30	2.00	2.80	2.95	4.75	2.10	2.40	2.55	0.60	2.80	0.45	0.70
5	D47	Parastanr	9.45	3.41	5.45	5.83	4.55	1.90	4.35	4.20	3.55	5.33	2.55	3.65
6	D55	Hariladih	9.42	3.88	8.60	8.62	8.42	2.97	5.47	8.62	4.42	8.42	1.57	4.02
7	D80	Bastacolla	4.30	2.08	4.90	5.00	5.00	2.30	3.05	3.80	4.35	9.35	3.28	4.20
Average WL (bgl)			5.56	1.85	3.71	4.05	4.23	1.68	2.85	3.59	2.33	4.87	1.54	2.50

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.75 m Max – 9.45 m
Post-monsoon GW Level (m): Min – 0.70 m Max – 8.60 m

LAND USE / LAND COVER MAP OF THE CLUSTER-VII MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	968.53 x 10 ⁴	968.53 x 10 ⁴	968.53 x 10 ⁴
2	Open Land	746.72 x 10 ⁴	746.72 x 10 ⁴	746.72 x 10 ⁴
3	Road/ Paved Area	380.73 x 10 ⁴	380.73 x 10 ⁴	380.73 x 10 ⁴
4	Rooftop area of building/ sheds	31.71 x 10 ⁴	31.71 x 10 ⁴	31.71 x 10 ⁴
5	Total	2127.70 x 10 ⁴	2127.70 x 10 ⁴	2127.70 x 10 ⁴

H. GROUND WATER LEVEL OF CLUSTER-VIII

Cluster - VIII of B.C.C.L mines under administrative control of Bastacolla Area of B.C.C.L (Jharia Coalfield) is located in Dhanbad district of Jharkhand. Cluster-VIII consists of ten mines namely; Bastacolla mixed mines (OC & UG), Bera mixed mines (OC&UG), Dobari UG, Kuya mixed mines (OC&UG), Proposed Goluckdih (NC) OC mine, Ghanoodih OC mine and Kujama OC mine are under Bastacolla Area of BCCL is located in the west part of Jharia Coalfield. All above the mines are contiguous in nature and the environmental impact is overlapping in ambient environment due to cumulative effect of the mining activities. The life of the project works out upto 25 years considering annual target production of 6.383 MTPA (toposheet no. 73 I/5 and I/6).

The present leasehold area of Cluster-VIII is 1331.95 Ha. The area has a general undulating topography with general slope towards south and south-west. The ground elevation in the area ranges from 175 m to 221 m AMSL. Chatkari Jore, Tisra Jore and its tributaries controlling the drainage pattern of the area. The area comes under the watershed of Chatkari Jore.

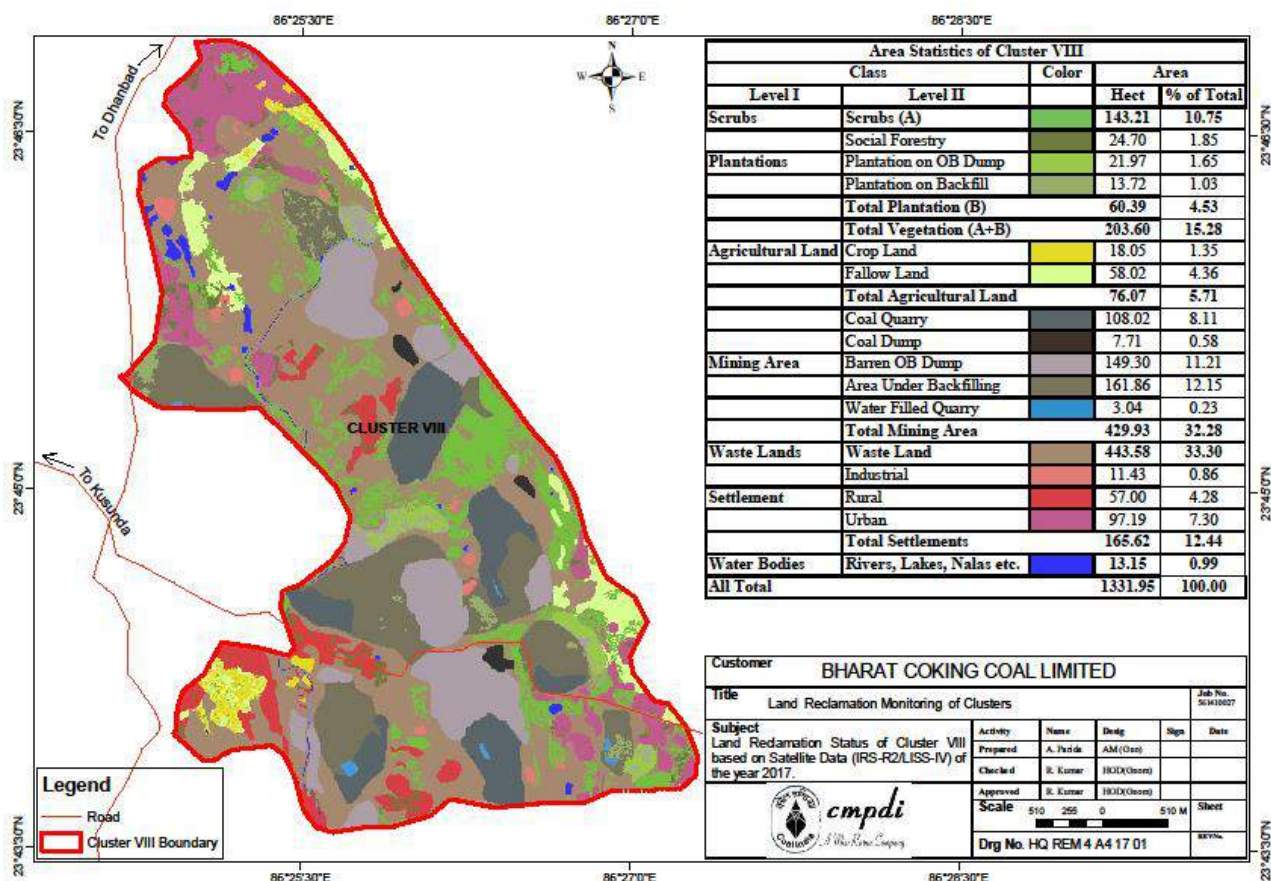
Monitoring stations (**D-8, D-43, D-49 and D-51**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	D-8	Alokdiha	5.83	1.70	2.75	3.20	4.80	1.95	2.85	4.25	3.20	5.65	1.65	1.85
2	D43	Alagdih	6.60	2.31	2.55	3.05	7.35	3.55	2.70	4.25	3.05	7.15	2.90	3.45
3	D49	Galucdih	3.25	1.41	1.65	1.98	1.75	0.60	1.50	1.25	1.98	3.45	1.45	2.45
4	D51	Chankuiya	8.45	6.03	5.70	7.35	9.95	8.05	5.75	7.75	8.26	10.93	4.80	7.10
Average WL (bgl)			6.03	2.86	3.16	3.90	5.96	3.54	3.20	4.38	4.12	6.80	2.70	3.71

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.75 m Max – 10.93 m
Post-monsoon GW Level (m): Min – 1.50 m Max – 5.75 m

LAND USE / LAND COVER MAP OF THE CLUSTER-VIII MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	279.69 x 10 ⁴	279.69 x 10 ⁴	279.69 x 10 ⁴
2	Open Land	886.66 x 10 ⁴	886.66 x 10 ⁴	886.66 x 10 ⁴
3	Road/ Paved Area	97.19 x 10 ⁴	97.19 x 10 ⁴	97.19 x 10 ⁴
4	Rooftop area of building/ sheds	68.43 x 10 ⁴	68.43 x 10 ⁴	68.43 x 10 ⁴
5	Total	1331.95 x 10 ⁴	1331.95 x 10 ⁴	1331.95 x 10 ⁴

I. GROUND WATER LEVEL OF CLUSTER-IX

Cluster - IX of B.C.C.L mines under administrative control of Lodna Area of B.C.C.L (Jharia Coalfield) is located in Dhanbad district of Jharkhand. Cluster- IX consists of eight mines namely; North Tisra/South Tisra OCP, Jeenagora OCP, North Tisra UG, Lodna UG, Bagdigi UG, Bararee UG, Joyrampur UG and Jealgora UG (closed) are under the administrative control of Lodna Area of Bharat Coking Coal Limited (B.C.C.L - A Subsidiary of Coal India Limited). Among them N. Tisra/S. Tisra OCP, Jeenagora OCP and N. Tisra UG mine will be amalgamated and will form North Tisra/South Tisra Expansion OCP. North Tisra/South Tisra Expansion OCP, Lodna UG, Bagdigi UG, Bararee UG and Joyrampur UG are under Lodna Area of BCCL is located in the west part of Jharia Coalfield. All above the mines are contiguous in nature and the environmental impact is overlapping in ambient environment due to cumulative effect of the mining activities. The life of the project works out upto 30 years considering annual target production of 8.513 MTPA (toposheet no. 73 I/6).

The present leasehold area of Cluster-IX is 1967.22 Ha. The topography of the area is undulating with gentle slope towards south. The RL varies from 221 m to 188.44 m AMSL. Chatkari Jore, Tisra Jore, Sulunga Jore and its tributaries controlling the drainage pattern of the area. The area comes under the watershed of Chatkari Jore.

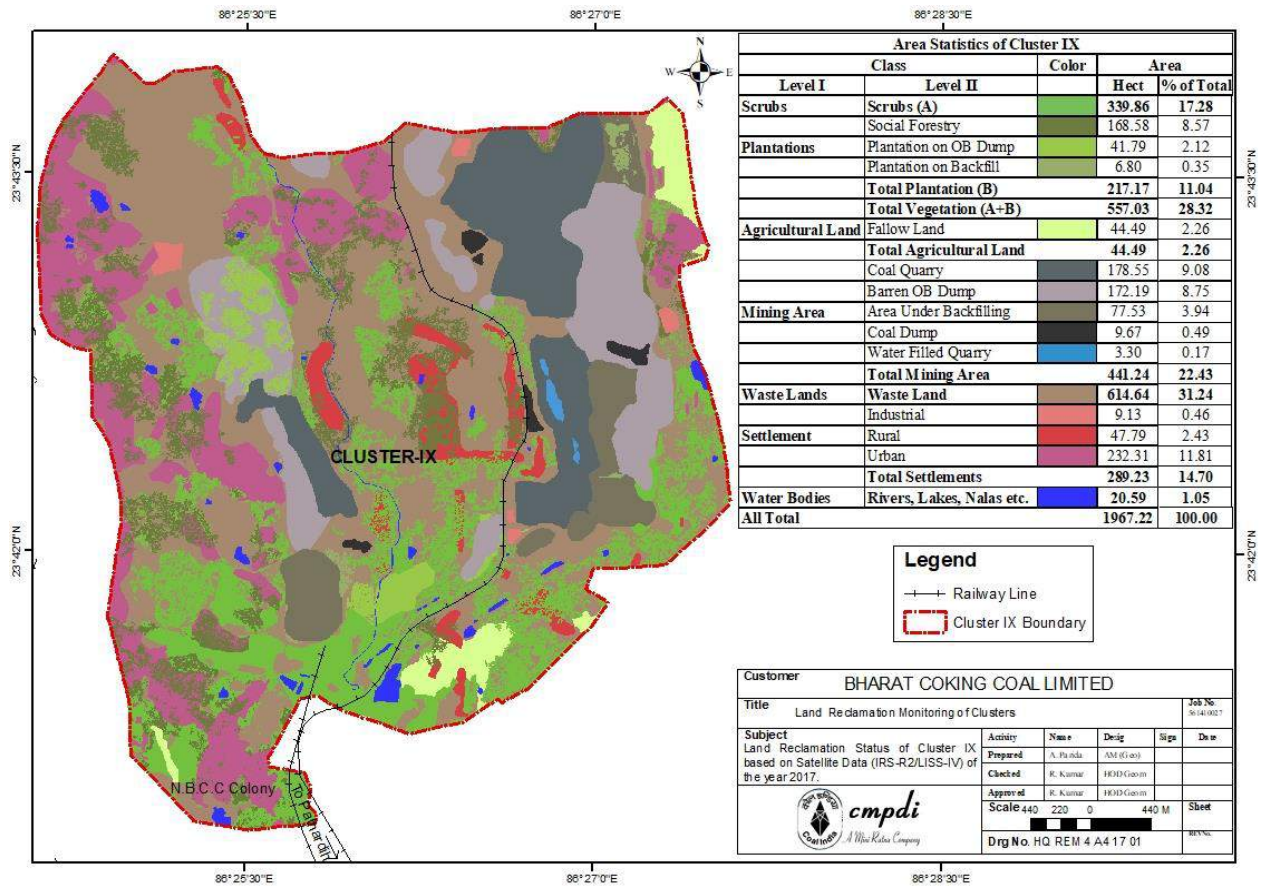
Monitoring stations (**D-5, D-7, D-39, D-40A, D-41 and D-74**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	D-5	Jiyalgora	8.60	3.20	7.70	7.90	8.25	2.90	4.85	8.20	5.80	7.80	4.39	5.30
2	D-7	Golden Pahari	7.33	2.56	5.13	5.35	8.23	1.88	3.28	4.86	5.15	7.53	2.23	2.83
3	D-39	Tilaboni	9.40	3.35	6.05	6.78	12.60	4.00	5.95	12.45	3.18	4.95	2.50	4.35
4	D40A	Khapa Dhawra	1.95	0.30	1.43	6.78	1.85	1.50	1.45	1.95	1.70	2.10	1.10	1.40
5	D-41	Joyrampur	3.30	1.43	1.45	1.60	2.30	0.70	1.25	1.40	1.30	1.59	1.08	1.32
6	D-74	Bhulan Bararee	4.30	2.58	3.93	4.00	5.80	2.35	3.57	4.95	5.80	8.60	3.40	4.80
Average WL (bgl)			5.81	2.24	4.28	4.54	6.51	2.22	3.39	5.64	3.82	5.43	2.45	3.33

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.59 m Max – 12.60 m
Post-monsoon GW Level (m): Min – 1.25 m Max – 7.70 m

LAND USE / LAND COVER MAP OF THE CLUSTER-IX MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	601.52 x 10 ⁴	601.52 x 10 ⁴	601.52 x 10 ⁴
2	Open Land	1076.47 x 10 ⁴	1076.47 x 10 ⁴	1076.47 x 10 ⁴
3	Road/ Paved Area	232.31 x 10 ⁴	232.31 x 10 ⁴	232.31 x 10 ⁴
4	Rooftop area of building/ sheds	56.92 x 10 ⁴	56.92 x 10 ⁴	56.92 x 10 ⁴
5	Total	1967.22 x 10 ⁴	1967.22 x 10 ⁴	1967.22 x 10 ⁴

J. GROUND WATER LEVEL OF CLUSTER-X

Cluster-X consists of Bhowrah North OC & UG, Bhowrah South OC & UG, Amalgamated Sudamdih Patherdih, Sudamdih Shaft, Amlabad UG (Closed) and Sudamdih Coal Washery comes under the administrative control of Eastern Jharia Area of Bharat Coking Coal Limited (B.C.C.L - A Subsidiary of Coal India Limited). This cluster of mines is located in eastern part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out is more than 30 years considering annual target production of 2.289 MTY.

Cluster-X mine involves leasehold area of about 2057.47 Ha of land. It covered in Survey of India toposheet no. 73 I/6. The area of Bhowrah North OC & UG, Bhowrah South OC & UG, Amalgamated Sudamdih Patherdih, Sudamdih Shaft, Amlabad UG (Closed) are 280.83 Ha, 571.58 Ha, 498.61 Ha, 391.50 Ha and 386.95 Ha respectively.

The present leasehold area of Cluster-X is 2057.47 Ha. The area has an undulating topography with gentle slope towards south and south east. The RL varies from 185 m to 150.0 m AMSL. Gaurkuthi Nala and few seasonal streams are controlling the drainage pattern of the area. The area comes under the watershed of Damodar River.

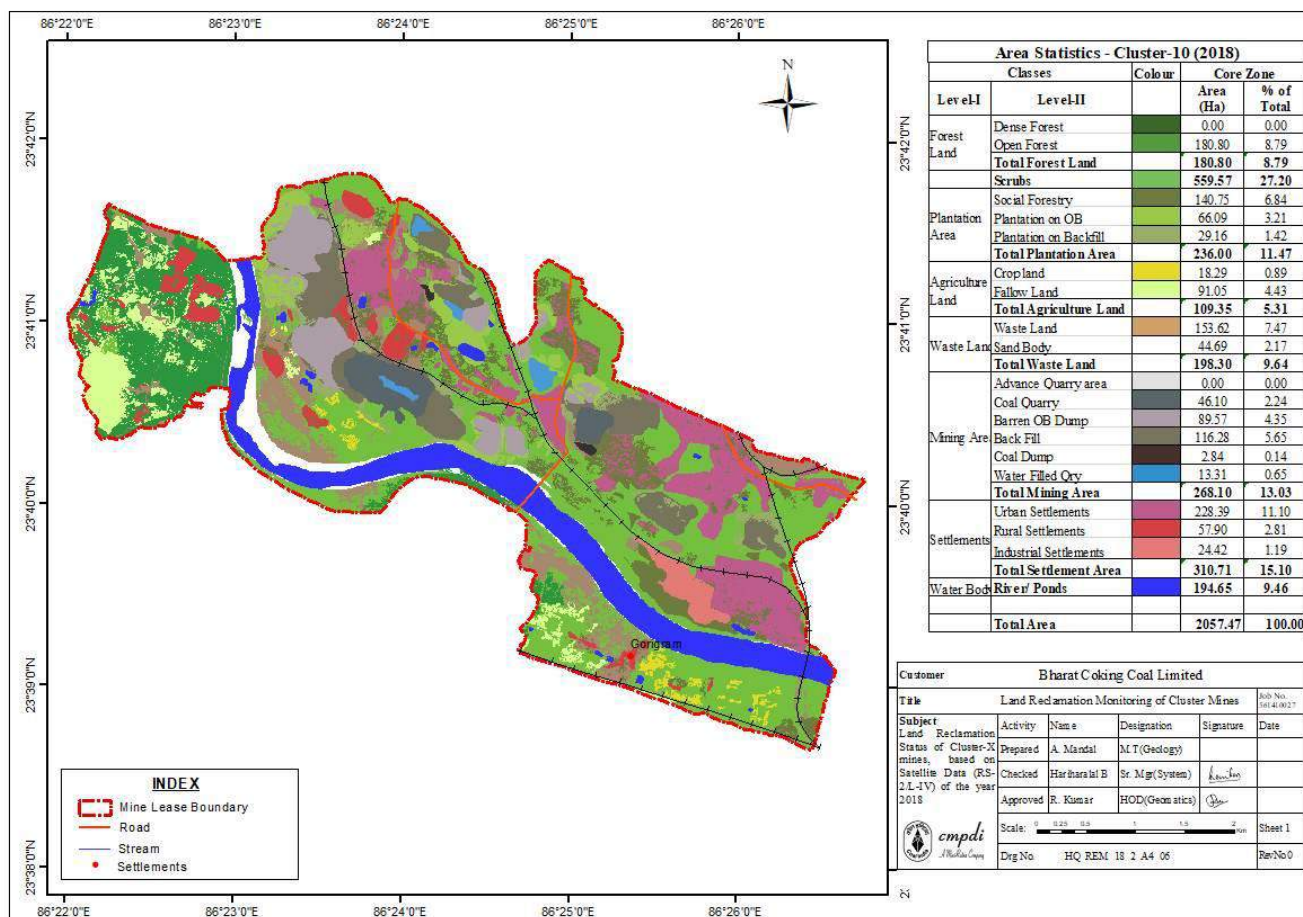
Monitoring stations (**A-19, D-35, D-36 and D-77**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

SI No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A-19	Bhowrah	6.05	2.30	3.25	3.70	4.85	0.95	3.43	4.95	2.95	5.55	1.85	2.45
2	D-35	Patherdih	8.20	2.98	5.40	5.62	8.00	3.15	3.80	5.90	6.58	8.40	3.58	4.45
3	D-36	Sudamdih	2.10	0.06	1.00	1.15	1.20	0.10	0.55	0.65	1.00	1.20	0.45	0.60
4	D-77	Amlabad	6.40	5.90	3.50	4.25	6.40	2.80	3.20	4.50	3.63	6.30	4.00	5.20
Average WL (bgl)			5.69	2.81	3.29	3.68	5.11	1.75	2.75	4.00	3.54	5.36	2.47	3.18

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.20 m Max – 8.40 m
Post-monsoon GW Level (m): Min – 0.55 m Max – 5.40 m

LAND USE / LAND COVER MAP OF THE CLUSTER-X MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	1085.72 x 10 ⁴	1085.72 x 10 ⁴	1085.72 x 10 ⁴
2	Open Land	661.04 x 10 ⁴	661.04 x 10 ⁴	661.04 x 10 ⁴
3	Road/ Paved Area	228.39 x 10 ⁴	228.39 x 10 ⁴	228.39 x 10 ⁴
4	Rooftop area of building/ sheds	82.32 x 10 ⁴	82.32 x 10 ⁴	82.32 x 10 ⁴
5	Total	2057.47 x 10 ⁴	2057.47 x 10 ⁴	2057.47 x 10 ⁴

K. GROUND WATER LEVEL OF CLUSTER-XI

Cluster–XI consists of eight coal mines; Moonidih UG, Gopalichak UG Project, Kachi Balihari 10/12 Pit UG, Pootkee Balihari Project UG, Bhagaband UG, Kendwadih UG (closed), Pootkee UG (closed), Kachi Balihari 5/6 Pit UG (closed) are under the administrative control of Western Jharia Area of Bharat Coking Coal Limited (B.C.C.L - A Subsidiary of Coal India Limited). The Cluster- XI is located in central part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out about upto 50 years considering annual target production of 6.604 MTPA (toposheet no. no. 73 I/5 7 73 I/6).

The present leasehold area of Cluster-XI is 3527.58 Ha. The area has an undulating topography with gentle slope towards south. The RL varies from 201 m to 166 m AMSL. Katri River, Jarian Nala, Ekra Jore and Kari Jore are controlling the drainage of the area. The area comes under the watershed of Katri River and Kari Jore.

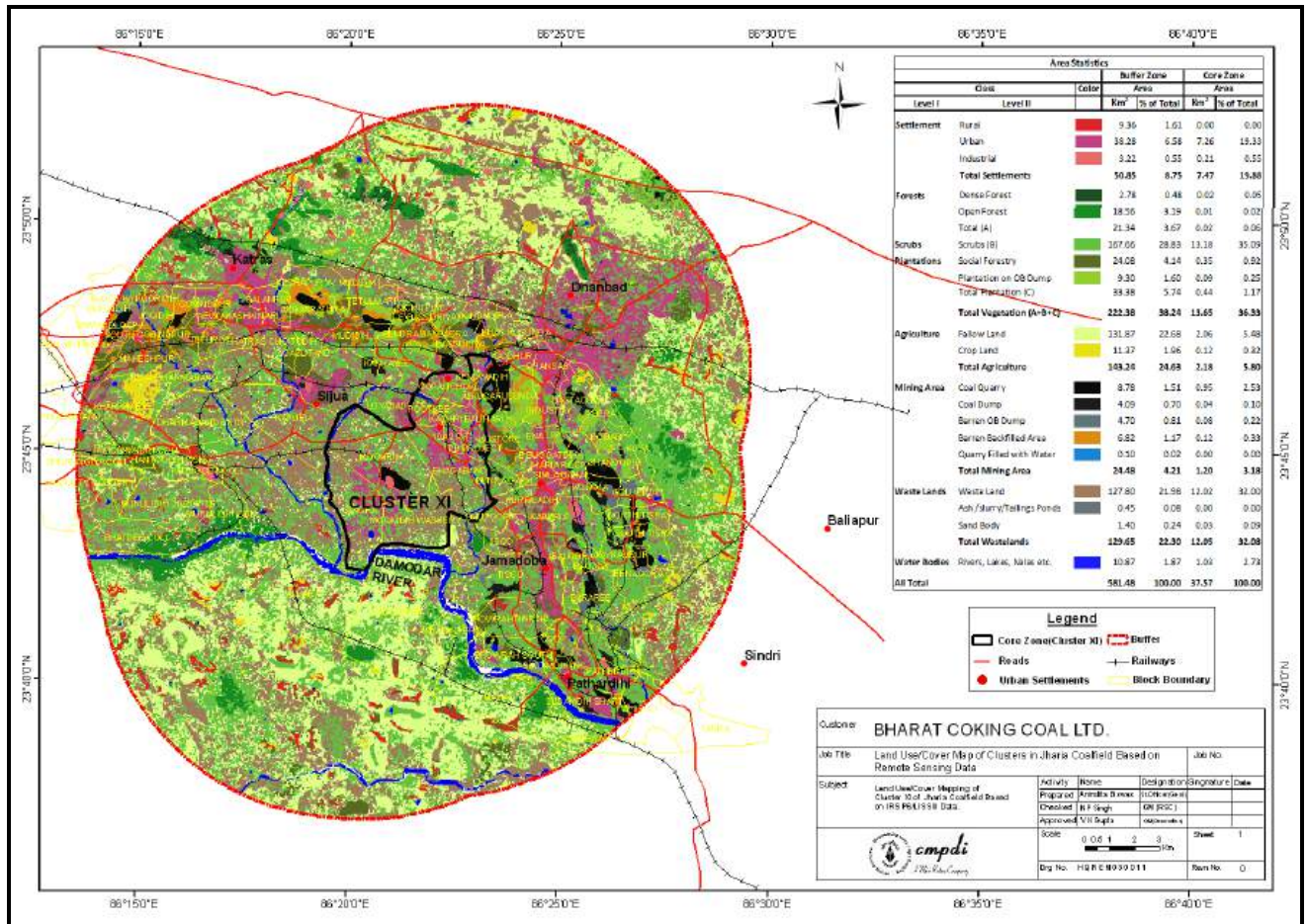
Monitoring stations (**A-17, A-18, A-20 and A-32**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A-17	Kachi Balihari	2.14	0.64	1.69	1.79	2.94	0.34	2.24	2.42	2.07	3.34	1.64	2.84
2	A-18	Baghaband	1.09	0.39	0.34	0.89	2.29	1.09	0.69	1.09	0.89	1.24	1.34	0.99
3	A-20	Gorbudih	8.47	1.44	3.87	4.42	4.57	3.32	1.82	4.02	3.59	4.57	1.92	2.57
4	A-32	Baludih	1.90	0.36	1.75	1.80	2.75	0.62	0.95	1.65	0.60	2.80	0.45	0.70
Average WL (bgl)			3.40	0.71	1.91	2.23	3.14	1.34	1.43	2.30	2.26	3.20	1.64	2.16

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 0.62 m Max – 8.47 m
Post-monsoon GW Level (m): Min – 0.34 m Max – 3.87 m

LAND USE / LAND COVER MAP OF THE CLUSTER-XI MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	1060.61 x 10 ⁴	1293.46 x 10 ⁴	1293.46 x 10 ⁴
2	Open Land	1518.33 x 10 ⁴	1509.06 x 10 ⁴	1509.06 x 10 ⁴
3	Road/ Paved Area	171.08 x 10 ⁴	171.08 x 10 ⁴	171.08 x 10 ⁴
4	Rooftop area of building/ sheds	777.56 x 10 ⁴	563.06 x 10 ⁴	563.06 x 10 ⁴
5	Total	3527.58 x 10 ⁴	3527.58 x 10 ⁴	3527.58 x 10 ⁴

L. GROUND WATER LEVEL OF CLUSTER-XIII

Cluster-XIII, consists of one running mine (Murulidih 20/21 pit UG mine) and six abandoned mines i.e. Bhurungiya colliery, Muchraidih colliery, Hantoodih colliery, Padugora colliery, Murulidih colliery and Bhatdee colliery of Western Jharia area, BCCL is located in the south-western part of Jharia coal field in Dhanbad district of Jharkhand. The area is covered by Survey of India toposheet no. 73 I/6. The life of the project works out about 15 years considering annual target production of 0.234 MTPA.

The present leasehold area of Cluster-XIII is 1898.62 Ha. The area has an undulating topography with gentle slope towards south-east. The maximum RL is 224 m AMSL in the north-western part of the area whereas the minimum RL is 179 m AMSL at southern part. The area comes under the watershed area of Jamunia River and Katri River.

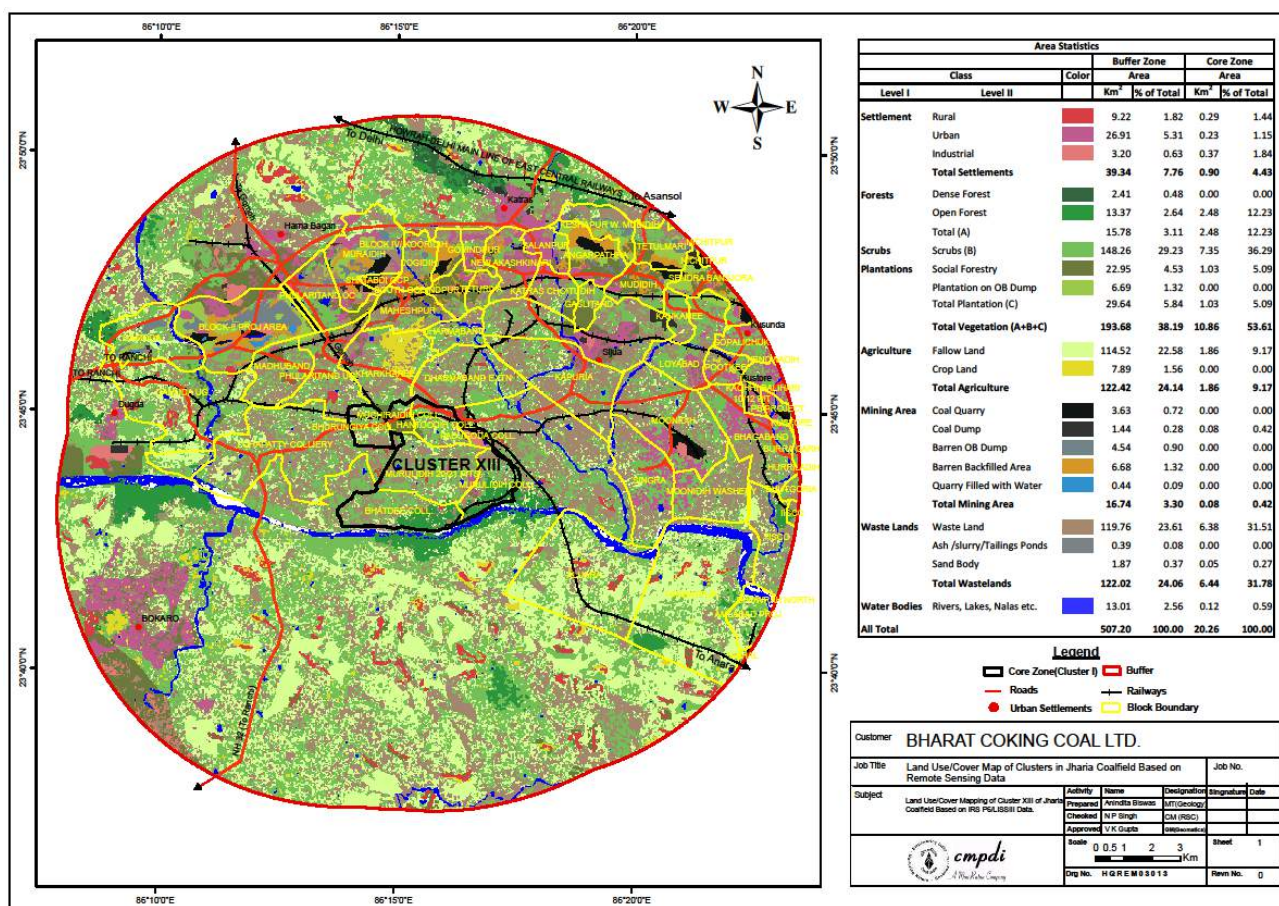
Monitoring stations (**A-22, A-23, A-33, A-34, B-25 and B-48**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A-22A	Nagdah Basti	2.90	0.20	1.98	2.00	2.60	1.75	2.00	2.85	1.70	3.35	1.10	1.30
2	A-23	Machhayara	8.92	1.12	5.62	7.12	11.97	5.37	3.77	6.57	8.92	11.15	6.46	7.17
3	A-33	Mahuda Washery	4.55	0.38	1.85	2.85	3.65	0.55	1.25	1.55	2.24	4.07	1.26	2.35
4	A-34	Mahuda Mosque	8.35	3.43	3.45	5.35	6.35	3.45	3.95	5.45	5.32	9.45	4.75	5.35
5	B-25	Mahuda More	7.90	3.02	2.55	3.45	4.80	1.38	1.40	3.50	3.68	5.90	2.90	3.70
6	B-48	Mahuda	8.20	3.37	3.85	4.51	7.05	2.85	4.35	5.45	3.55	7.33	2.95	3.97
Average WL (bgl)			6.80	1.92	3.22	4.21	6.07	2.56	2.79	4.23	4.24	6.88	3.24	3.97

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 2.60 m Max – 11.15 m
Post-monsoon GW Level (m): Min – 1.25 m Max – 5.62 m

LAND USE / LAND COVER MAP OF THE CLUSTER-XIII MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	1484.41 x 10 ⁴	1570.48 x 10 ⁴	1570.48 x 10 ⁴
2	Open Land	183.28 x 10 ⁴	97.22 x 10 ⁴	97.22 x 10 ⁴
3	Road/ Paved Area	71.84 x 10 ⁴	71.83 x 10 ⁴	71.83 x 10 ⁴
4	Rooftop area of building/ sheds	159.09 x 10 ⁴	159.09 x 10 ⁴	159.09 x 10 ⁴
5	Total	1898.62 x 10 ⁴	1898.62 x 10 ⁴	1898.62 x 10 ⁴

M. GROUND WATER LEVEL OF CLUSTER-XIV

Cluster-XIV of B.C.C.L mines under administrative control of Western Jharia Area of B.C.C.L (Jharia Coalfield) is located in Dhanbad district of Jharkhand. Lohapatty UG and Lohapatty OC patch (proposed) are under the administrative control of Western Jharia Area of Bharat Coking Coal Limited (B.C.C.L - A Subsidiary of Coal India Limited). The Cluster- XIV is located in western part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out upto 08 years considering annual target production of 0.526 MTPA. Cluster-XIV mine involves leasehold area of about 1418.25 Ha of land. It covered in Survey of India toposheet no. 73 I/2.

The present leasehold area of Cluster-XIV is 1418.25 Ha. The topography of the area is undulating with slope towards south west. The maximum RL is 224 m in the north-eastern part whereas the minimum RL is 170 m above mean sea level on the south-western part of the area. Jamunia River and its tributaries are controlling the drainage of the area. The area comes under the watershed area of Jamunia River.

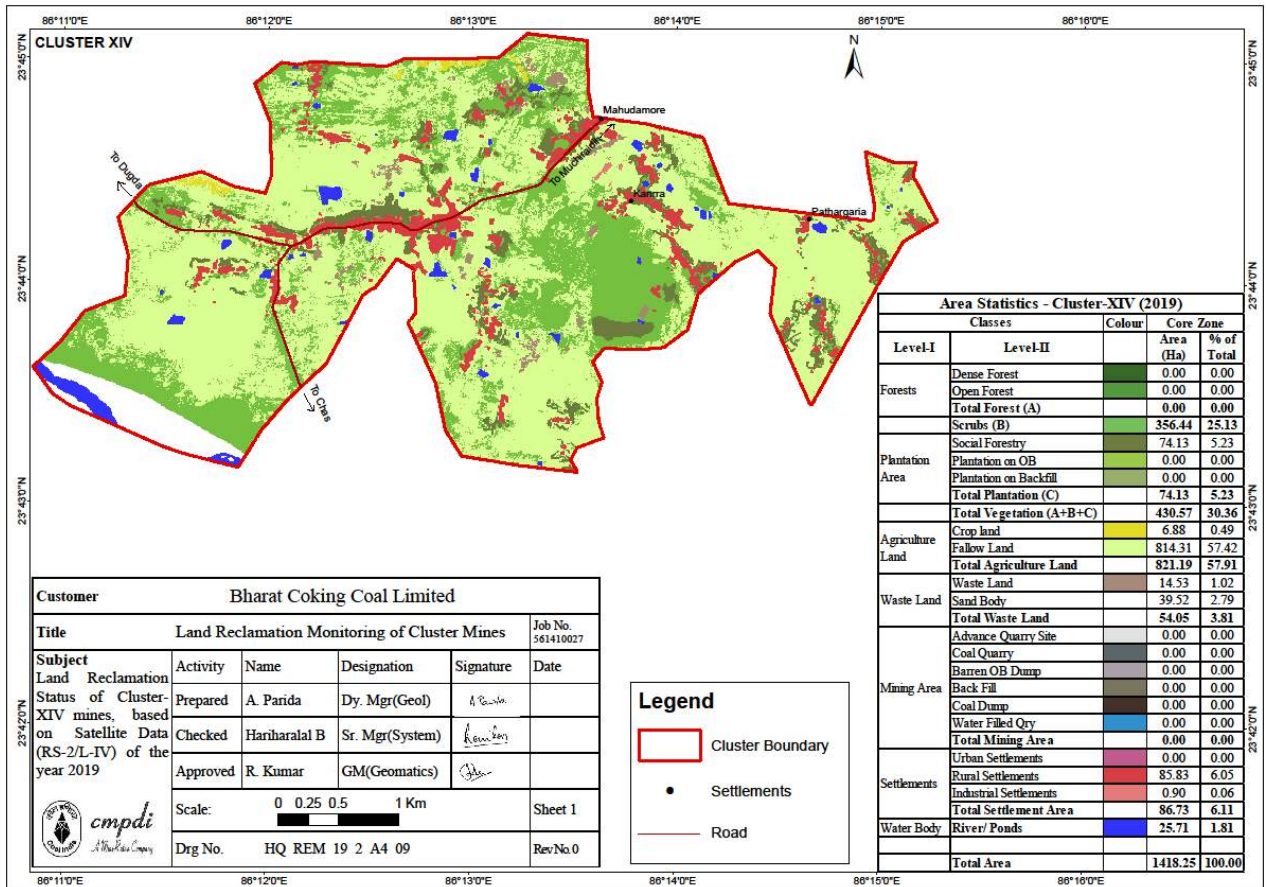
Monitoring stations (**B-23, B-24 and B-67**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	B-23	Lohapatti	3.24	0.77	1.76	2.69	2.84	1.12	1.34	2.24	3.04	6.64	1.74	2.14
2	B-24	Telmuchu	5.48	1.13	3.53	4.38	4.58	1.23	2.33	3.63	6.43	9.28	3.31	4.33
3	B-67	Simatanr	7.55	1.83	3.95	5.90	8.57	3.37	4.35	4.65	6.50	9.55	3.60	4.00
Average WL (bgl)			5.42	1.24	3.08	4.32	5.33	1.91	2.67	3.51	5.32	8.49	2.88	3.49

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 2.84 m Max – 9.55 m
Post-monsoon GW Level (m): Min – 1.34 m Max – 4.35 m

LAND USE / LAND COVER MAP OF THE CLUSTER-XIV MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	1251.76 x 10 ⁴	1251.76 x 10 ⁴	1251.76 x 10 ⁴
2	Open Land	79.76 x 10 ⁴	79.76 x 10 ⁴	79.76 x 10 ⁴
3	Road/ Paved Area	85.83 x 10 ⁴	85.83 x 10 ⁴	85.83 x 10 ⁴
4	Roof top area of building/ sheds	0.90 x 10 ⁴	0.90 x 10 ⁴	0.90 x 10 ⁴
5	Total	1418.25 x 10 ⁴	1418.25 x 10 ⁴	1418.25 x 10 ⁴

N. GROUND WATER LEVEL OF CLUSTER-XV

Cluster - XV of B.C.C.L mines under administrative control of Govindpur Area and barora Area of B.C.C.L (Jharia Coalfield) is located in Dhanbad district of Jharkhand. Cluster-XV consists of four coal mines; Kharkharee UG (underground mine) and Dharmaband UG are under the administrative control of Govindpur Area and Madhuband UG & Phularitand UG are under the administrative control of Barora Area of Bharat Coking Coal Limited (B.C.C.L - A Subsidiary of Coal India Limited). The Cluster-XV is located in western part of Jharia Coalfield in Dhanbad district of Jharkhand. The life of the project works out upto 30 years considering annual target production of 0.423 MTPA. Cluster-XV mine involves leasehold area of about 1696.55 Ha of land. It covered in Survey of India toposheet no. 73 I/1 and 73 I/5.

The present leasehold area of Cluster-XV is 1696.55 Ha. The topography of the area is undulating with slope towards south-west. The maximum RL is 235 m in the Kharkharee mine area whereas the minimum RL is 165 m AMSL on the eastern & western part of the Cluster. Jamunia River and Khudia River are controlling the drainage of the area. The area comes under the watershed area of both Jamunia River and Khudia River.

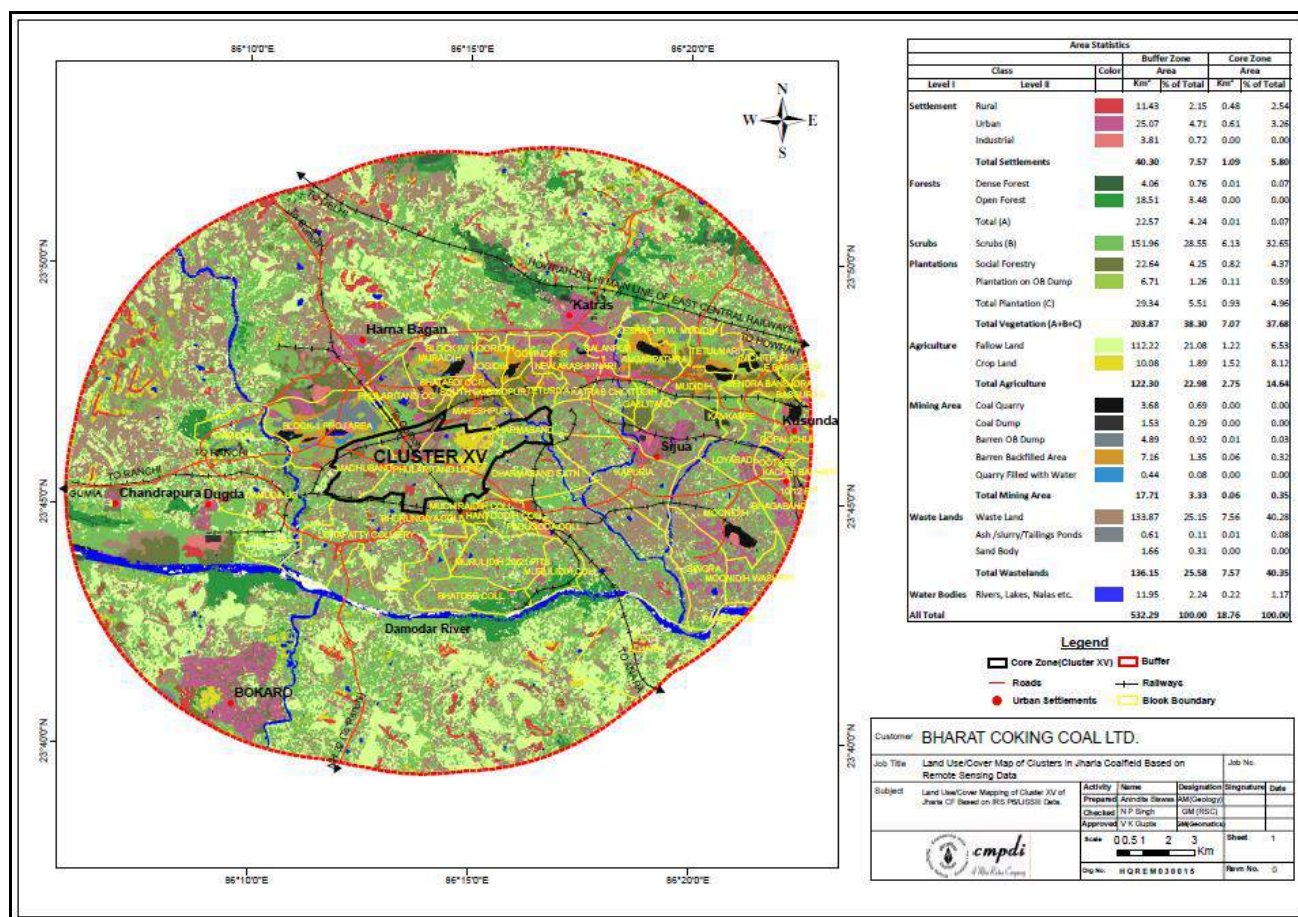
Monitoring stations (**A-24, B-32A and B-61A**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	A24	Pipratn	4.88	-	4.28	4.68	15.88	1.73	2.48	4.08	11.68	14.58	5.78	6.88
2	B32A	Madhuband	3.30	1.18	2.00	2.21	5.55	1.25	1.70	2.35	3.23	6.75	2.80	3.90
3	B61A	Kesargora	3.32	0.85	1.60	2.07	3.35	1.39	0.52	1.12	1.27	2.57	2.0	2.02
Average WL (bgl)			3.83	1.02	2.63	2.99	8.25	1.46	1.57	2.52	5.39	7.97	3.63	4.27

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 2.57 m Max – 15.88 m
Post-monsoon GW Level (m): Min – 0.52 m Max – 6.88 m

LAND USE / LAND COVER MAP OF THE CLUSTER-XV MINES, BCCL



Sl no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	365.18 x 10 ⁴	957.34 x 10 ⁴	957.34 x 10 ⁴
2	Open Land	1130.53 x 10 ⁴	538.37 x 10 ⁴	538.37 x 10 ⁴
3	Road/ Paved Area	101.67 x 10 ⁴	101.67 x 10 ⁴	101.67 x 10 ⁴
4	Rooftop area of building/ sheds	99.17 x 10 ⁴	99.17 x 10 ⁴	99.17 x 10 ⁴
5	Total	1696.55 x 10 ⁴	1696.55 x 10 ⁴	1696.55 x 10 ⁴

O. GROUND WATER LEVEL OF CLUSTER-XVI

Cluster - XVI of B.C.C.L mines under administrative control of Chanch Victoria Area of B.C.C.L (Raniganj Coalfield) is located in Dhanbad district of Jharkhand. The Cluster-XVI (Dahibari-Basantimata Group of mines) is located on the western part of the Raniganj Coalfield and falls within Dhanbad district of Jharkhand. There are total five collieries within this Clusture- XVI (Dahibari-Basantimata OC, Basantimata UG, New Laikdih OC, Laikdih Deep UG and Chanch UG Colliery). All above the mines are contiguous in nature and the environmental impact is overlapping in ambient environment due to cumulative effect of the mining activities. The life of the project works out upto 24 years considering annual target production of 1.963 MTPA. Cluster-XVI mine involves leasehold area of about 2008.40 Ha of land. It covered in Survey of India toposheet no. 73 I/14.

The present leasehold area of Cluster-XVI is 2008.40 Ha. The topography of the area is undulating with slope towards south west. The area is plain with gently undulating with elevation varying from 100 m to 140 m AMSL. The general slope of the area is towards southeast. Barakar River and Khudia River are controlling the drainage of the area. The area comes under the watershed area of Barakar River.

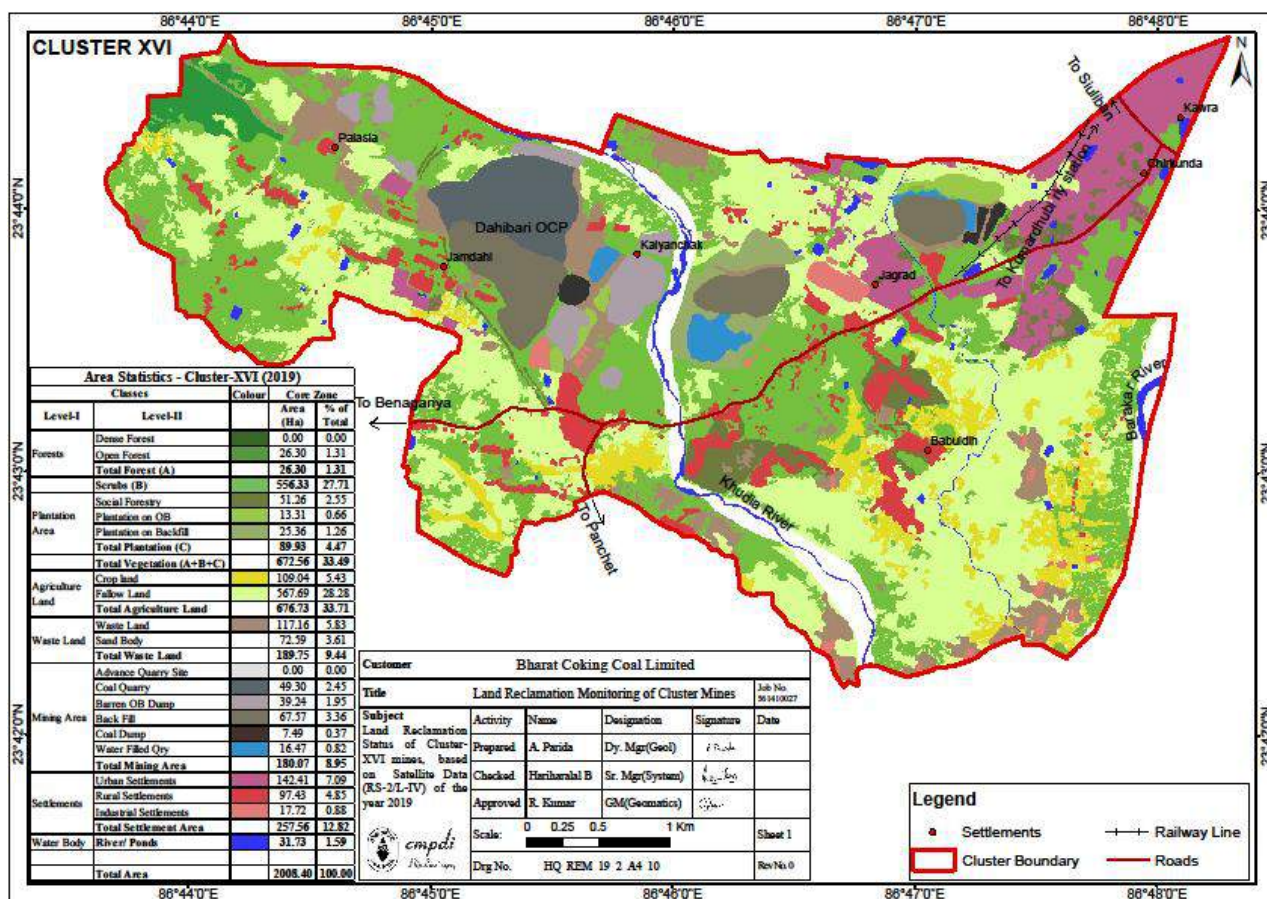
Monitoring stations (**DB-22, DB-23, DB-24 & DB-25**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has done in the months of May'20, August'20, and Nov'20 and January'21, the Ground water level data enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)											
			2020-21				2019-20				2018-19			
			May	Aug	Nov	Jan	May	Aug	Nov	Jan	Feb	May	Aug	Nov
1	DB22	Dahibari, Niche Basti	2.63	1.30	2.25	2.38	4.93	1.38	1.63	1.73	1.98	2.34	1.35	1.93
2	DB23	Dahibari OC	2.50	0.70	1.95	2.17	1.60	0.88	0.80	1.00	2.00	2.85	1.20	1.75
3	DB24	Dahibari	3.60	1.57	5.70	5.90	9.35	3.20	3.88	4.80	8.70	8.25	4.43	5.70
4	DB25	Basantimata UG	3.98	1.19	2.63	2.68	-	-	-	-	3.23	3.93	1.41	1.63
Average WL (bgl)			3.18	1.19	3.13	3.28	4.53	1.82	2.10	2.51	3.98	4.34	2.10	2.75

LAST THREE-YEAR ASSESSMENT:

Pre-monsoon GW Level (m): Min – 1.60 m Max – 9.35 m
Post-monsoon GW Level (m): Min – 0.80 m Max – 5.70 m

LAND USE / LAND COVER MAP OF THE CLUSTER-XVI MINES, BCCL



SI no	Land Use Details	Existing (sq. meter)	Proposed (sq. meter)	Grand Total (sq. meter)
1	Green Belt Area	1349.29 x 10 ⁴	1349.29 x 10 ⁴	1349.29 x 10 ⁴
2	Open Land	401.55 x 10 ⁴	401.55 x 10 ⁴	401.55 x 10 ⁴
3	Road/ Paved Area	142.41 x 10 ⁴	142.41 x 10 ⁴	142.41 x 10 ⁴
4	Rooftop area of building/ sheds	115.15 x 10 ⁴	115.15 x 10 ⁴	115.15 x 10 ⁴
5	Total	2008.40 x 10 ⁴	2008.40 x 10 ⁴	2008.40 x 10 ⁴

4.0 GROUND WATER LEVEL SCENARIO

The summarized water level data of all clusters given in **Table – 7**.

Table –7: Groundwater level data Cluster-wise

Sl. No.	Cluster of BCCL	No. of Monitoring Wells	Water level fluctuation Below ground level (May, Aug, Nov'20 & Jan'21)	Avg. Fluctuation (in meters) during 2020-21	Geological Formation
1	I	4 nos.	0.15 to 10.00 m	2.76 m	Barakar
2	II	5 nos.	0.67 to 10.33 m	3.66 m	Barakar
3	III	5 nos.	0.32 to 10.33 m	2.95 m	Barakar
4	IV	4 nos.	0.03 to 9.25 m	3.27 m	Barakar
5	V	4 nos.	0.02 to 5.60 m	2.51 m	Barakar
6	VI	2 nos.	1.65 to 10.50 m	4.02 m	Barakar
7	VII	7 nos.	0.48 to 9.45 m	2.26 m	Barakar
8	VIII	4 nos.	1.41 to 8.45 m	2.87 m	Barakar
9	IX	6 nos.	0.30 to 9.40 m	1.53 m	Barakar
10	X	4 nos.	0.06 to 6.40 m	2.40 m	Barakar
11	XI	4 nos.	0.36 to 8.47 m	1.50 m	Barakar & Barren Measure
12	XIII	6 nos.	0.20 to 8.92 m	3.60 m	Raniganj
13	XIV	3 nos.	0.77 to 7.55 m	2.35 m	Raniganj
14	XV	3 nos.	0.85 to 4.88 m	1.20 m	Barakar & Barren Measure
15	XVI	3 nos.	0.70 to 5.90 m	0.75 m	Barakar

Depth to water level (in bgl) values described that water level goes down to maximum 10.50 m during pre-monsoon'2020 and maximum upto 8.60 m during post-monsoon'2020. Un-confined aquifer affected around 20 m to 30 m maximum close to active opencast mining areas, showing steep gradient towards mine void. Other than that, there is no mining effect in the water level within JCF area and RCF area (part). Historical water level data and hydrograph of permanent observation stations from CGWB shown in **Annexure–VII**. Water Table contour map and Depth to water level map shown in **Plate-IV & V**.

Monitoring groundwater (quantity & quality) to assess the present condition and resource has done regularly in the coalfield areas. Well hydrographs (**Annexure–VI and VII**) are prepared and studied to identify potentially adverse trends so that appropriate action can protect groundwater resource. Hydrograph trend analysis of CGWB monitoring wells and CMPDI observation wells, reveals decline

trends in both Pre and Post-monsoon GW level trends (max. upto 0.55 cm/year in Cluster-I, Cluster-V and Cluster-VII) but no significant decline trend (>1.0 m/year) of water level is noticed in any particular area for the last 10 years within the coalfield area. Regarding quality monitoring, the water sample location map (**Plate-II**) with collection points details (dug wells) given in **Annexure-V** and Quality is given in **Annexure-VII**.

5.0 GROUND WATER QUALITY

The ground water sample of the study area (15 nos. of Cluster of mines, BCCL) collected from dug wells and analyzed. Fifteen ground water samples (GW-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15 & 16) analyzed during the month of June'2020 at CMPDI, RI-II, Dhanbad. The water sampling details given in **Annexure-V** and Water sample locations shown in **Plate-II**. The water quality data enclosed in **Annexure-VII**.

The study of the variations in water quality parameters described below:

The pH of the groundwater samples varies between 7.81 (GW-6) to 8.21 (GW-3), the pH is within the IS 10500 limit of drinking water standard.

The mineral constituents dissolved in water constitute the dissolved solids. The total dissolve solids vary from 178 (GW-11) to 764 mg/l (GW-5), the TDS values ranges from well within the IS 10500:2012 standards to occasionally exceeding the standard limits of drinking water.

The alkalinity of the water samples varies from 76 (GW-6) to 152 mg/l (GW-11) and are within the stipulated standard of (200 mg/l) drinking water. The concentrations of calcium in the water samples vary from 32 (GW-11) to 180 mg/l (GW-15) and are **slightly above** the permissible limit (75 mg/l) of drinking water standards. The total hardness ranges between 148 (GW-8) to 680 mg/l (GW-5) and the value of total hardness in water samples are **above** the permissible limit (200 mg/l). The sulphate ranges between 38 (GW-8) to 178 mg/l (GW-13) and the value of sulphate in water sample are within the permissible limit (200 mg/l). The Iron, Copper, Manganese, Lead, Zinc and Chromium concentration in the water samples found to be below the upper ISI limits for drinking water.

6.0 STAGE OF GROUNDWATER EXTRACTION

The groundwater mainly utilized for domestic needs and for irrigation purposes. The groundwater abstraction is mainly through dug wells and bore wells. The stage of groundwater development in Dhanbad District is 76.30% (as per 2017 GWRE). The highest stage of development is in Jharia Block (127.0%) & Dhanbad Block (107.50%) and lowest stage of development is in Baliapur Block (78.24%) as per GWRE-2013. The Gondwana sandstones in general, known to constitute good aquifers at many places. However, the yield potential of the area adjoining to active mines in the coal belt is poor. The active mines often act as groundwater “sinks”. In contrast, the water logged abandoned mines and pits act as potential sources of groundwater. As per the assessment by Central Ground Water Board (CGWB), Patna in 2017, Block wise data of Dhanbad District given below:

Table–8A: Block wise Stage of Groundwater development

SI No.	Administrative Unit		Stage of GW Development	Category (GWRE-2013)	Category (GWRE-2017)
	District	Block			
1	Bokaro	Bermo	156.30%	Over- exploited	Over- exploited
2	Dhanbad	Baghmara	91.74%	Critical	Critical
3	Dhanbad	Baliapur	78.24%	Semi- Critical	Semi- Critical
4	Dhanbad	Dhanbad	107.50%	Over- exploited	Over- exploited
5	Dhanbad	Jharia	127.0%	Over- exploited	Over- exploited
6	Dhanbad	Topchachi	98.45%	Critical	Critical

- **Dynamic Groundwater Resource Assessment, CGWB as per 2013 & 2017.**

Table-8B: Cluster wise Groundwater development scenario

Cluster/ Area	Adminis- trative Blocks/Stage Of GW Extraction	Total Water demand (cum/day)				Avg. GW level (bgl in m) 2020		GW level declining trend 2005-2020		Remarks
		Mine Discharge + BH pumping	Surface Water Source	Total Use (Domestic + Industrial)	Excess Or other use	Pre- monsoon	Post- monsoon	Pre- monsoon	Post- monsoon	
Cluster-I	Bermo (SOD: Over- exploited)	2173 (2065+108)	NIL	2112 (1698+414)	61	5.46	2.69	YES	YES	Recharge structure needed
Cluster-II	Baghmara (SOD: Critical)	8350	Jamunia river	6737 (2755+3982)	1613	5.83	2.17	NO	NO	Excess mine water needed to be utilized
Cluster-III		12760 (10960+1800)	NIL	8946 (7849+1097)	3814	4.91	1.96	NO	NO	
Cluster-IV		5900	MADA	5100 (3605+1495)	800	5.52	2.25	NO	NO	
Cluster-V		12690 (11025+1665)	MADA	11063 (5710+5353)	1897	4.18	1.67	YES	YES	
Cluster-VI	Dhanbad	4150	MADA	4150 (1664+2486)	0.0	7.50	3.49	YES	NO	--
Cluster-VII	(SOD: Over- exploited)	21565	MADA	20826 (17596+3230)	739	5.56	3.71	YES	YES	Excess mine water needed to be utilized water
Cluster-VIII	Jharia (SOD: Over- exploited)	9320	MADA	5294 (3730+1564)	4026	6.03	3.16	NO	NO	
Cluster-IX		12980	MADA	9358 (4549+4809)	3622	5.81	4.28	NO	NO	
Cluster-X		11825	Damodar river	6201 (4255+1946)	5624	5.69	3.29	YES	NO	
Cluster-XI	Dhanbad (SOD: Over- exploited)	24960	MADA & DVC	19425 (14015+5410)	5535	3.40	1.91	NO	NO	
Cluster-XIII	Baghmara	4815	Damodar river	4815 (4679+136)	0.0	6.80	3.22	NO	NO	--
Cluster-XIV	(SOD: Critical)	2600	NA	2550 (2412+138)	50	5.42	3.08	NO	NO	--
Cluster-XV		6200	NA	5941 (4600+1341)	259	3.83	2.63	NO	NO	--
Cluster-XVI	Nirsa (SOD:Safe)	1910	DVC (Barakar river)	1730 (1380+350)	180	3.18	3.13	NO	NO	--

MADA – Mineral Area Development Authority, Jharkhand, Dhanbad (payment basis).

DVC – Damodar Valley Corporation, Maithon/Panchet, Jharkhand (payment basis).

7.0 IMPACT OF MINING ON GROUND WATER REGIME

7.1 GENERAL CONSEQUENCES OF COAL MINES ON AMBIENT HYDROGEOLOGICAL REGIME

Mining of coal either by opencast or underground method is bound to incise one or more water bearing strata (aquifers) which in turn may result in depletion or draw down in water levels and a corresponding inflow of water into the mine workings. The potential effects of coal mining operations on the hydrogeological regime are as under:

- ❖ Creates disruption in formation/aquifer
- ❖ Dewatering of aquifers
- ❖ Change in hydraulic gradient
- ❖ Modification of recharge to aquifers
- ❖ Change in groundwater flow pattern

The general need in mine planning from the hydrogeological point of view is the estimation of make of water (ground water seepage) into the mine, its rate, the mine pumping capacity to meet the storm rainwater accumulation, extent of depression of water surface and management of mine effluent (mine water). It is also desirable that the consequences of mining operation on the groundwater regime be determined in advance. However, the mine pumping in most of the cases are passive dewatering for the safety of the mine pit, active mine dewatering is done in few cases for very high potential aquifers.

7.2 POTENTIAL CONSEQUENCES OF OPENCAST AND UNDERGROUND COAL MINES OF JHARIA COALFIELD ON HYDROGEOLOGICAL REGIME

Generally, in the opencast and underground mines of Jharia Coalfield, alluvium and overlying weathered mantle are the first to excavate followed by upper Barakar Formation / Aquifer. Since these formations vary in thickness, compaction and their constituents over the area, their aquifer properties also vary.

The porosity and the compactness in the sandstone controls the discharge from these aquifers. The alluvium and weathered Formation wherever loose and fragile possess more porosity and this has high groundwater potential. Due to the mine cut, the depression in the water table created. The initial discharges due to this depression is large in amount due to concentration of flow to that region. In the top zones, water table condition prevails and away from the opening in the stratified section, semi-confined conditions exist. With progress of mine operations, there is an increase in the depth of incision as a result; the semi-confined aquifers are also punctured.

During mining the hydraulic gradients generally, steepens down near mine i.e. within the mine influence area. In the up-dip region, only un-confined aquifer punctured through the mining process and thus only it

affected whereas in the down-dip region both un-confined and semi-confined aquifers may be affected. The confined aquifers of lower Barakar Formation in the mining area not punctured as it lies below the working coal seams and hence normally there is no noticeable effect in the aquifer related to this formation.

7.3 ESTIMATION OF RADIUS OF MINE INFLUENCE ZONE

Radius of Influence can be defined as the radial distance from the center of the borehole to the point where there is no lowering of groundwater table/potentiometric surface.

The radius of influence (R) for Opencast and UG Mines within Jharia CF calculated by using Sichardt's formula based on present mining scenario.

$$R_0 = C \cdot (H-h) \cdot \sqrt{K}$$

Where, R_0 - Radius of influence (m), C - Constant = 3000,

(H-h) - Drawdown (m), K - Hydraulic conductivity (m/s).

Here, K has been used for Barakar Formations i.e. 0.05 m/d or 5.7×10^{-7} m/sec.

It may be appropriate to mention here that the presence of prominent boundaries/water bodies, faults or interfringing of sandstone and shale beds may restrict propagation of the drawdown cone. With the presence of low permeable beds such as clay/shale and younger coal seams in the formation, lying above the working seams the water level in the phreatic aquifer is not directly affected. During the working of board and pillar method, subsidence takes place during the extraction of total coal (depillaring), both the phreatic and semi-confined aquifers get affected. Surface vigilance and filling up subsided zone, if any, has to be constantly in view. The effect on groundwater level for most of the coal mine in Jharia coalfield has been observed in the down-dip side, generally within a distance up to 500 m and becomes milder/negligible thereafter.

8.0 CONSERVATION MEASURES & FUTURE STRATEGY

- BCCL has installed 25 Pressure Filter Plant of total capacity of 4.16 MGD to meet drinking water requirement nearby the area. At present 63 Water Treatment Plants are operational having capacity of 16.16 MGD within Jharia Coalfield area. Further installation of 28 more Pressure Filter Plants with the capacity of 5.84 MGD are in progress.

- BCCL participated in development of low cost technology for drinking water in a CSIR project along with CIMFR, Dhanbad and a pilot plant of 4000 Liters/hour is functional at PB Project site of BCCL. Similar plant has proposed at other sites of BCCL.
- A scheme entitled 'Scheme for multi-purpose utilization of surplus mine water of Barora Area, Block II and Govindpur Area of BCCL' was prepared with a view to harness the excess water discharge to take care of the persistence problem of water scarcity in the nearby villages. In the scheme, two water reservoirs of capacity 27 MG and 17 MG have been proposed in the non-coal bearing area for storage of 3250 GPM and 2000 GPM surplus mine water which will be fed through pipe line by mine discharge at mines of Barora, Block-II and Govindpur Area.
- Rooftop rainwater harvesting (RWH) will took up in the project area using the administrative buildings. 138 no. of quarters having roof-top area of about 14950 sq. m. is already prepared to harvest rainwater and around 13150 cum/annum of water is going to be recharged the nearby groundwater system through RWH structures. Proposal already made to facilitate this kind of RWH structure at suitable locations i.e. Lodna Area, Kusunda Area (Jawahar Nagar, Matkuria, Coal Board Colony), Sijua Area (Nichitpur and Tetulmari Colony) within Jharia Coalfield to augment groundwater recharge.
- After cessation of mining, with plenty rainfall and abundant ground water recharge, the water levels will recoup and attain normalcy. Thus, the impact of mining on groundwater system may considered as a temporary phenomenon. The abandoned mine workings (UG) behave as water pool and improves the resources availability in the coalfield area.
- Utilization of treated mine water discharge by both industry and local people in the mine influence area. The excess mine water can be used to recharge groundwater system through connecting pipeline to abandoned dug wells. Utilization of mine water for irrigation use will also enhance the ground water recharge potential through artificial recharge in the area.
- Increase vegetative cover by plantation in the mine area under land amelioration measures. This will contain the surface run-off and increase the groundwater recharge.
- Creation of awareness among workers and local peoples about Rainwater harvesting and artificial recharge will have priority. This aspect usually covered during the Environmental Week celebrated every year (5 to 12 June).
- 23 nos. of Piezometer proposed to install within JCF and RCF to monitor GW level (**Plate-III**).

Monitoring of water quality of mine water discharge, local River/nala and domestic water source (dug well/hand pump wells) will continued under routine monitoring (May, August, November & Jan).

9.0 EXISTING/PROPOSED RAINWATER HARVESTING STRUCTURES IN BCCL COAL MINES

Fig-3 to 4.



Proposed Rain Water Harvesting Site GVTC, Cluster-I, Barora Area



Proposed Rain Water Harvesting Site Nehru Balika Vidhalaya, Cluster-I, Barora Area

Fig-5 to 6.



Proposed Rain Water Harvesting Site Barora Area Guest House, Cluster-I, Barora Area



Proposed Rain Water Harvesting Site Regional Hospital Baghmara, Cluster-I, Barora Area

Fig-7 to 8.



Proposed Rain Water Harvesting Site – Barora Area Office, Cluster-I, Barora Area

RECHARGE POND / ABANDONDED IN THE JCF MINE AREA

Fig-9 to 10.



RECHARGE POND / ABANDONDED IN THE JCF MINE AREA



RECHARGE POND / ABANDONDED IN THE JCF MINE AREA

Fig-11 to 12.



RECHARGE POND / ABANDONDED IN THE JCF MINE AREA



RECHARGE POND / ABANDONDED IN THE JCF MINE AREA

Fig-13 to 14.



RECHARGE POND / ABANDONDED IN THE JCF MINE AREA



FILTER PLANT IN THE MINE AREA

Fig-15.



Government of India
Ministry of Environment, Forest and Climate Change
Wetlands Division

List of Ramsar Sites in India

S. No	Name of Ramsar site	State	Area in hectares	Date of designation	Coordinates
1.	Ashtamudi Wetland	Kerala	6,140	19/08/2002	08°57'N 076°34'E
2.	Beas Conservation Reserve	Punjab	6,429	26/09/2019	31°23'N 075°11'E
3.	Bhitarkanika Mangroves	Odisha	65,000	19/08/2002	20°39'N 086°54'E
4.	Bhoj Wetland	Madhya Pradesh	3,201	19/08/2002	23°13'N 077°19'E
5.	Chandertal Wetland	Himachal Pradesh	49	08/11/2005	32°28'N 077°36'E
6.	Chilika Lake	Odisha	116,500	01/10/1981	19°42'N 085°21'E
7.	Deepor Beel	Assam	4,000	19/08/2002	26°07'N 091°39'E
8.	East Calcutta Wetlands	West Bengal	12,500	19/08/2002	22°27'N 088°27'E
9.	Harike Lake	Punjab	4,100	23/03/1990	31°13'N 075°12'E
10.	Hokera Wetland	Jammu & Kashmir	1,375	08/11/2005	34°04'N 074°42'E
11.	Kanjli	Punjab	183	22/01/2002	31°25'N 075°22'E
12.	Keoladeo National Park (MR)	Rajasthan	2,873	01/10/1981	27°13'N 077°31'E
13.	Keshopur-Miani Community Reserve	Punjab	344	26/09/2019	32°05'N 075°23'E
14.	Kolleru Lake	Andhra Pradesh	90,100	19/08/2002	16°37'N 081°12'E
15.	Loktak Lake (MR)	Manipur	26,600	23/03/1990	24°25'N 093°49'E
16.	Nalsarovar	Gujarat	12,000	24/09/2012	22°46'N 072°02'E
17.	Nandur Madhameshwar	Maharashtra	1,437	21/06/2019	20°01'N 074°06'E
18.	Nangal Wildlife Sanctuary	Punjab	116	26/09/2019	31°23'N 076°22'E
19.	Nawabganj Bird Sanctuary	Uttar Pradesh	225	19/09/2019	26°36'N 080°39'E
20.	Parvati Arga Bird Sanctuary	Uttar Pradesh	722	02/12/2019	26°56'N 082°09'E
21.	Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu	38,500	19/08/2002	10°19'N 079°37'E
22.	Pong Dam Lake	Himachal Pradesh	15,662	19/08/2002	32°01'N 076°04'E
23.	Renuka Wetland	Himachal Pradesh	20	08/11/2005	31°37'N 077°27'E
24.	Ropar	Punjab	1,365	22/01/2002	31°01'N 076°30'E
25.	Rudrasagar Lake	Tripura	240	08/11/2005	23°28'N 091°16'E
26.	Saman Bird Sanctuary	Uttar Pradesh	526	02/12/2019	27°00'N 079°10'E
27.	Samaspur Bird Sanctuary	Uttar Pradesh	799	03/10/2019	25°59'N 081°23'E
28.	Sambhar Lake	Rajasthan	24,000	23/03/1990	27°00'N 075°00'E
29.	Sandi Bird Sanctuary	Uttar Pradesh	309	26/09/2019	27°18'N 079°58'E
30.	Sarsai Nawar Jheel	Uttar Pradesh	161	19/09/2019	26°58'N 079°15'E

Annexure – IV

Rainfall Data (in mm) At Dhanbad Observatory Station, IMD (Source: WRIS Website data)

Year	January	February	March	April	May	June	July	August	Sep	Oct	Nov	Dec	Annual
1994	26.5	20.0	3.3	23.5	4.5	289.5	245.5	240.0	134.0	40.5	0.0	0.0	1027.3
1995	15.0	18.3	20.0	0.0	34.5	122.0	140.1	257.0	446.0	0.0	34.0	5.5	1092.4
1996	12.5	12.5	5.2	0.0	0.0	210.5	138.5	400.0	214.0	24.0	0.0	0.0	1017.2
1997	10.5	17.5	2.8	63.5	41.5	231.5	599.3	621.1	196.8	16.5	34.0	16.0	1851.0
1998	20.5	21.0	160.0	18.0	40.0	80.0	347.0	409.0	123.0	120.5	11.0	0.0	1350.0
1999	0.0	0.0	0.0	0.0	64.0	150.0	511.0	336.0	510.5	124.0	0.0	0.0	1695.5
2000	2.0	15.0	0.0	20.0	68.0	452.5	270.5	89.0	234.5	-	0.0	0.0	1151.5
2001	0.0	0.0	34.0	13.0	104.0	448.7	552.5	121.0	107.0	126.5	0.0	0.0	1506.7
2002	12.0	10.0	26.0	0.0	32.5	185.0	150.0	125.5	310.0	64.0	0.0	0.0	915.0
2003	6.0	58.5	38.5	40.0	24.0	-	366.1	279.0	145.1	151.6	0.0	2.3	1111.1
2004	18.45	2.13	1.55	53.93	9.53	95.95	408.57	261.07	174.01	63.01	51.10	12.85	1152.15
2005	44.49	23.11	26.16	17.90	28.95	272.26	388.86	158.86	69.03	117.63	0.09	1.67	1149.01
2006	0.00	0.00	3.11	12.64	86.68	113.20	505.72	316.06	339.51	9.80	3.73	0.00	1390.45
2007	0.00	58.69	35.76	21.08	25.33	139.60	666.30	416.85	363.93	43.63	1.57	0.00	1772.74
2008	16.44	1.96	6.27	6.78	37.26	180.58	422.25	275.33	198.31	27.64	0.00	0.00	1172.82
2009	0.00	0.26	5.81	0.19	105.82	78.32	232.20	370.39	429.16	68.56	11.31	0.98	1303.00
2010	0.59	19.64	7.62	38.24	93.72	146.68	157.31	198.97	239.75	78.76	5.26	40.53	1027.07
2011	0.00	1.60	18.25	12.81	102.58	294.61	174.35	445.43	214.88	30.35	0.69	0.00	1295.55
2012	18.45	2.13	1.55	53.93	9.53	95.95	408.57	261.07	174.01	63.01	51.10	12.85	1152.15
2013	0.07	17.62	0.79	15.24	105.51	176.77	170.14	276.70	135.76	304.46	0.00	0.00	1203.06
2014	9.27	35.71	21.21	8.16	62.77	112.58	283.73	223.38	214.48	30.30	0.00	0.00	1001.59
2015	12.06	3.33	26.71	45.73	32.91	162.96	385.21	239.38	71.34	15.62	0.00	0.61	995.86
2016	6.16	17.59	1.73	1.33	73.90	197.34	248.86	395.33	424.81	30.45	0.00	0.00	1397.50
2017	5.12	0.00	34.96	59.89	81.01	141.66	502.58	168.84	111.95	274.18	0.64	4.12	1384.95
2018	0.00	0.06	2.90	159.52	31.22	202.84	344.59	211.91	153.63	16.31	0.04	20.99	1144.01
2019	0.00	25.18	7.24	46.99	109.43	109.11	292.02	234.65	327.95	199.63	0.10	5.13	1357.43
2020	21.14	5.94	74.96	27.94	71.32	218.12	187.01	258.74	196.87	52.23	1.23	0.00	1115.50

Rainfall Data (in mm) At Dhansar (Rescue station) Observatory Station
State Sec Deptt of Coord, BCCL

Year	January	February	March	April	May	June	July	August	Sep	Oct	Nov	Dec	Annual
2005	34.20	22.80	41.80	32.20	33.00	193.00	542.00	107.80	185.60	39.20	0.00	2.00	1233.60
2006	0.00	0.00	34.40	33.80	87.60	214.20	477.70	246.30	172.00	0.00	1.00	0.00	1267.00
2007	0.00	22.00	37.80	0.00	78.70	167.20	545.00	426.40	351.40	52.00	0.00	0.00	1680.50
2008	5.80	4.80	17.80	18.40	18.00	216.10	433.48	183.80	297.80	85.80	0.00	0.00	1281.78
2009	0.00	0.00	1.60	2.20	112.00	72.80	269.20	192.80	333.00	98.20	10.20	0.00	1092.00
2010	0.00	12.20	7.60	9.20	64.30	206.20	199.40	212.60	230.10	45.30	3.4	----	991.90
2011	7.60	0.00	18.0	11.40	121.60	344.20	163.40	452.0	374.0	41.80	0.00	0.00	1534.20
2012	17.6	13.4	1.0	9.0	6.60	52.0	328.20	315.10	367.70	11.60	61.60	18.0	1201.80
2013	0.0	32.0	3.0	33.90	190.40	244.20	192.80	364.40	304.70	233.60	0.0	0.0	1599.0
2014	12.40	36.80	21.80	2.60	79.80	217.60	305.30	315.60	178.0	6.40	0.0	0.0	1176.0
2015	23.80	0.0	6.20	76.20	35.80	122.10	407.60	244.40	145.20	25.60	0.0	6.20	1093.10
2016	3.0	20.60	5.50	0.0	99.40	181.60	248.80	456.70	443.60	50.40	0.0	0.0	1509.60
2017	8.80	0.0	3.80	17.90	33.20	120.0	533.40	284.70	247.40	207.70	3.40	0.0	1460.30
2018	0.0	0.0	0.0	102.90	76.30	270.60	382.30	338.80	159.50	38.90	2.40	37.90	1346.60
2019	0.0	49.60	10.20	54.20	132.0	188.0	319.10	343.60	403.10	156.40	3.20	10.80	1667.00
2020	22.0	7.60	77.80	76.80	86.20	214.10	296.80	351.40	214.0	92.0	0.0	0.0	1438.70

Location of Hydrograph Stations (Dug Wells)

Well No	Latitude	Longitude	Well No	Latitude	Longitude
A-3	23°47'53.35" N	86°19'55.14" E	B-63	Abandoned due to OCP	
A-12	23°48'20.31" N	86°16'51.64" E	B-64	23°48'43.14" N	86°18'44.25" E
A-16	23°46'57.00" N	86°21'38.57" E	B-65A	23°48'53.65" N	86°18'11.82" E
A-17	23°45'09.44" N	86°22'16.35" E	B-67	23°43'30.70" N	86°14'01.45" E
A-18	23°44'37.65" N	86°22'58.90" E	D-3	23°46'46.31" N	86°24'49.30" E
A-19	23°41'12.86" N	86°23'55.27" E	D-4	23°44'29.37" N	86°24'42.88" E
A-20	23°44'56.64" N	86°19'55.35" E	D-5	23°42'20.05" N	86°24'86.06" E
A-22	23°43'06.65" N	86°14'48.53" E	D-7	23°43'12.08" N	86°27'11.89" E
A-23	23°45'06.38" N	86°15'12.69" E	D-8	23°44'06.13" N	86°27'20.72" E
A-24	23°45'20.44" N	86°13'45.12" E	D-23	23°47'20.89" N	86°20'09.96" E
A-25	23°47'06.20" N	86°15'27.79" E	D-25	23°47'03.28" N	86°23'29.56" E
A-26	23°46'49.24" N	86°18'12.12" E	D-30	23°48'36.10" N	86°21'50.07" E
A-27	23°48'42.55" N	86°20'21.80" E	D-33	23°45'34.62" N	86°23'18.50" E
A-28A	23°47'34.74" N	86°18'04.18" E	D-34	23°45'36.50" N	86°23'02.45" E
A-29	23°47'08.02" N	86°16'02.72" E	D-35	23°40'46.54" N	86°25'46.33" E
A-32	23°44'15.56" N	86°20'43.80" E	D-36	23°40'19.26" N	86°25'18.98" E
A-33	23°44'32.58" N	86°16'58.28" E	D-39	23°43'28.50" N	86°26'0.10" E
A-34	23°42'58.63" N	86°15'19.31" E	D-40A	23°43'20.18" N	86°25'45.70" E
B-1	23°48'48.06" N	86°14'16.87" E	D-41	23°42'40.00" N	86°26'17.20" E
B-14	23°48'00.81" N	86°16'25.88" E	D-43*	NA	NA
B-15	23°46'06.92" N	86°08'59.30" E	D-47	23°45'20.59" N	86°24'34.86" E
B-21A	23°45'10.50" N	86°09'36.38" E	D-49	23°44'08.96" N	86°26'32.71" E
B-23	23°44'13.05" N	86°11'46.56" E	D-51	23°44'20.86" N	86°27'11.37" E
B-24	23°44'26.80" N	86°13'09.38" E	D-55	23°43'58.37" N	86°24'07.45" E
B-25	23°44'44.98" N	86°13'57.80" E	D-74	23°41'33.66" N	86°25'06.10" E
B-32A	23°45'49.18" N	86°13'03.64" E	D-77	23°41'00.74" N	86°22'25.55" E
B-48	23°43'35.09" N	86°16'38.30" E	D-80	23°46'09.46" N	86°24'33.08" E
B-51	23°47'40.20" N	86°09'11.90" E	DB-22	23°43'38.81" N	86°45'09.00" E
B-53	23°45'55.25" N	86°09'35.44" E	DB-23	23°43'44.24" N	86°45'06.39" E
B-53A	DO	DO	DB-24	23°43'53.00" N	86°45'03.88" E
B-59	23°47'59.87" N	86°13'37.97" E	DB-25	23°44'10.75" N	86°44'35.84" E
B-60	23°48'7.87" N	86°15'37.12" E			
B-61A	23°45'59.85" N	86°11'40.80" E			
B-62A	23°45'44.15" N	86°11'27.80" E			

Details of Hydrograph Stations (Dug Wells)

Well No	Location	M.P. (agl) in m	Well Dia in m	Well Depth (m bmp)	R.L. (G.L) (m)	Formation	Owner	Utility
A-3	Sijua	0.53	3.00	5.20	203	Barakar	Govt.	Domestic
A-12	Jamua	0.80	1.90	3.30	202	Barakar	Govt.	Domestic
A-16	Ekra, Kalali More	0.45	3.10	6.50	205	Barakar	Govt.	Domestic
A-17	Kachi Balihari	0.56	1.60	5.30	182	Barakar	Govt.	Domestic
A-18	Bhagabandh	0.61	1.45	3.37	182	Barakar	Govt.	Domestic
A-19	Bhaura	0.54	3.15	11.65	162	Barakar	Govt.	Domestic
A-20	Gorbhudi	0.43	3.30	8.30	181	BM	Govt.	Domestic
A-22	Nagdah, Niche	0.00	1.40	9.50	171	Raniganj	Govt	Irrigation
A-23	Machhyara	0.43	1.85	12.40	203	Raniganj	Govt	Domestic
A-24	Pipra Tanr	0.22	1.80	19.55	208	Raniganj	Govt	Domestic
A-25	Sinidih	0.22	2.00	11.30	203	Barakar	Govt	Domestic
A-26	Pasitanr	0.32	1.80	9.65	198	Barakar	Govt	Domestic
A-27	Chandor	0.60	2.50	5.50	221	Barakar	Govt	Domestic
A-28A	Lakarka 6 no.	0.65	1.30	5.25	199	Barakar	BCCL	Domestic
A-29	Aambagan	0.10	2.60	9.15	186	Barakar	Govt	Domestic
A-32	Baludih	0.55	2.30	6.85	182	BM	Govt	Domestic
A-33	Mahuda	0.75	2.00	10.80	195	BM	BCCL	Domestic
A-34	Bhatdih	0.55	3.50	24.50	162	Raniganj	BCCL	Domestic
B-1	Muraidih	0.47	1.80	5.35	212	Talchir	Govt	Domestic
B-14	Mathadih	0.76	2.15	3.75	201	Barakar	Govt	Domestic
B-15	Bera Basti	0.55	1.60	2.50	221	Talchir	Dhanu Roy	Domestic
B-21A	Dugdha	0.55	2.10	10.35	220	Metamorphics	Govt	Domestic
B-23	Lohapati	0.26	3.60	10.85	204	Raniganj	Govt	Domestic
B-24	Telmuchu	0.67	4.35	10.83	207	Raniganj	Govt	Domestic
B-25	Mahuda More	0.10	2.45	8.45	205	Raniganj	Govt	Domestic
B-32A	Madhuband	0.80	4.30	8.60	205	Barakar	BCCL	Domestic
B-48	Mahuda	0.65	2.10	11.50	181	Raniganj	Mosque	Domestic
B-51	Taranga	0.00	2.50	5.75	215	Metamorphics	Bisun	Irrigation
B-53	Karmatanr	0.58	2.70	13.25	195	Barakar	Govt	Domestic
B-53A	Damoda OCP							
B-59	Khodovaly	0.60	2.40	9.30	202	Barakar	BCCL	Domestic
B-60	Bahiyardi	0.77	3.00	15.60	196	Barakar	BCCL	Domestic
B-61A	Kesargora	0.48	2.00	11.20	201	Barakar	BCCL	Domestic
B-62A	Sadariyadi	0.15	3.10	9.50	188	Barakar	Govt	Domestic

Details of Hydrograph Stations (Dug Wells)

Well No	Location	M.P. (agl) in m	Well Dia in m	Well Depth (m bmp)	R.L. (G.L) (m)	Formation	Owner	Utility
B-63	West Mudidih	0.60	1.70	3.35	196	Barakar	BCCL	Domestic
B-64	Keshalpur	0.65	1.10	3.40	195	Barakar	BCCL	Domestic
B-65A	Jhinjipahari	0.95	2.20	12.40	196	Barakar	Shiv Temple	Domestic
B-67	Simatanr	0.55	2.20	11.80	198	Raniganj	Govt	Domestic
D-3	Dhansar	0.60	1.70	8.70	217	Barakar	Govt	Domestic
D-4	Jharia	0.59	1.90	5.73	218	Barakar	Govt	Domestic
D-5	Jiyalgora	0.70	2.80	10.55	183	Barakar	Govt	Domestic
D-7	Golden Pahari	0.67	2.85	10.05	201	Barakar	BCCL	Domestic
D-8	Alokdiha	0.35	1.75	7.57	201	Metamorphics	BCCL	Domestic
D-23	Jogta (Sindra)	0.40	3.10	7.25	205	Barakar	BCCL	Domestic
D-25	Godhar More	0.60	2.75	5.60	219	Barakar	Govt	Domestic
D-30	Borkiboa	0.70	2.00	5.60	221	Talchir	H.Kumbhakar	Domestic
D-33	Kustore-4	0.55	1.85	3.45	196	Barakar	BCCL	Domestic
D-34	Kusunda-7	0.60	1.50	3.45	201	Barakar	BCCL	Domestic
D-35	Patherdih	0.40	2.00	11.20	160	Barakar	BCCL	Domestic
D-36	Sudamdih	0.90	2.00	6.20	141	Barakar	BCCL	Domestic
D-39	Tilabani	0.85	2.00	5.90	178	Barakar	BCCL	Domestic
D-40A	Khapra Dhaora	0.55	1.95	3.70	180	Barakar	Panchayat	Domestic
D-41	Joyrampur	0.50	1.80	4.00	180	Barakar	BCCL	Domestic
D-43	Alagdiha	0.45	2.20	8.90	200	Metamorphics	Govt	Domestic
D-47	Parastanr	0.45	3.20	23.80	206	Barakar	BCCL	Domestic
D-49	Goluckdih	0.55	1.80	6.15	192	Barakar	BCCL	Domestic
D-51	Chankuiya	0.55	3.70	11.90	197	Barakar	BCCL	Domestic
D-55	Hariladih	0.48	2.80	11.80	184	Barakar	Govt	Domestic
D-74	Bhulan Barari	0.10	1.60	12.80	173	Barakar	Govt	Domestic
D-77	Rohoniatanr	0.40	3.15	6.70	156	Barakar	Govt	Domestic
D-80	Bastacolla	0.70	2.50	24.95	219	Barakar	Govt	Domestic
DB-22	Nichebasti	0.67	2.40	10.65	121	Barakar	Govt	Domestic
DB-23	Dahibari OC	0.70	2.30	8.00	-	Barakar	BCCL	Domestic
DB-24	Dahibari	0.60	3.60	13.70	125	Barakar	BCCL	Domestic
DB-25	Palasya	0.37	1.55	5.25	127	Barakar	Govt	Domestic

MP: Measuring Point
Abn.: Abandoned
G.L.: Ground Level

R.L.: Reduced Level
b.g.l.: Below Ground Level
bmp: Below Measuring Point

W.L.: Water Level

m: Meter

BM: Barren Measure

Historical Water Level data of Hydrograph Stations

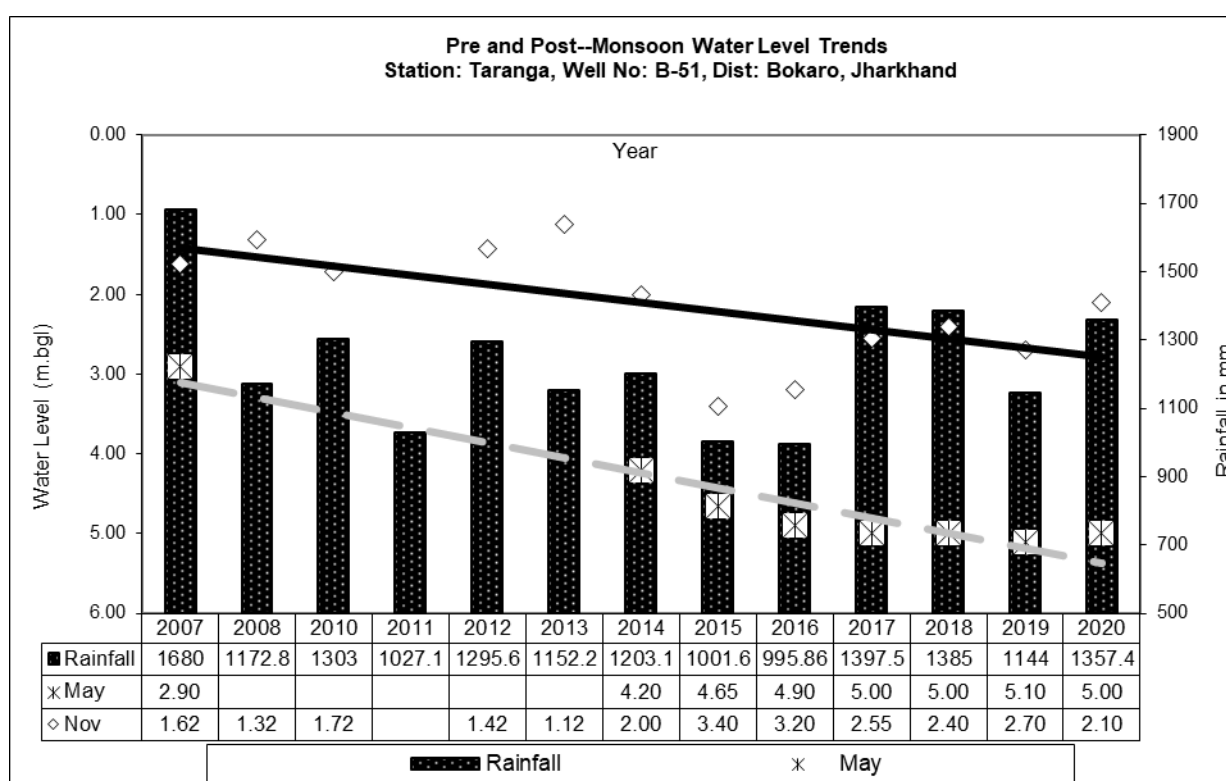
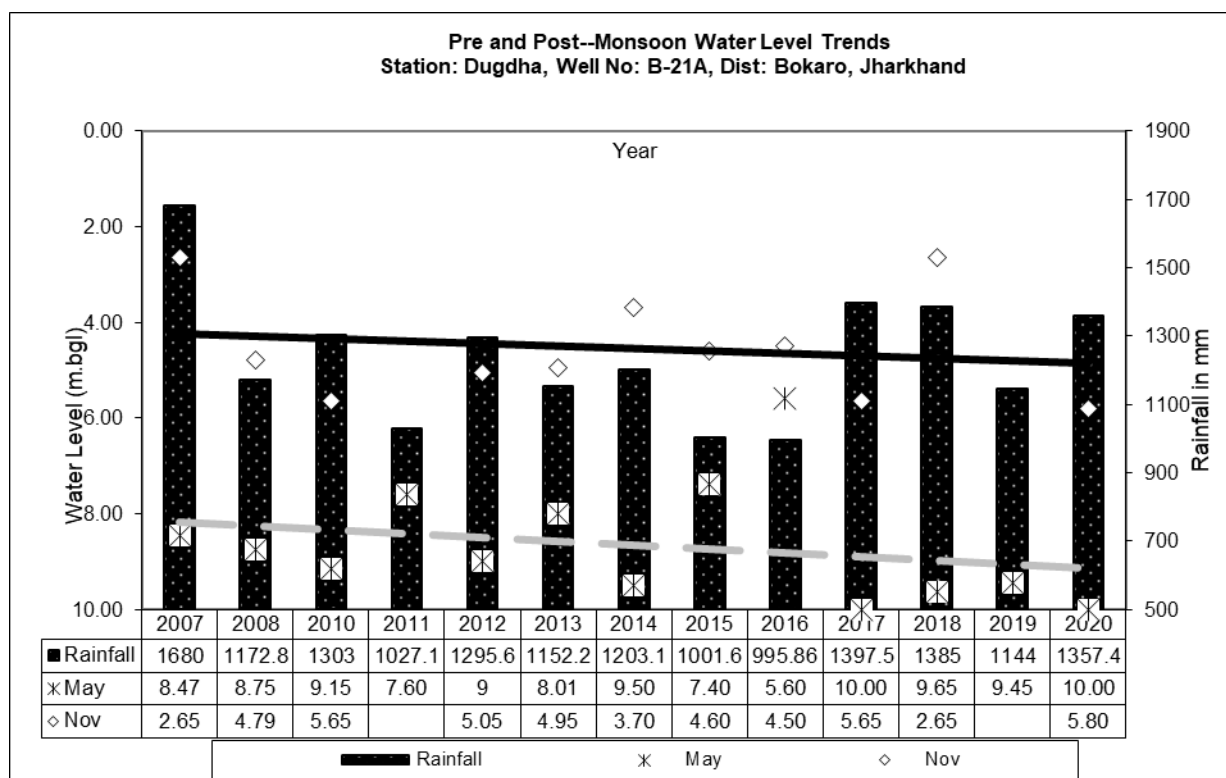
Well No	Water level below ground level (bgl) in meters													
	May 14	Nov 14	May 15	Nov 15	May 16	Nov 16	May 17	Nov 17	May 18	Nov 18	May 19	Nov 19	May 20	Nov 20
A-3	4.67	2.37	3.70	3.42	4.87	0.47	0.67	0.77	1.27	0.47	3.47	0.47	1.57	0.47
A-12	2.45	1.4	3.00	2.68	2.50	0.70	2.55	0.85	2.80	1.0	2.10	0.45	2.60	0.50
A-16	5.5	2.9	5.55	4.17	5.85	3.15	3.65	2.20	4.30	3.65	5.45	1.95	7.15	1.75
A-17	2.19	1.91	3.79	2.64	2.44	2.69	2.44	2.24	3.34	2.84	2.94	2.24	2.14	1.69
A-18	1.76	1.19	2.84	1.29	1.14	0.89	1.29	0.99	1.24	0.99	2.29	0.69	1.09	0.34
A-19	3.00	2.75	3.05	2.75	7.81	4.11	6.37	2.45	5.55	2.45	4.85	3.43	6.05	3.25
A-20	3.97	2.55	4.59	2.93	7.49	3.50	4.27	1.77	4.57	2.57	4.57	1.82	8.47	3.87
A22A	1.50	2.0	3.20	1.96	3.25	1.75	4.27	1.77	3.35	1.30	2.60	2.00	2.90	1.98
A-23	8.76	6.82	11.3	9.37	11.87	8.13	6.40	1.50	11.15	7.17	11.97	3.77	8.92	5.62
A-24	16.28	14.98	17.2	14.5	16.62	12.43	11.87	6.97	14.58	6.88	15.88	2.48	*4.88	4.28
A-25	7.03	5.28	7.78	5.85	7.43	4.58	6.38	2.88	6.63	3.13	6.08	1.93	2.98	1.83
A-26	7.71	4.58	7.73	3.18	8.93	4.48	5.28	2.53	6.23	3.88	6.58	3.33	6.98	3.18
A-27	1.63	1.55	4.40	3.95	4.85	1.80	2.90	1.25	2.90	1.0	2.40	0.92	2.40	1.10
A28A	3.29	1.91	4.35	3.60	3.35	1.47	4.30	1.55	4.15	2.51	2.45	3.15	4.00	3.03
A-29	3.3	2.35	4.55	4.60	5.92	6.96	4.40	1.30	6.45	2.10	4.85	3.40	6.20	3.20
A-32	3.15	2.45	4.41	2.13	4.75	2.10	3.15	1.55	2.80	0.70	2.75	0.95	1.90	1.75
A-33	4.08	1.57	4.91	1.97	5.75	2.60	6.45	1.55	4.07	2.35	3.65	1.25	4.55	1.85
A-34	4.45	4.45	8.40	4.81	4.75	4.45	12.45	4.45	5.90	3.70	6.35	3.95	8.35	3.45
B-1	2.43	1.81	3.28	2.75	3.58	1.93	2.33	0.85	2.88	2.08	3.18	1.73	3.28	1.63
B-14	3.24	4.44	2.94	2.29	2.44	0.47	2.94	1.84	3.64	2.84	2.24	0.94	2.44	1.04
B-15	0.95	1.45	1.50	0.45	1.85	0.55	4.85	0.15	1.85	0.85	1.90	1.65	3.70	1.47
B21A	9.54	3.7	7.37	4.65	5.55	4.50	8.85	5.65	9.65	2.65	9.45	-	10.00	5.80
B-23	6.57	2.74	7.86	4.29	6.81	2.41	7.74	2.14	6.64	2.14	2.84	1.34	3.24	1.76
B-24	9.40	2.21	10.0	5.78	10.63	4.28	10.03	4.03	9.28	4.33	4.58	2.33	5.48	3.53
B-25	5.82	5.15	6.88	-	7.05	1.70	6.70	1.40	5.90	3.70	4.80	1.40	7.90	2.55
B32A	8.33	2.05	7.55	3.32	6.95	3.07	6.95	2.80	6.75	3.90	5.55	1.70	3.30	2.00
B-48	6.38	4.35	7.90	5.42	9.35	4.60	7.70	4.15	7.33	3.97	7.05	4.35	8.20	3.85
B-51	2.09	1.98	4.65	3.40	4.90	3.18	4.98	2.55	5.02	2.42	5.10	2.70	5.00	2.10
B-53	3.39	-	5.58	2.82	4.70	1.45	4.02	1.92	3.92	1.42	3.22	1.42	3.12	1.40
B-59	2.65	1.0	4.12	1.60	4.40	0.50	5.40	0.60	5.47	1.10	6.20	0.90	5.25	1.40
B-60	9.82	4.59	9.21	5.28	10.33	5.03	13.23	3.18	13.68	4.23	8.13	3.23	10.33	3.21
B61A	6.93	3.57	6.15	4.52	6.58	3.87	2.57	0.82	2.57	2.02	3.32	0.52	3.32	1.60
B62A	8.83	5.85	9.10	5.21	9.30	4.95	8.15	4.35	8.27	4.78	7.55	3.25	6.95	3.00

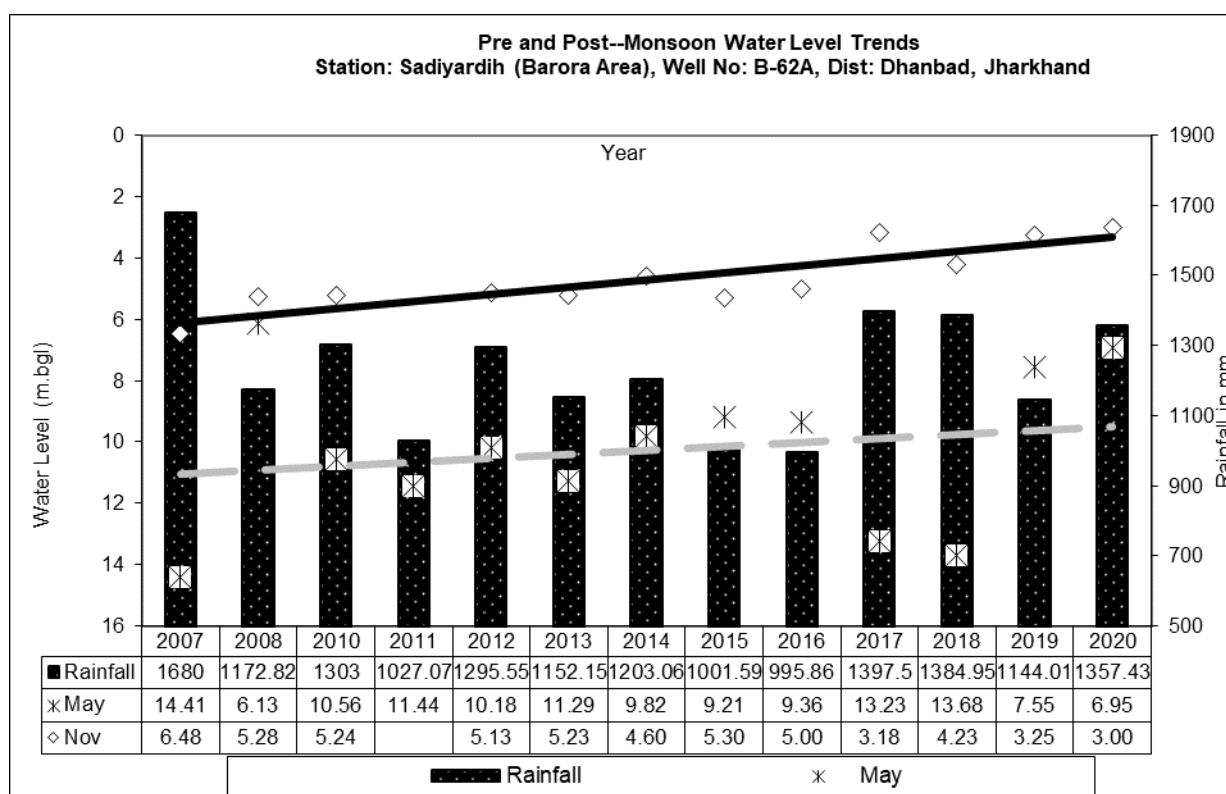
Historical Water Level data of Hydrograph Stations

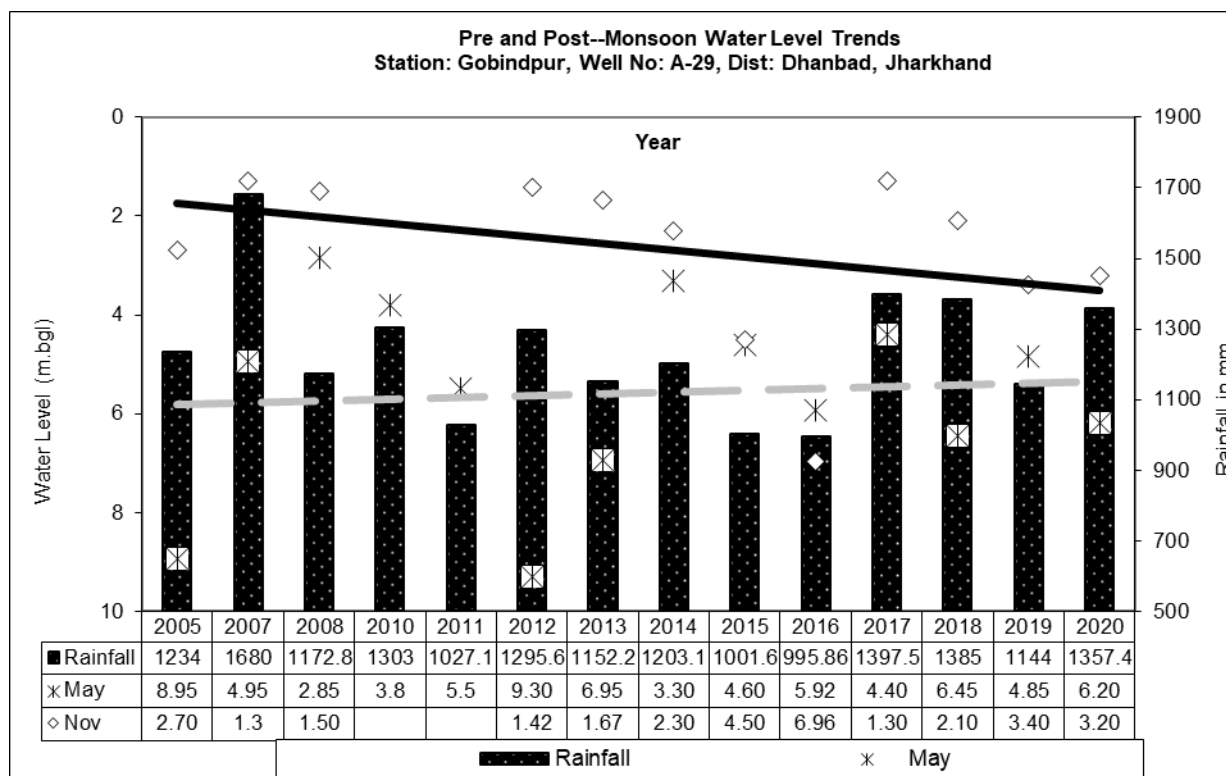
Well No	Water level below ground level (bgl) in meters													
	May 14	Nov 14	May 15	Nov 15	May 16	Nov 16	May 17	Nov 17	May 18	Nov 18	May 19	Nov 19	May 20	Nov 20
B-64	0.7	1.15	1.38	0.95	2.35	0.55	1.25	0.85	2.15	1.85	0.95	0.45	1.85	0.50
B65A	10.45	2.4	7.82	5.87	7.15	2.68	9.05	1.25	10.03	2.40	11.05	0.95	9.25	2.30
B-67	9.80	3.72	9.23	5.53	9.53	4.30	10.00	2.15	9.55	4.0	8.57	4.35	7.55	3.95
D-3	2.54	2.11	4.25	2.25	2.35	1.90	2.15	2.30	3.43	2.45	1.75	1.30	5.40	1.38
D-4	1.23	0.91	2.41	1.27	1.21	1.36	1.21	1.46	1.91	1.56	2.81	1.71	3.41	1.41
D-5	9.0	7.8	9.37	8.33	9.40	6.40	7.90	5.20	7.80	5.30	8.25	4.85	8.60	7.70
D-7	5.28	5.53	8.25	5.61	7.53	4.03	7.33	2.88	7.53	2.83	8.23	3.28	7.33	5.13
D-8	7.73	-	6.24	4.38	8.00	3.43	5.15	1.85	5.65	1.85	4.80	2.85	5.83	2.75
D-23	6.38	2.4	6.55	3.48	5.70	1.63	2.80	2.98	4.40	3.40	4.70	1.40	5.60	3.35
D-25	4.42	2.9	4.48	2.45	2.40	1.90	2.40	1.20	2.60	2.40	*9.90	*5.38	10.50	5.62
D-30	4.17	3.3	4.55	3.15	4.45	3.20	4.40	1.25	4.58	1.10	4.60	0.75	4.50	1.35
D-33	1.72	0.35	2.25	1.10	2.50	1.95	0.75	0.75	2.85	0.95	2.35	1.65	3.65	1.45
D-34	2.80	0.30	2.55	1.45	2.30	0.30	0.80	0.55	2.80	0.45	4.75	2.40	3.30	2.80
D-35	6.94	6.15	9.80	7.90	9.52	6.45	8.80	3.60	8.40	4.45	8.00	3.80	8.20	5.40
D-36	1.82	0.75	1.66	1.13	0.78	0.95	1.30	0.70	1.20	0.60	1.20	0.55	2.10	1.00
D-39	5.03	2.25	5.00	2.61	2.18	2.65	6.17	4.75	4.95	4.35	*12.60	*5.95	9.40	6.05
D40A	2.35	2.45	3.07	2.45	1.40	0.85	1.45	1.35	2.10	1.40	1.85	1.45	1.95	1.43
D-41	3.20	1.35	2.65	2.32	1.30	1.52	1.40	1.20	1.59	1.32	2.30	1.25	3.30	1.45
D-43	6.0	4.75	6.61	5.05	8.20	3.35	7.50	3.60	7.15	3.45	7.35	2.70	6.60	2.55
D-47	8.0	2.37	9.60	3.60	3.18	2.95	3.15	2.85	5.33	2.55	4.55	4.35	9.45	5.45
D-49	2.51	1.65	3.55	2.35	2.45	1.72	2.70	2.05	3.45	2.45	1.75	1.50	3.25	1.65
D-51	9.60	9.05	10.48	9.15	11.15	6.45	10.45	5.43	10.93	7.10	9.95	5.75	8.45	5.70
D-55	1.95	2.07	6.15	1.57	2.52	3.62	6.42	2.37	8.42	1.57	8.42	5.47	9.42	8.60
D-74	5.0	4.0	10.05	7.20	7.73	5.00	9.25	3.85	8.60	4.80	5.80	3.57	4.30	3.93
D-77	6.23	6.0	6.44	5.60	4.60	2.90	6.50	4.90	6.30	5.20	6.40	3.20	6.40	3.50
D-80	13.3	3.15	10.97	3.35	6.55	4.15	8.65	3.70	9.35	4.20	5.00	3.05	4.30	4.90
RCF (part)	May 14	Nov 14	May 15	Nov 15	May 16	Nov 16	May 17	Nov 17	May 18	Nov 18	May 19	Nov 19	May 20	Nov 20
DB22	6.48	3.03	4.59	3.53	5.38	3.33	1.93	1.63	2.34	1.93	4.93	1.63	2.63	2.25
DB23	3.95	2.13	3.38	6.04	5.30	0.90	2.05	1.90	2.85	1.75	1.60	0.80	2.50	1.95
DB24	-	8.45	9.52	8.20	10.65	6.50	5.80	3.78	8.25	5.70	9.35	3.88	5.70	3.60
DB25	3.27	2.73	3.83	2.68	3.61	1.98	3.23	2.58	3.93	1.63	-	-	3.98	2.63

*New well

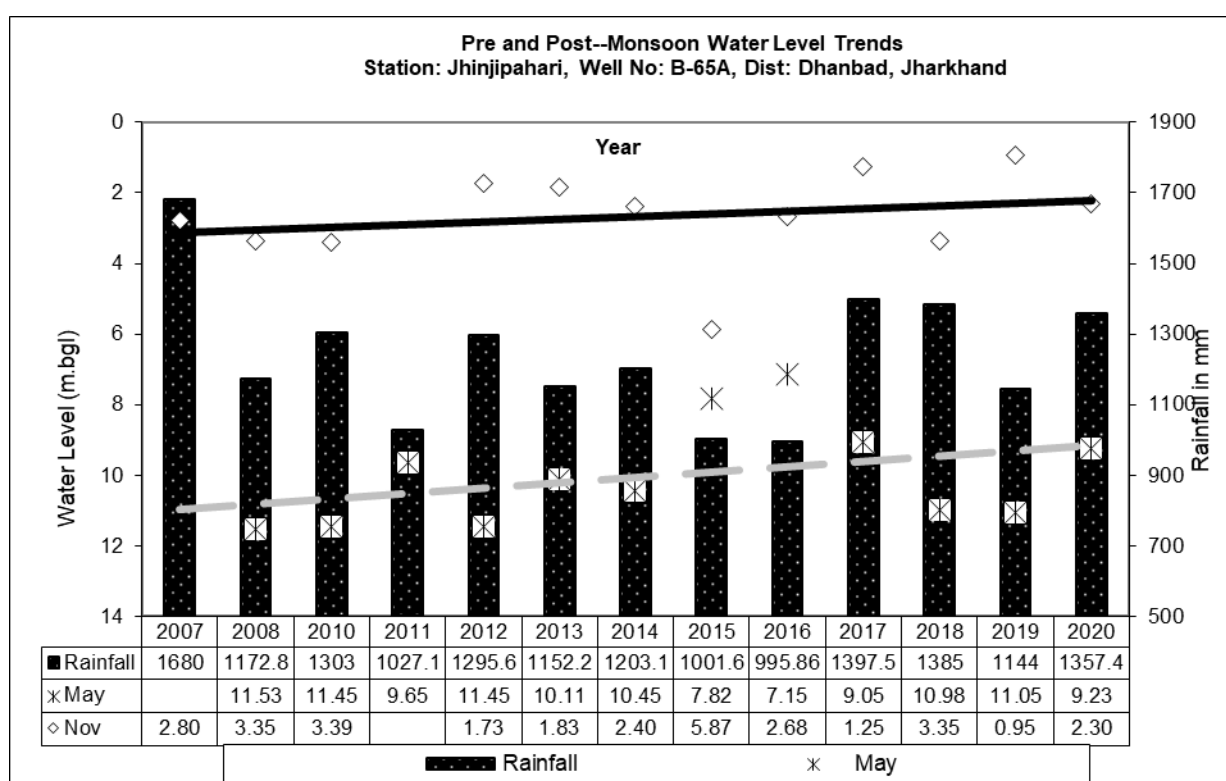
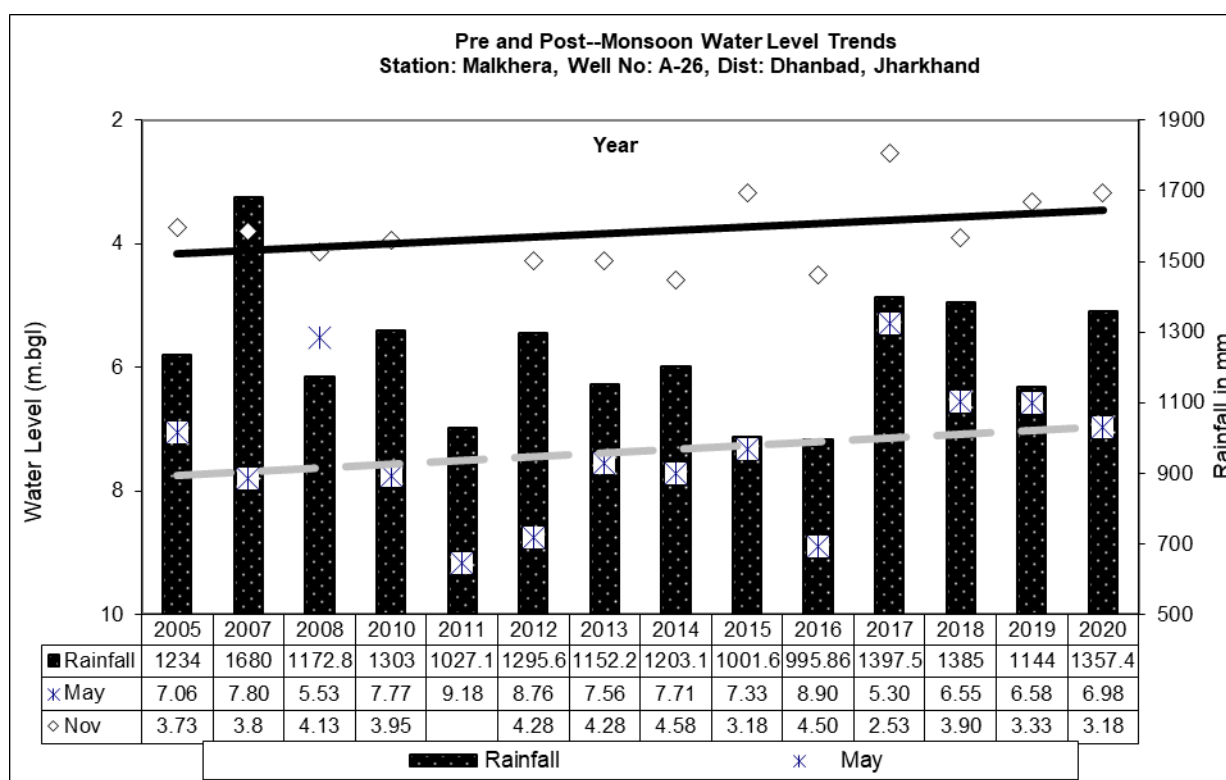
HYDROGRAPHS OF CLUSTER-I



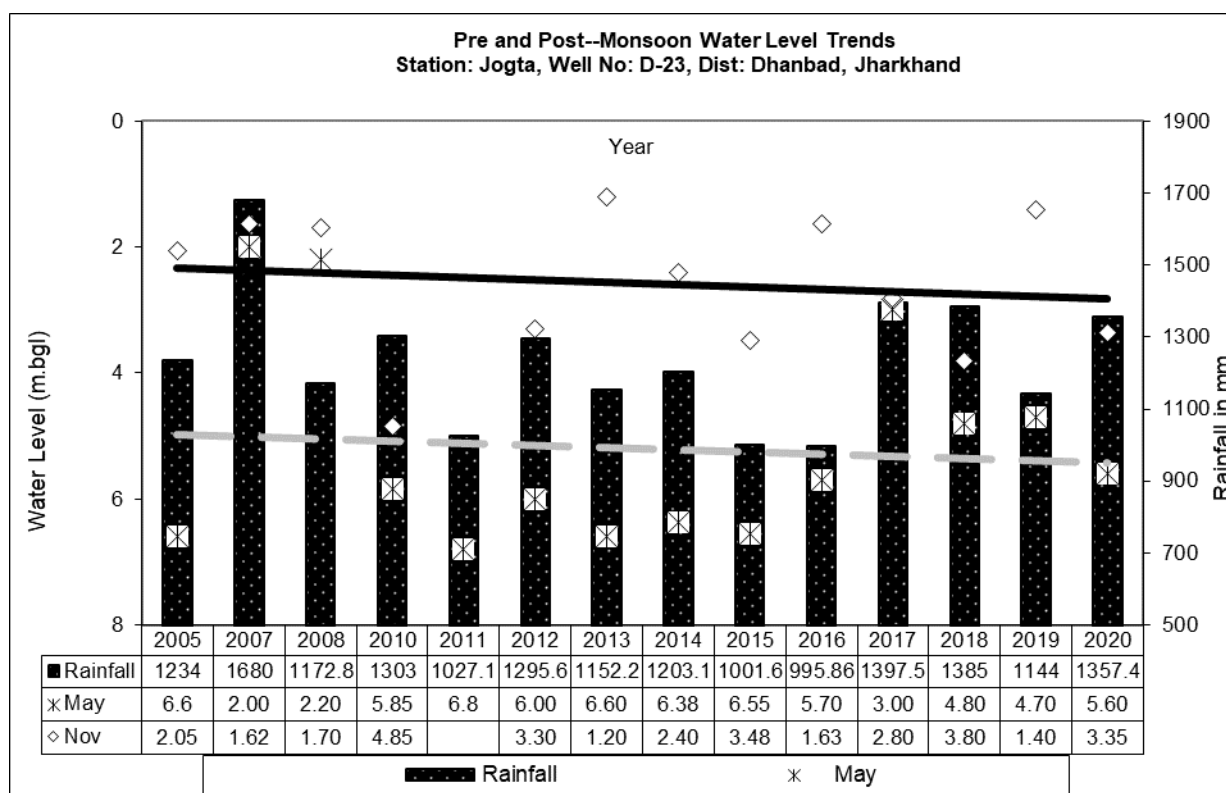
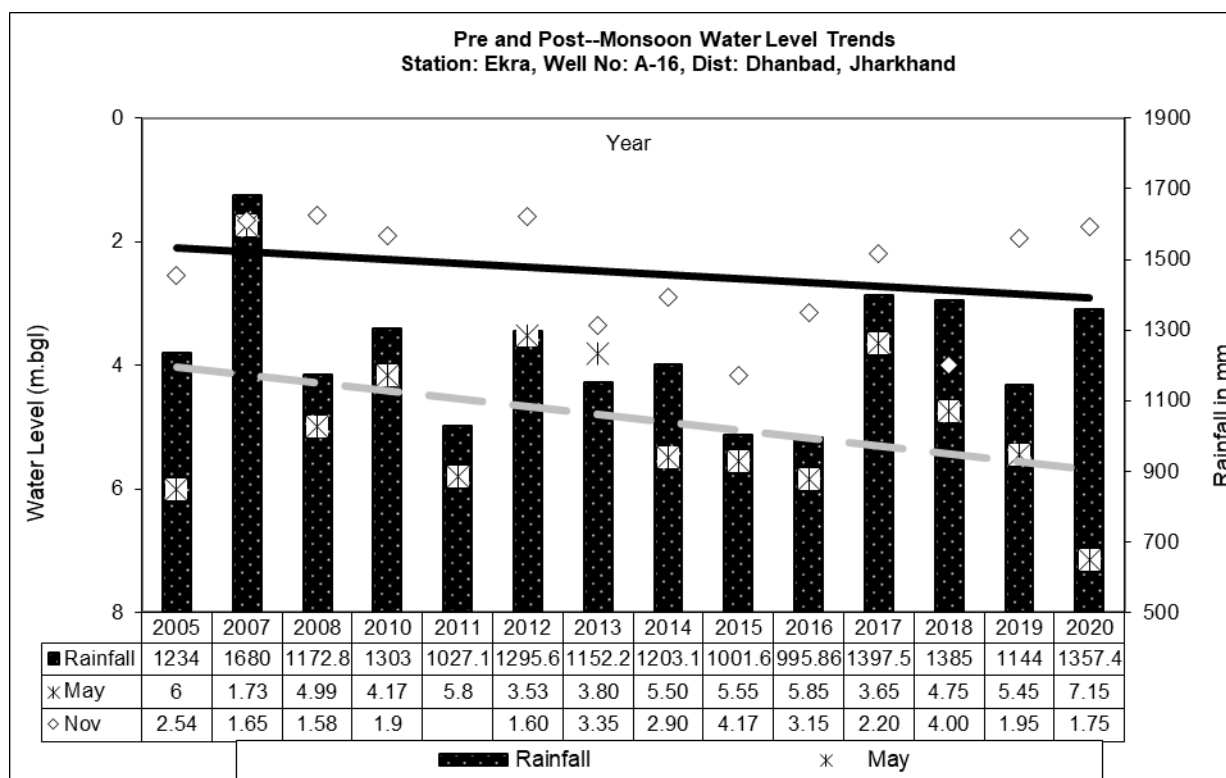


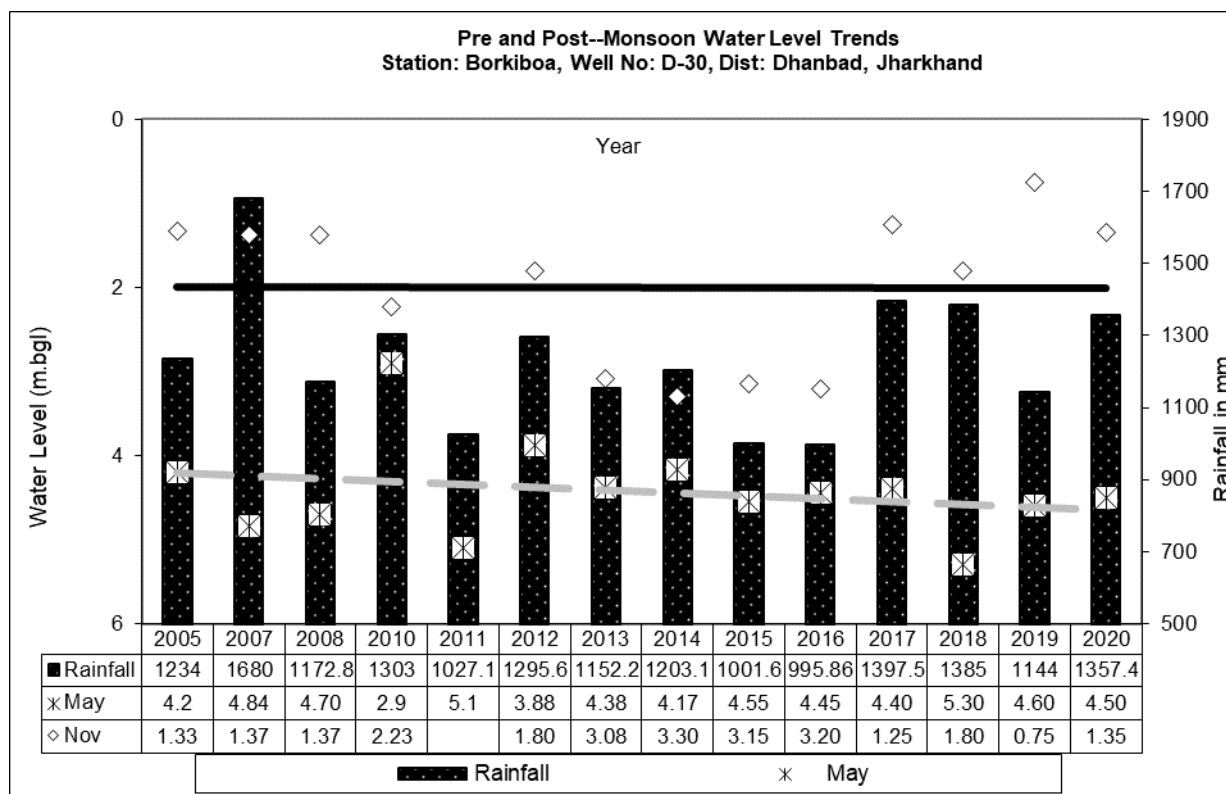


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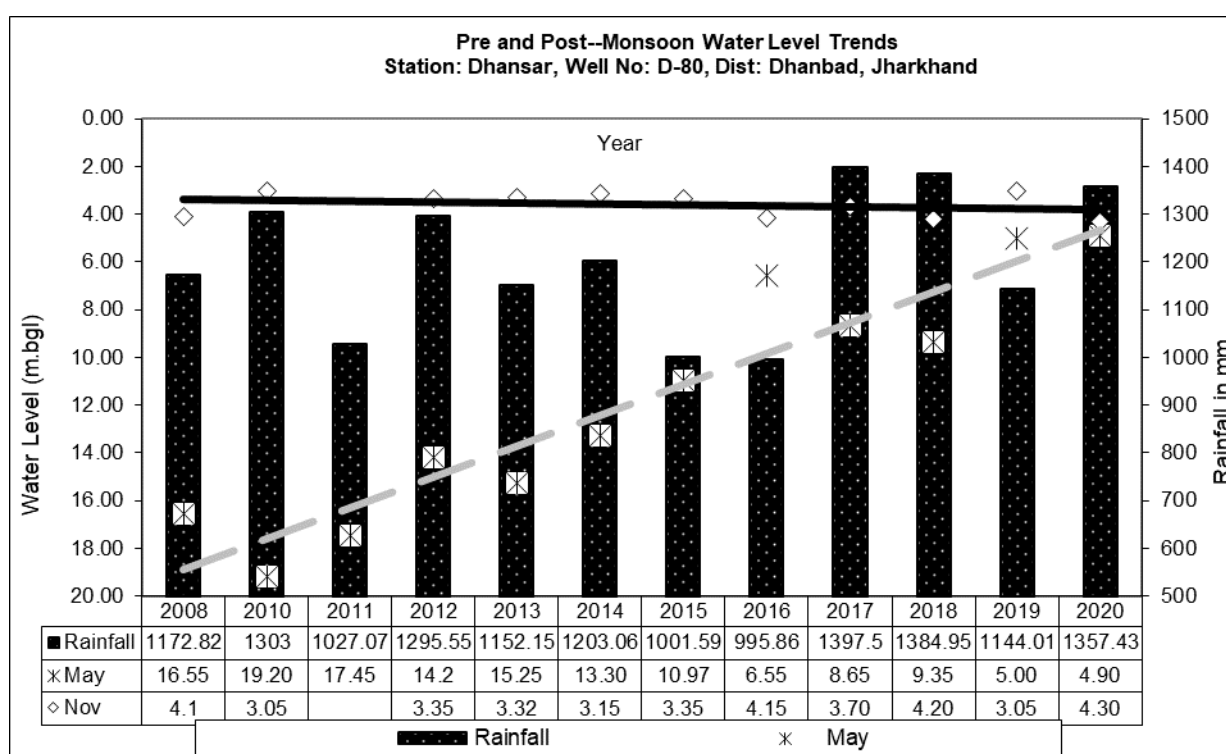
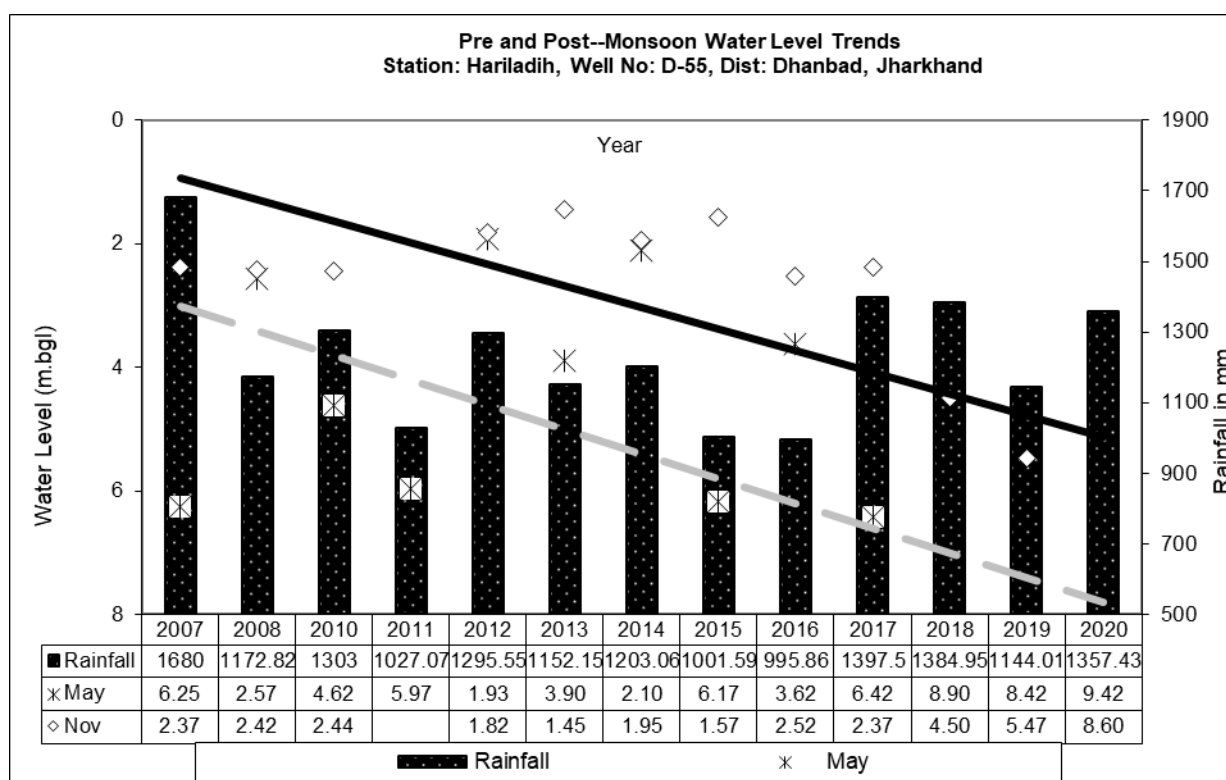


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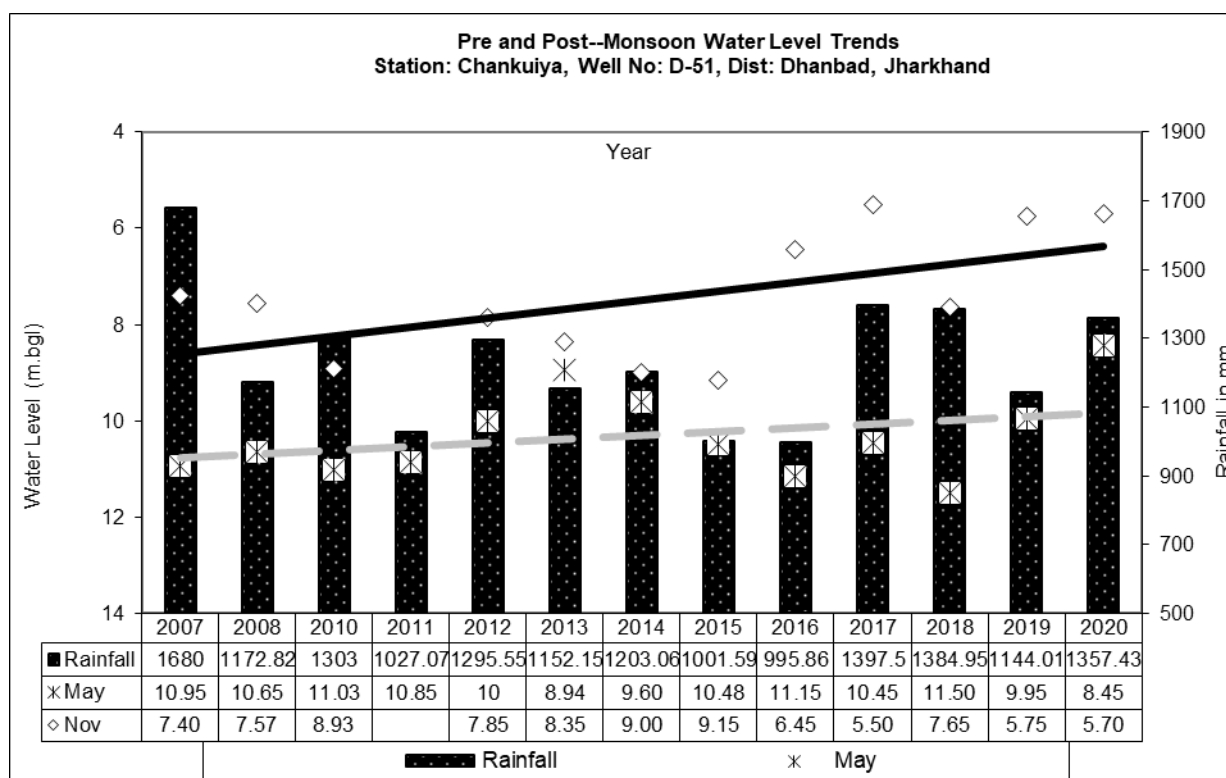
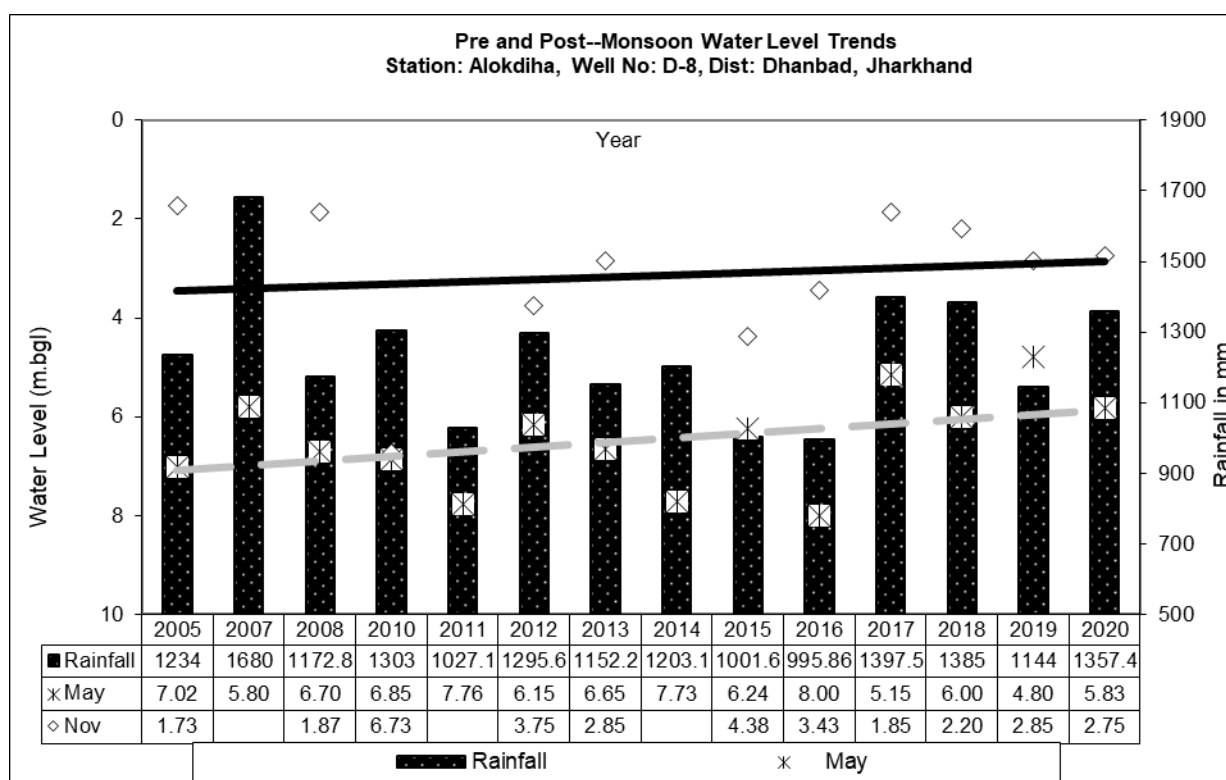




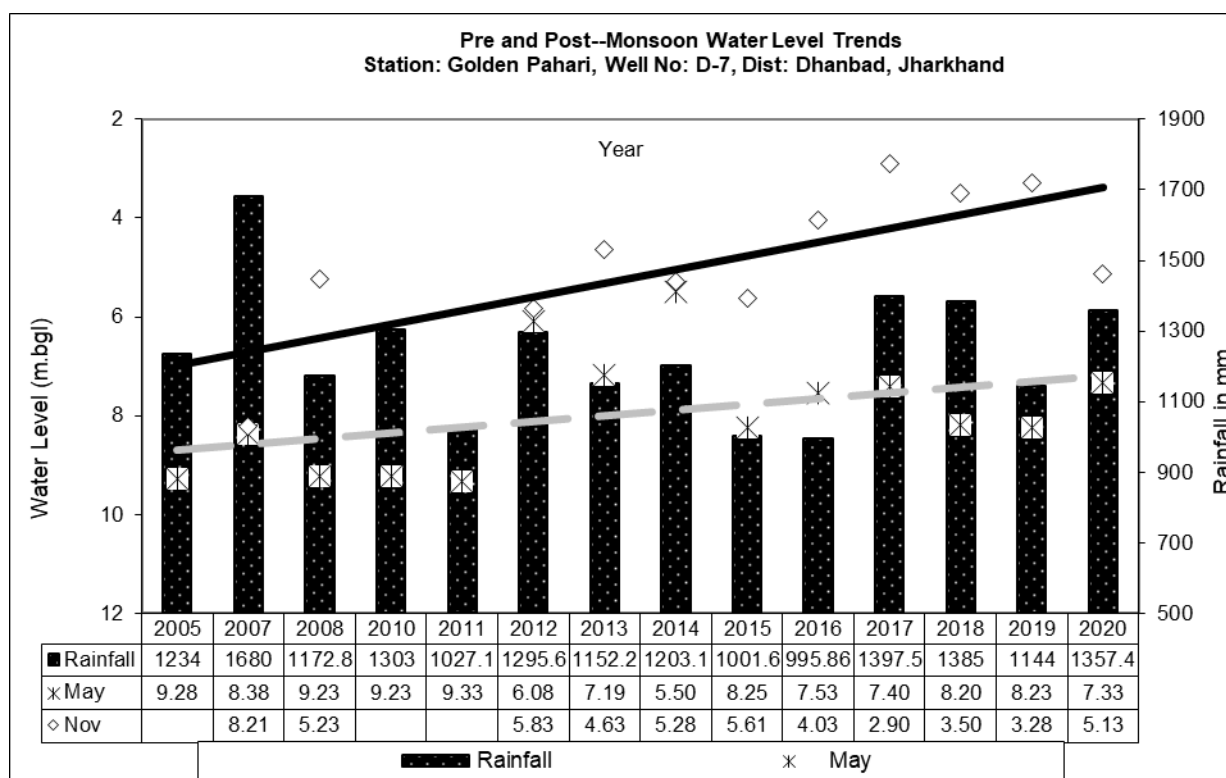
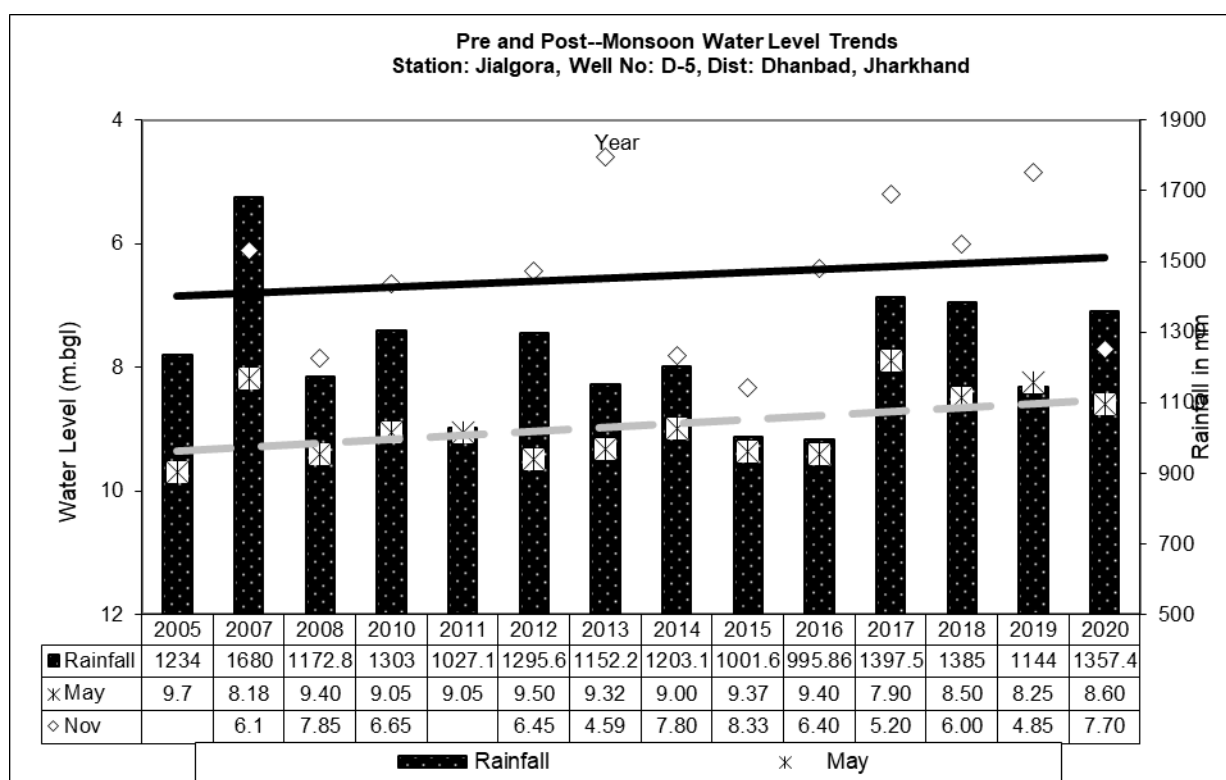
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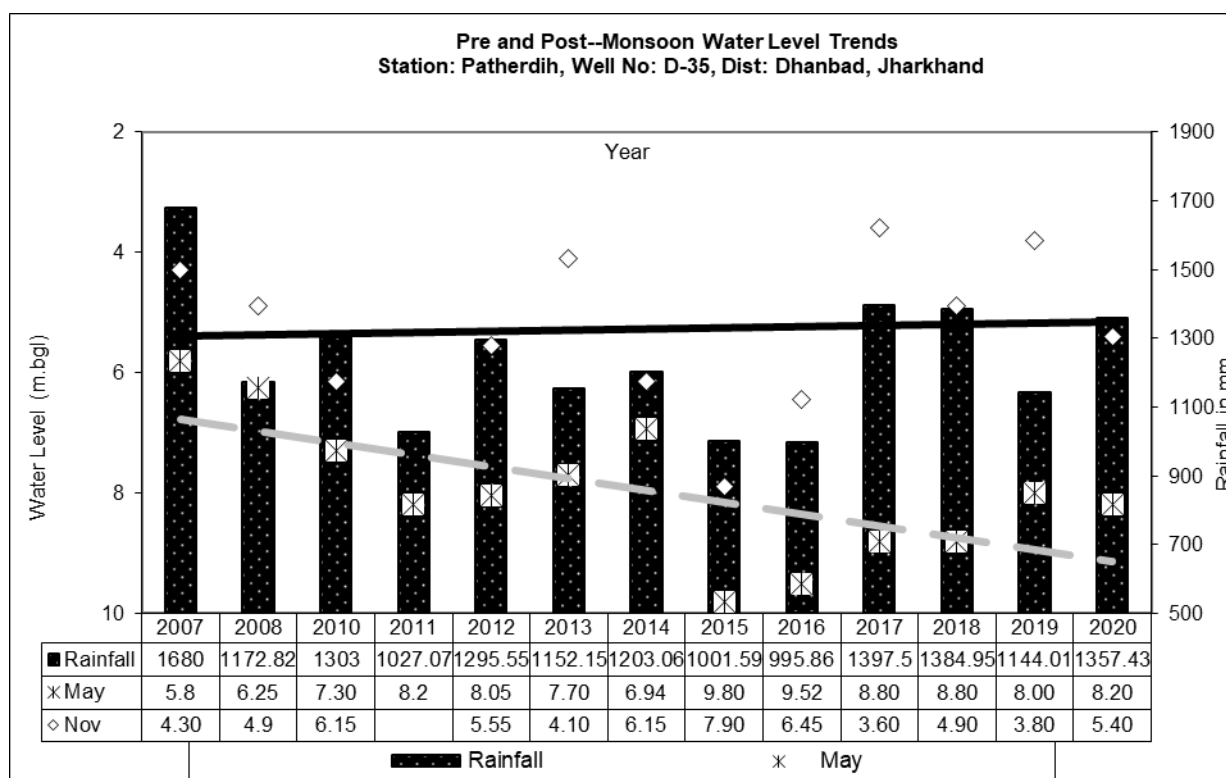
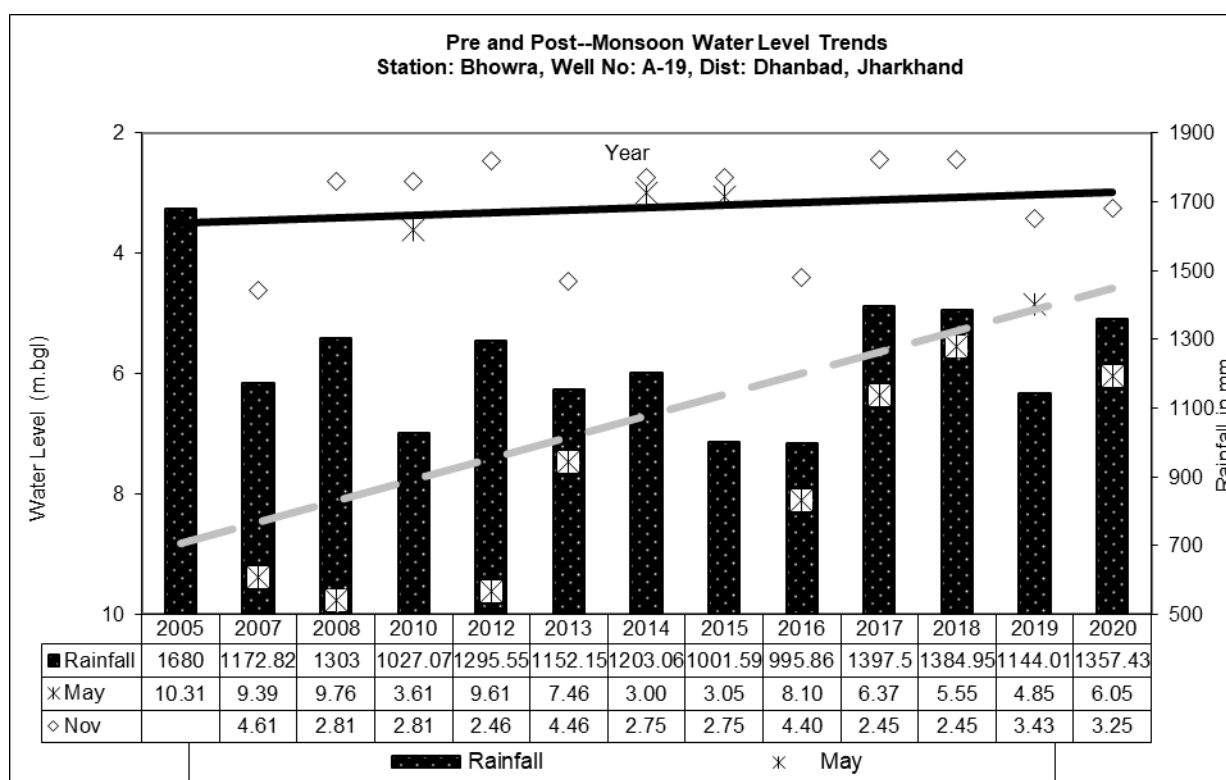
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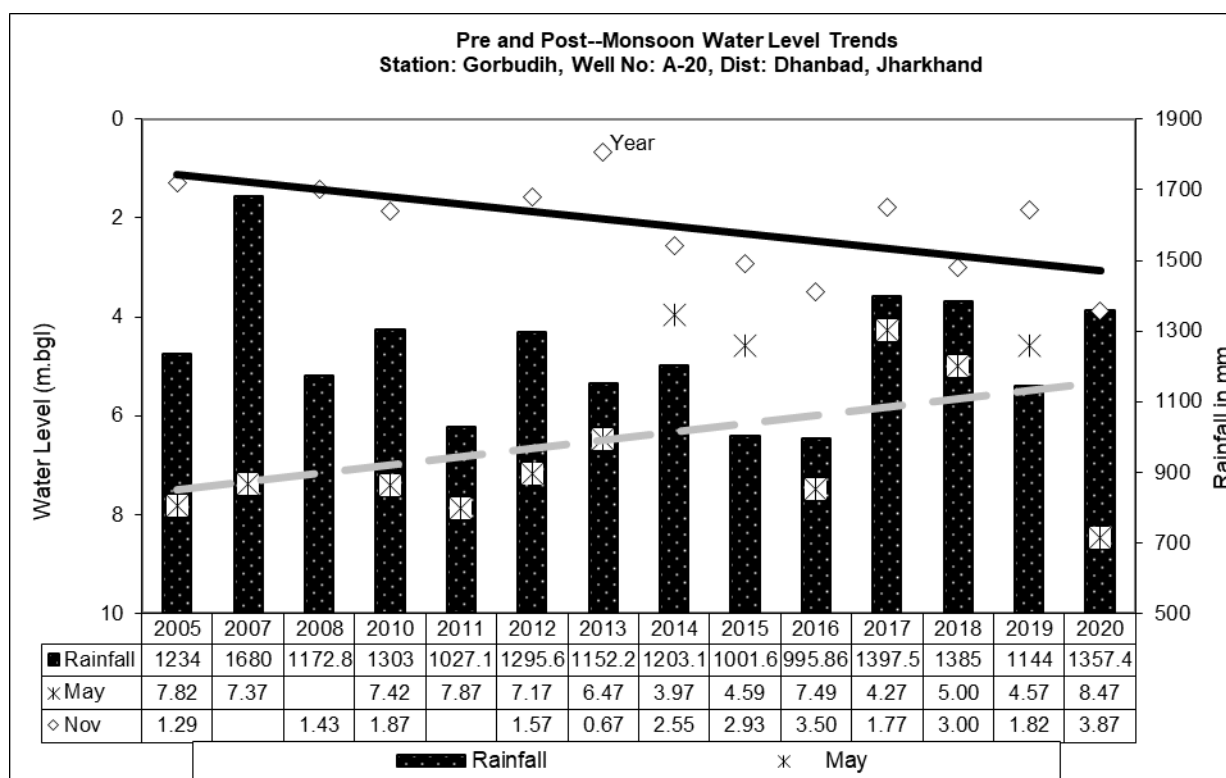
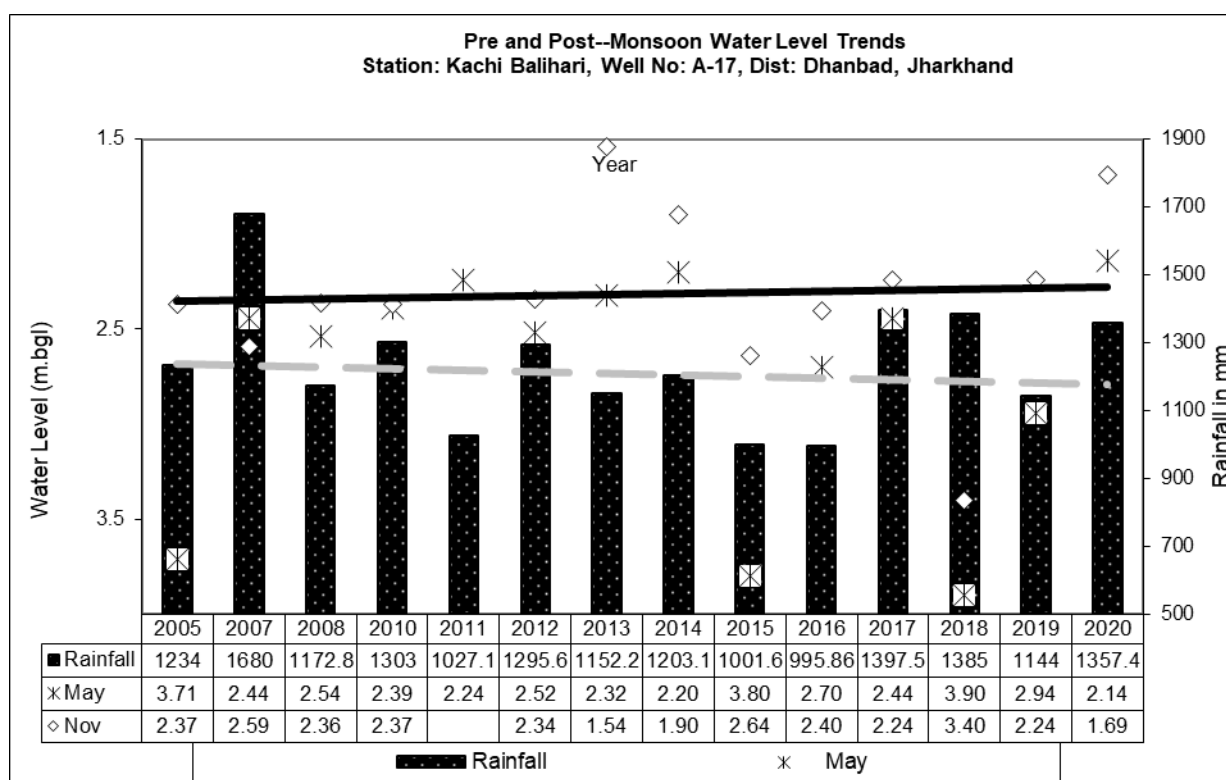
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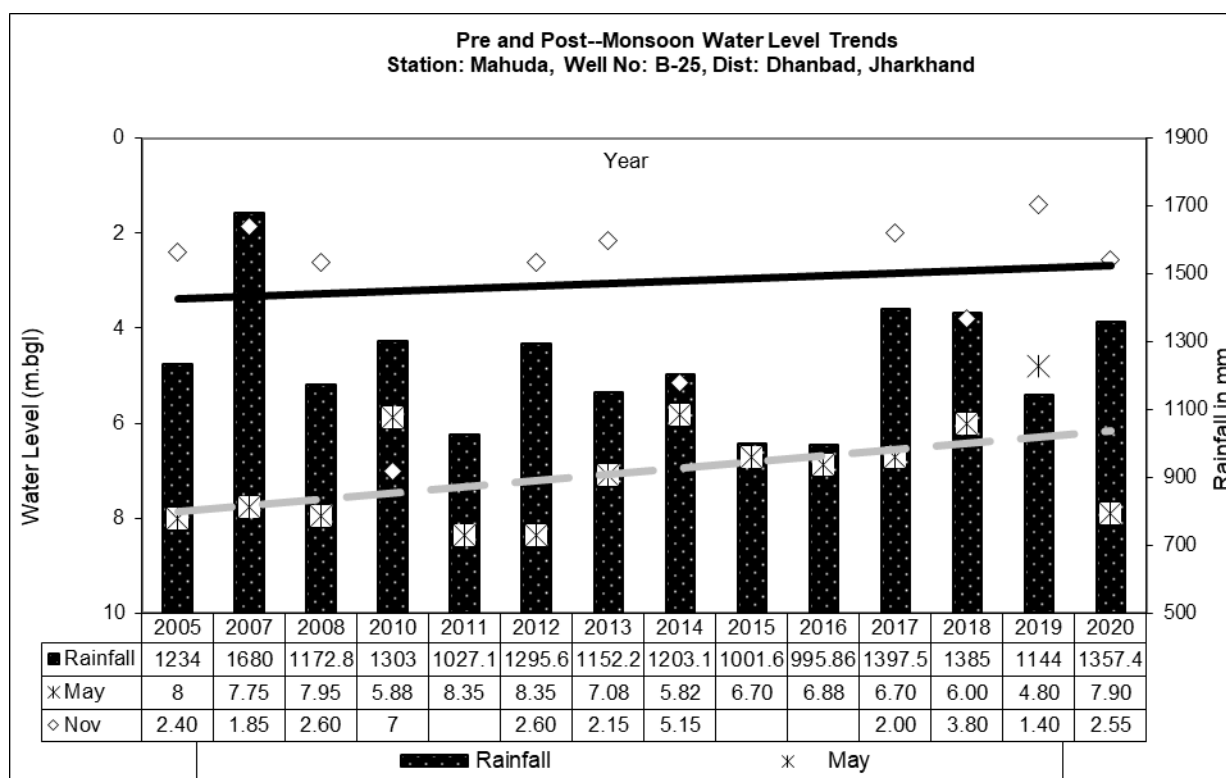


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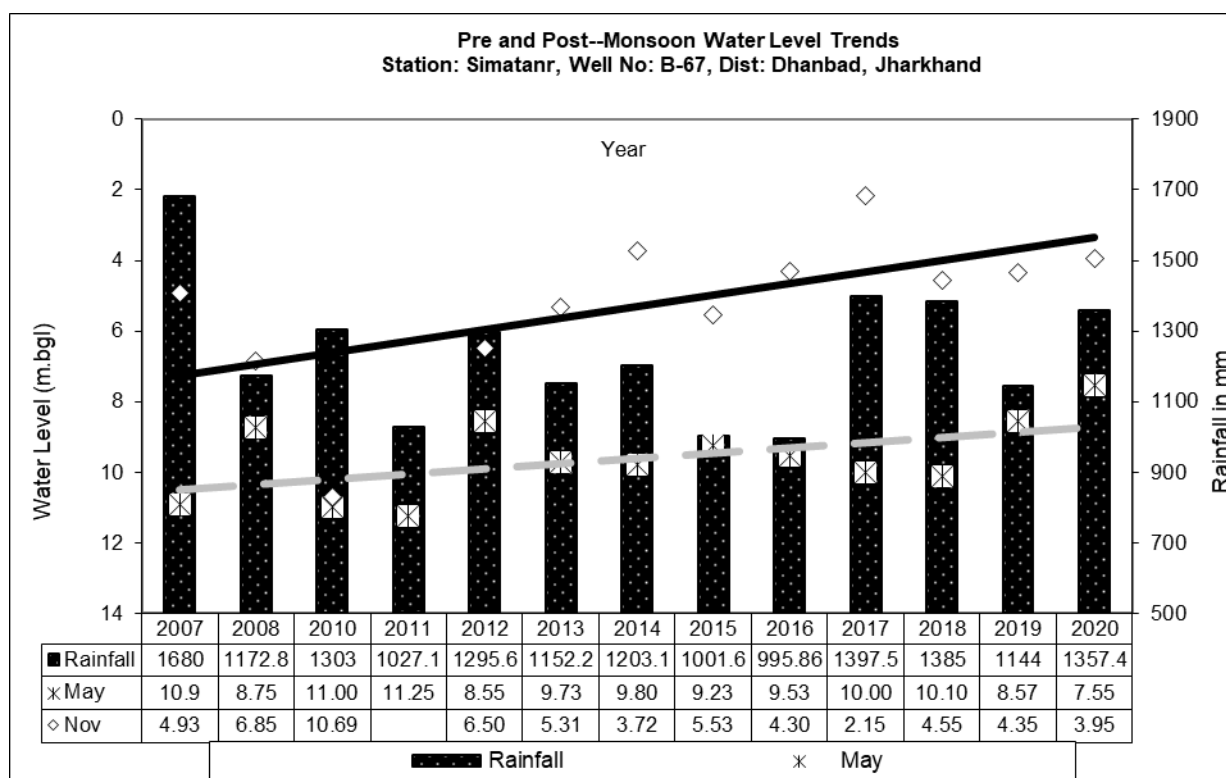
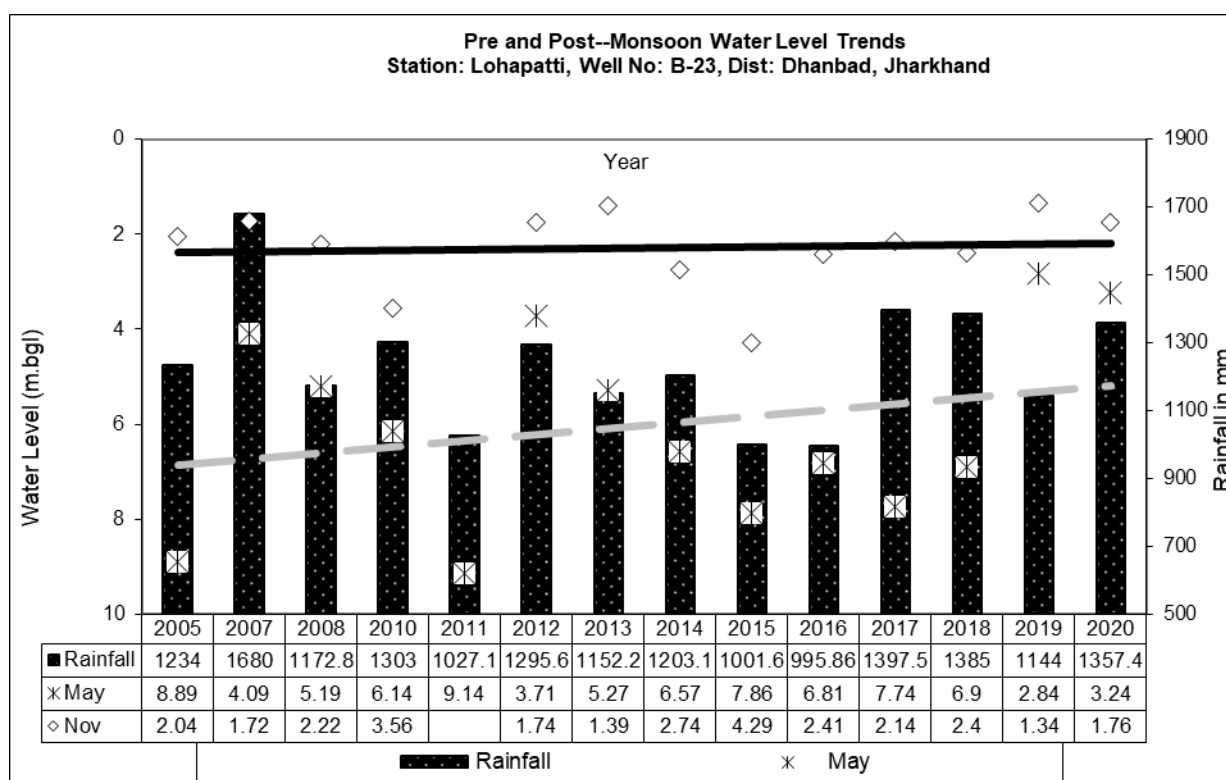


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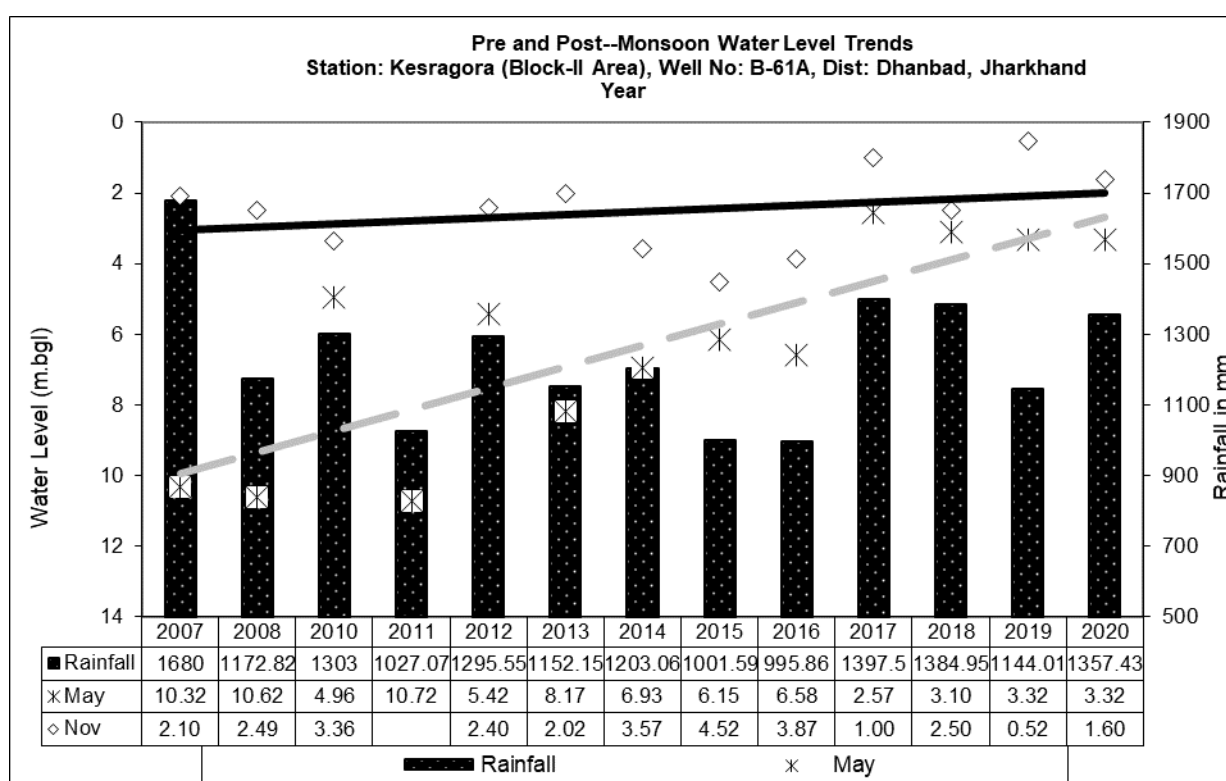
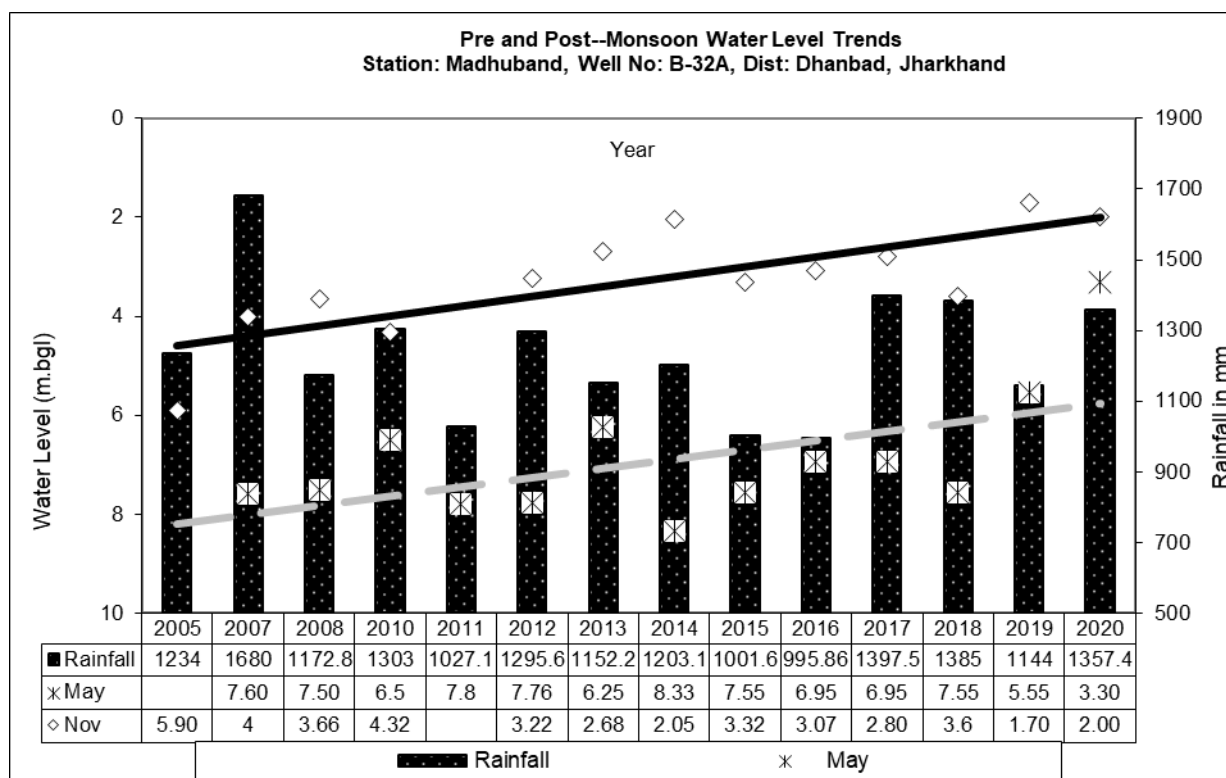




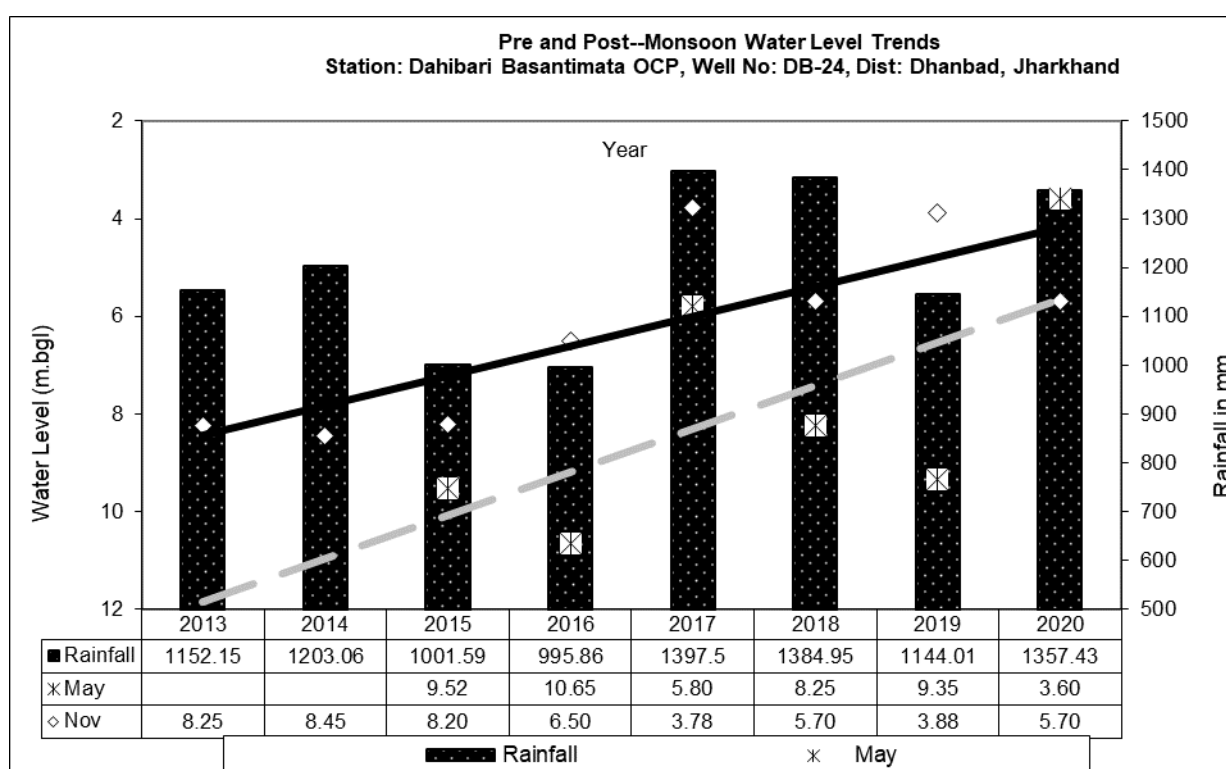
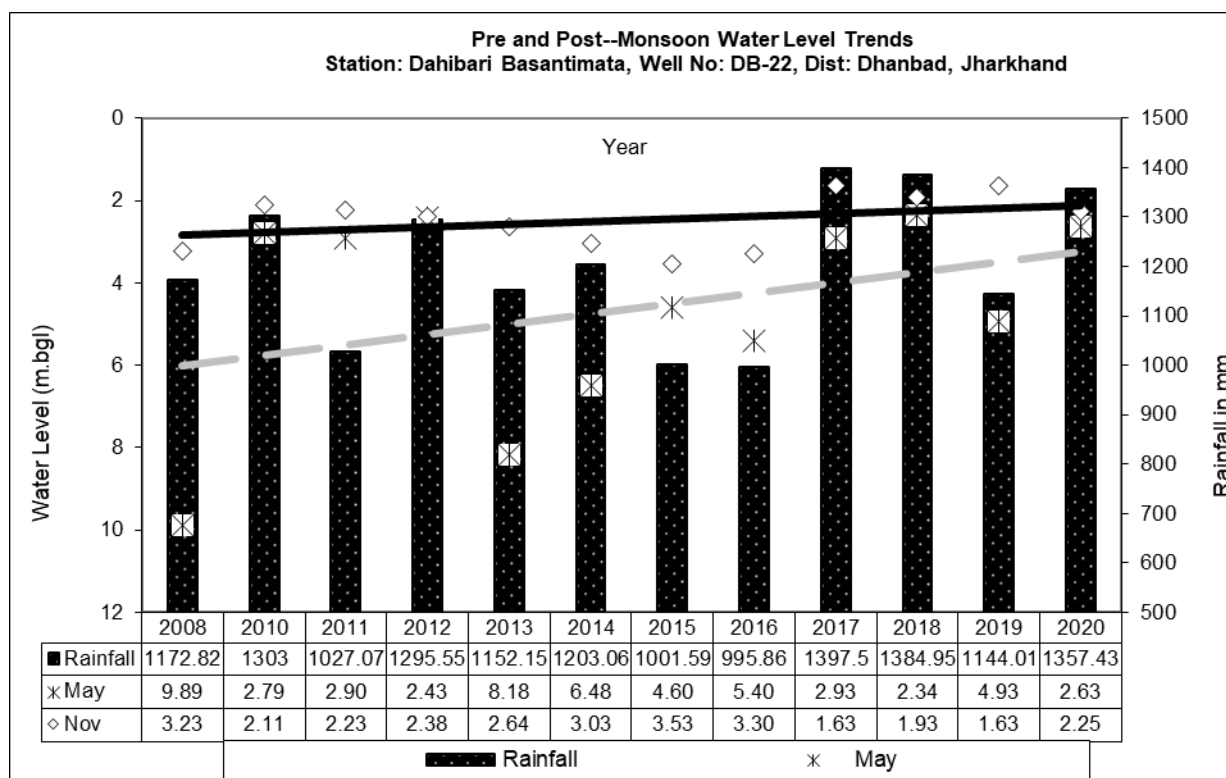
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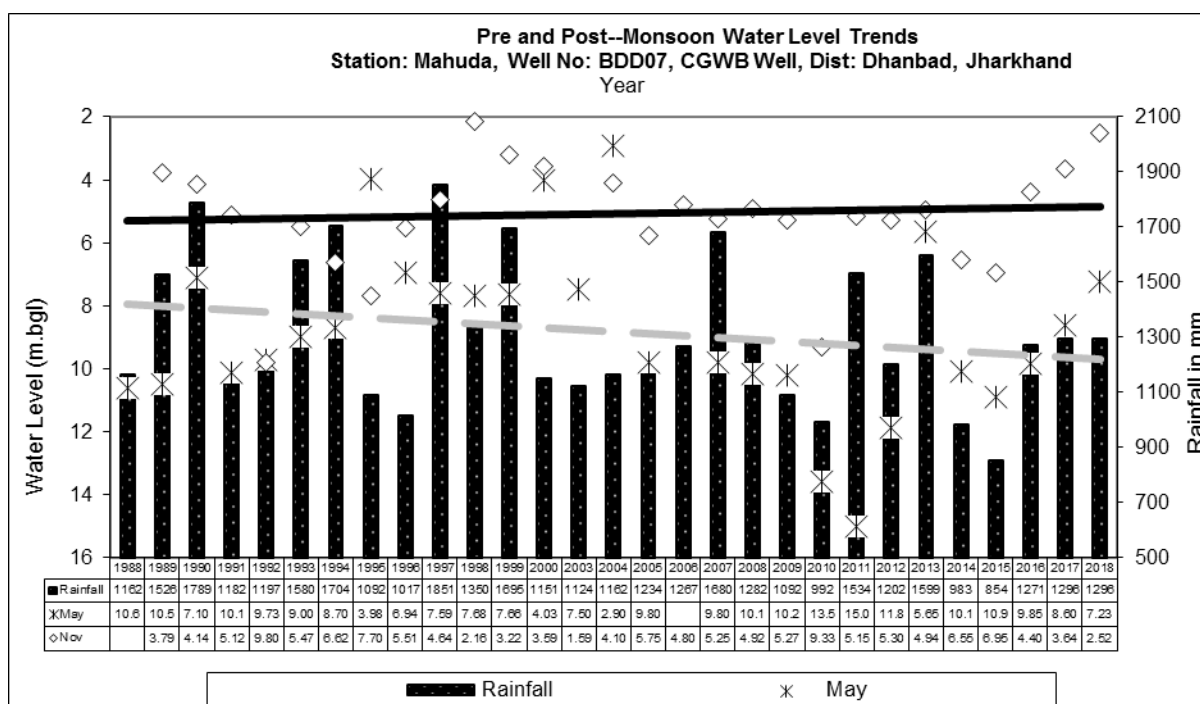
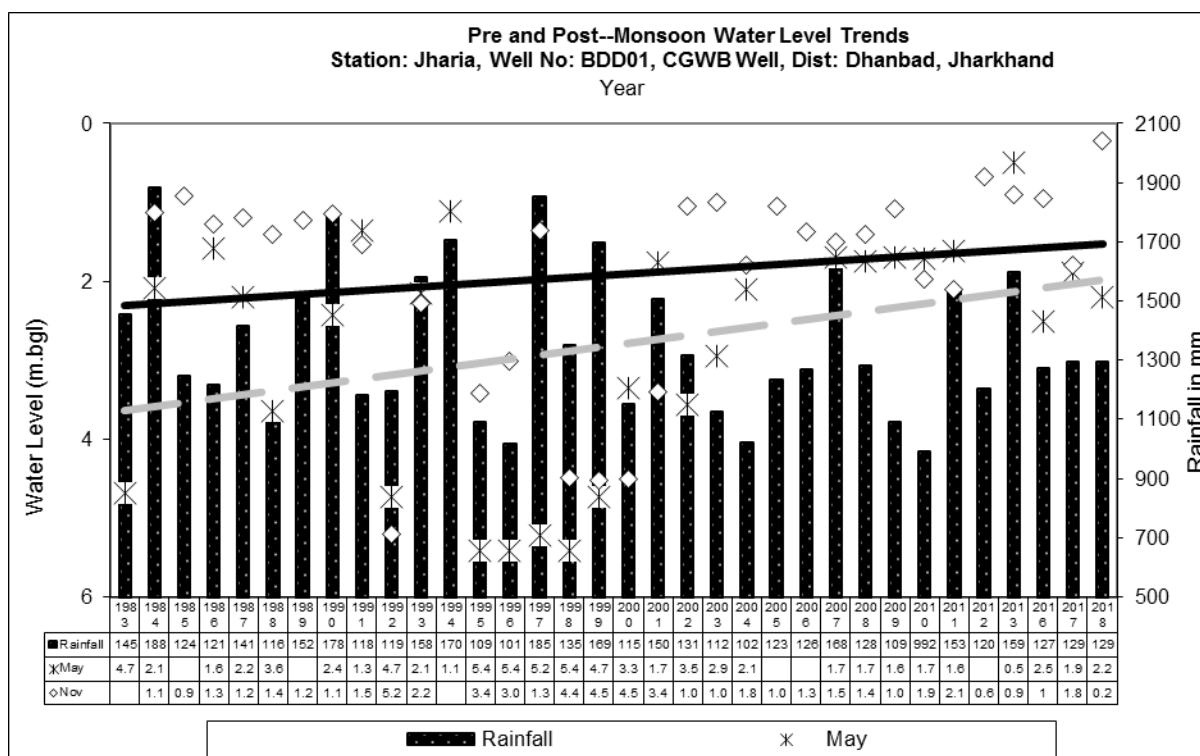
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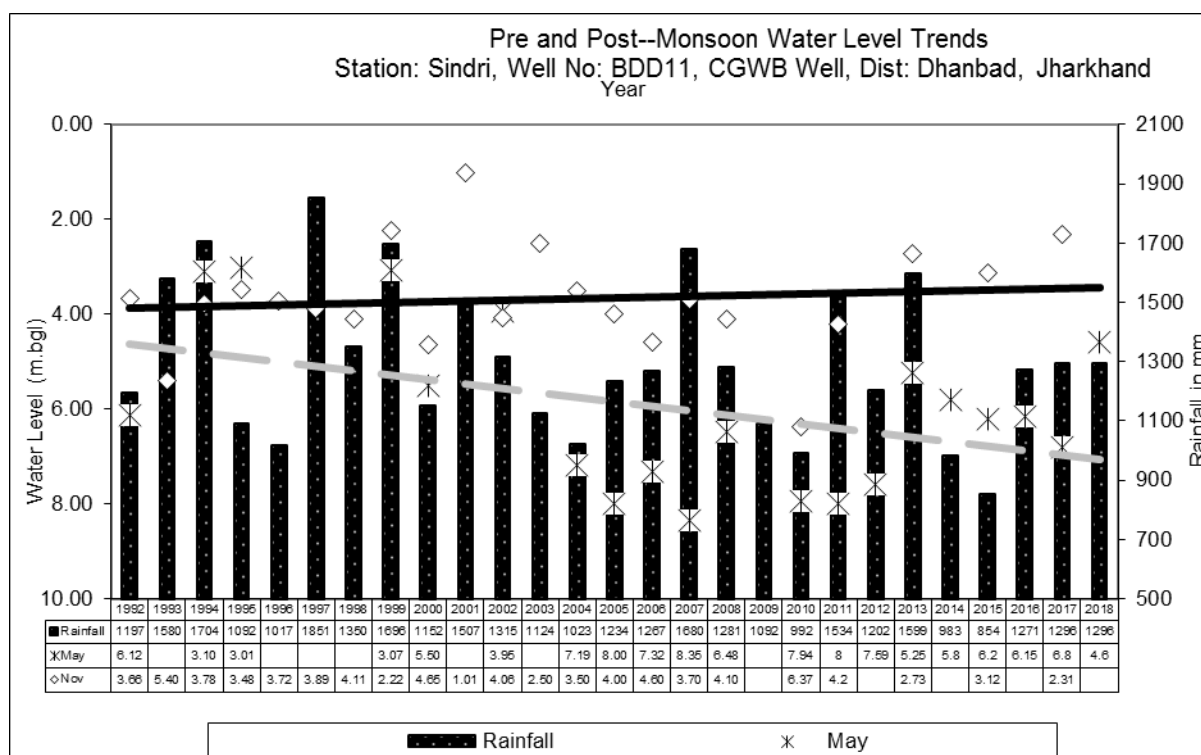
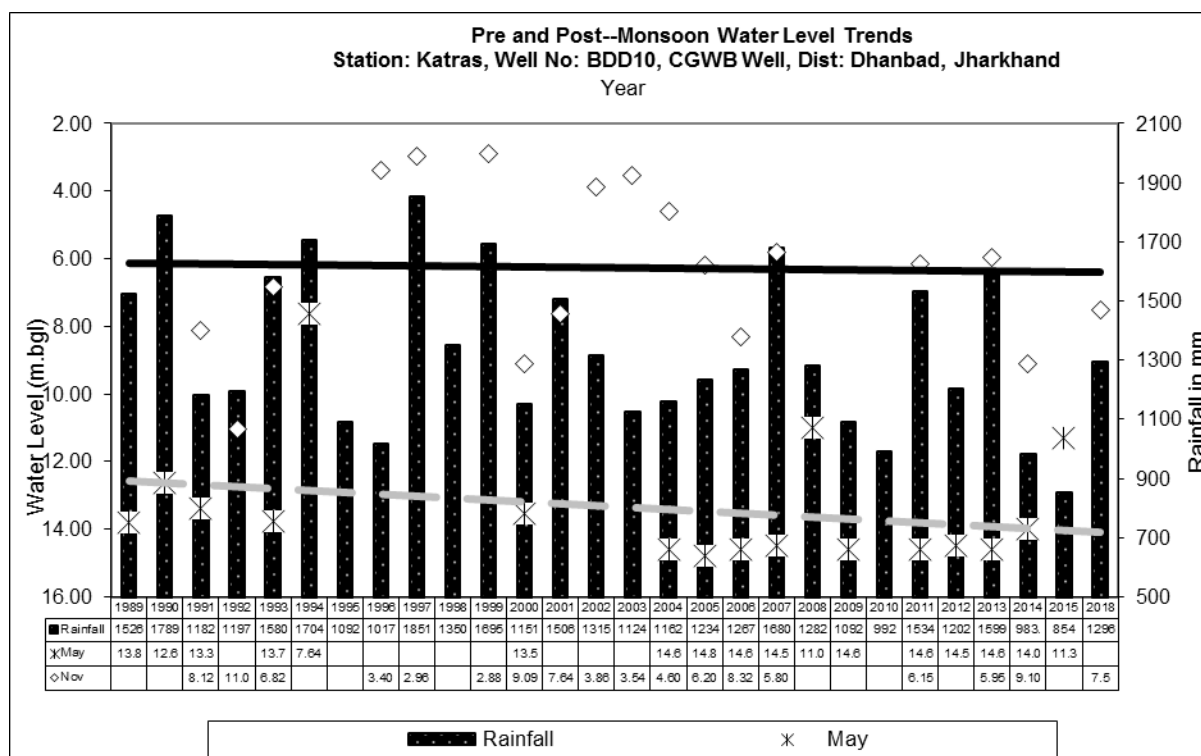
HYDROGRAPHS OF CLUSTER-XVI



HYDROGRAPHS OF CGWB PERMANENT OBSERVATION STATIONS



HYDROGRAPHS OF CGWB PERMANENT OBSERVATION STATIONS



GROUNDWATER SAMPLE LOCATION DETAILS

Sampling month: June month of the assessment year of 2020-21

SI No	Name of Cluster	Ground Water Sample	Dug well (CMPDI)	Location	Sampling Date
					June'2020
1	CLUSTER-I	GW-1	B-15	BERA VILLAGE	01.06.2020
2	CLUSTER-II	GW-2	B-59	KHODOVALY VILLAGE	01.06.2020
3	CLUSTER-III	GW-3	A-29	GOVINDPUR,AMBAGAN VILLAGE	01.06.2020
4	CLUSTER-IV	GW-4	B-63	KESHALPUR, BATIGHAR	01.06.2020
5	CLUSTER-V	GW-5	D-30	BORKIBOA VILLAGE	01.06.2020
6	CLUSTER-VI	GW-6	D-25	GODHUR MORE	01.06.2020
7	CLUSTER-VII	GW-7	D-80	DHANSAR MINE RESCUE STN.	02.06.2020
8	CLUSTER-VIII	GW-8	D-49	NEAR GHANOODIH OC	02.06.2020
9	CLUSTER-IX	GW-9	D-5	JEALGORA, NEAR P.O.	02.06.2020
10	CLUSTER-X	GW-10	D-35	PATHERDIH RLY. COLONY	02.06.2020
11	CLUSTER-XI	GW-11	A-32	MONNIDIH BAZAR	01.06.2020
12	CLUSTER-XIII	GW-13	A-23	MACHHAYARA	01.06.2020
13	CLUSTER-XIV	GW-14	B-23	LOHAPATTI VILLAGE	01.06.2020
14	CLUSTER-XV	GW-15	B-32A	MADHUBAND VILLAGE	01.06.2020
15	CLUSTER-XVI	GW-16	DB-22	DAHIBARI,NICHE BASTI	02.06.2020

WATER QUALITY

(GROUND WATER- ALL PARAMETERS)

Year: 2020-21

Sl. No	Parameter	Sampling Stations			Detection Limit	IS:10500 Drinking Water Standards	Standard / Test Method
		GW-1 01.06.2020	GW-2 01.06.2020	GW-3 01.06.2020			
1	Boron (as B), mg/l, Max	<0.2	<0.2	<0.2	0.2	0.5	APHA, 23 rd Edition ,Carmin
2	Colour,in Hazen Units	1	2	1	1	5	APHA, 23 rd Edition ,Pt.-Co. Method
3	Calcium (as Ca), mg/l, Max	40	48	54	1.6	75	IS 3025, Part 40: 1991 R 2019 EDTA Method
4	Chloride (as Cl), mg/l, Max	18	22	28	2	250	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.03	<0.03	<0.03	0.03	0.05	IS 3025/Part 42 : 1992 R : 2019, AAS-Flame APHA, 23 rd Edition, AAS-GTA
6	Fluoride (as F) mg/l, Max	0.62	0.78	0.54	0.2	1.0	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
7	Free Residual Chlorine, mg/l, Min	<0.04	<0.04	<0.04	0.04	0.2	APHA, 23 rd Edition , 4500-Cl ⁻ B. (Iodometric Method-I)
8	Iron (as Fe), mg/l, Max	<0.2	<0.2	<0.2	0.2	1.0	IS 3025 Part 53 : 2003, R : 2019 , AAS-Flame Method
9	Lead (as Pb), mg/l, Max	<0.005	<0.005	<0.005	0.005	0.01	IS:3025(Part 47):1994 (Reaffirmed 2019) APHA, 23 rd Edition, AAS-GTA
10	Manganese (as Mn), mg/l, Max	<0.02	<0.02	<0.02	0.02	0.1	APHA, 23 rd Edition, 3111B, Direct Air Acetylene Flame AAS-Flame
11	Nitrate (as NO ₃), mg/l, Max	6.72	5.48	10.18	0.5	45	APHA, 23 rd Edition, P-4-127, 4500 - NO ₃ ⁻ B , UV-Spectrophotometric Screening Method
12	Odour	Agreeable	Agreeable	Agreeable	Qualitative	Agreeable	APHA, 23 rd Edition , 2150-C
13	pH value	8.21	8.10	8.12	0.2	6.5-8.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
14	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.001	<0.001	<0.001	0.001	0.002	APHA, 22 nd Edition, 4-Amino Autipyrine
15	Selenium, mg/l, Max	<0.007	<0.007	<0.007	0.007	0.01	IS -3025,part 56:2003,R-2019/APHA 23 rd Edition, AAS-VGA
16	Sulphate (as SO ₄) mg/l, Max	42	54	38	10	200	APHA -23 rd Edition. P-4-199, 4500 SO ₄ ²⁻ E
17	Taste	Acceptable	Acceptable	Acceptable	Qualitative	Acceptable	APHA, 23 rd Edition, 2160-C Flavour Rating Assesment
18	Total Alkalinity (CaCO ₃), mg/l, Max	112	138	140	4	200	IS 3025, Part 23: 1986 R 2019 Titration Method
19	Total Arsenic (as As), mg/l,Max	<0.006	<0.006	<0.006	0.006	0.01	IS-3025, part 37:1988,R-2019/APHA23 rd Edition AAS-VGA
20	Total Chromium (as Cr), mg/l, Max	<0.04	<0.04	<0.04	0.04	0.05	IS-3025 Part 52:2003, R:2019,AAS-Flame APHA, 23 rd Edition, AAS-GTA
21	Total Dissolved Solids, mg/l, Max	204	244	214	25	500	IS 3025, Part 16: 1984 R 2017 Gravimetric method
22	Total Hardness (CaCO ₃), mg/l, Max	182	206	198	4	200	IS 3025, Part 21, 2009 R 2019 EDTA Method
23	Turbidity, NTU, Max	2	2	2	1	5	IS 3025, Part 10 : 1984 R 2017 Nephelometric Method
24	Zinc (as Zn), mg/l, Max	<0.1	<0.1	<0.1	0.1	5	IS 3025 Part 49 : 1994,R : 2019, AAS-Flame
25	Nickel as Ni, mg/l Max	<0.01	<0.01	<0.01	0.01	0.02	IS 3025 Pat 54 : 2003,R : 2019, AAS-Flame APHA 23 rd Edition, AAS-GTA

WATER QUALITY

(GROUND WATER- ALL PARAMETERS)

Year: 2020-21

Sl. No	Parameter	Sampling Stations			Detection Limit	IS:10500 Drinking Water Standards	Standard / Test Method
		GW-4 01.06.2020	GW-5 01.06.2020	GW-6 01.06.2020			
1	Boron (as B), mg/l, Max	<0.2	<0.2	<0.2	0.2	0.5	APHA, 23 rd Edition ,Carmine
2	Colour,in Hazen Units	3	1	1	1	5	APHA, 23 rd Edition ,Pt.-Co. Method
3	Calcium (as Ca), mg/l, Max	36	156	64	1.6	75	IS 3025, Part 40: 1991 R 2019 EDTA Method
4	Chloride (as Cl), mg/l, Max	20	98	36	2	250	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.03	<0.03	<0.03	0.03	0.05	IS 3025 Part 42 : 1992 R : 2019, AAS-Flame APHA, 23 rd Edition, AAS-GTA
6	Fluoride (as F) mg/l, Max	0.52	0.72	0.74	0.2	1.0	APHA, 23RD Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
7	Free Residual Chlorine, mg/l, Min	<0.04	<0.04	<0.04	0.04	0.2	APHA, 23rd Edition, , 4500-Cl ⁻ B. (Iodometric Method-I)
8	Iron (as Fe), mg/l, Max	<0.2	<0.2	<0.2	0.2	1.0	IS 3025 Part 53 : 2003, R : 2019 , AAS-Flame Method
9	Lead (as Pb), mg/l, Max	<0.005	<0.005	<0.005	0.005	0.01	IS:3025(Part 47):1994 (Reaffirmed 2019) APHA, 23 rd Edition, AAS-GTA
10	Manganese (as Mn), mg/l, Max	<0.02	<0.02	<0.02	0.02	0.1	APHA, 23 rd Edition, 3111B, Direct Air Acetylene Flame AAS-GTA
11	Nitrate (as NO ₃), mg/l, Max	12.84	33.08	15.28	0.5	45	APHA, 23rd Edition, P-4-127, 4500 - NO ₃ ⁻ B , UV-Spectrophotometric Screening Method
12	Odour	Agreeable	Agreeable	Agreeable	Qualitative	Agreeable	APHA, 23rd Edition, , 2150-C
13	pH value	7.96	8.04	7.81	0.2	6.5-8.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
14	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.001	<0.001	<0.001	0.001	0.002	APHA, 22 nd Edition, 4-Amino Autipyrine
15	Selenium, mg/l, Max	<0.007	<0.007	<0.007	0.007	0.01	IS -3025, part 56:2003, R-2019/APHA 23 rd Edition, AAS-VGA
16	Sulphate (as SO ₄) mg/l, Max	48	127	64	2	200	APHA –23rd Edition, P-4-199, 4500 SO ₄ ²⁻ E
17	Taste	Acceptable	Acceptable	Acceptable	Qualitative	Acceptable	APHA, 23rd Edition, 2160-C Flavour Rating Assessment
18	Total Alkalinity (CaCO ₃),, mg/l, Max	144	96	112	4	200	IS 3025, Part 23: 1986 R 2019 Titration Method
19	Total Arsenic (as As), mg/l, Max	<0.006	<0.006	<0.006	0.006	0.01	IS-3025, part 37:1988, R-2019/APHA 23rd Edition AAS-VGA
20	Total Chromium (as Cr), mg/l, Max	<0.04	<0.04	<0.04	0.04	0.05	IS-3025 Part 52:2003, R:2019, AAS-Flame APHA, 23 rd Edition, AAS-GTA
21	Total Dissolved Solids, mg/l, Max	208	764	236	25	500	IS 3025, Part 16: 1984 R 2017 Gravimetric method
22	Total Hardness (CaCO ₃), mg/l, Max	182	680	204	4	200	IS 3025, Part 21, 2009 R 2019 EDTA Method
23	Turbidity, NTU, Max	2	3	1	1	5	IS 3025, Part 10 : 1984 R 2017 Nephelometric Method
24	Zinc (as Zn), mg/l, Max	<0.1	<0.1	<0.1	0.1	5	IS 3025 Part 49 : 1994, R : 2019, AAS-Flame
25	Nickel as Ni, mg/l Max	<0.01	<0.01	<0.01	0.01	0.02	IS 3025 Part 54 : 2003, R : 2019, AAS-Flame APHA 23 rd Edition, AAS-GTA

WATER QUALITY

(GROUND WATER- ALL PARAMETERS)

Year: 2020-21

Sl. No	Parameter	Sampling Stations			Detection Limit	IS:10500 Drinking Water Standards	Standard / Test Method
		GW-7 02.06.2020	GW-8 02.06.2020	GW-9 02.06.2020			
1	Boron (as B), mg/l, Max	<0.2	<0.2	<0.2	0.2	0.5	APHA, 23 rd Edition ,Carmine
2	Colour,in Hazen Units	1	1	1	1	5	APHA, 23 rd Edition ,Pt.-Co. Method
3	Calcium (as Ca), mg/l, Max	64	52	144	1.6	75	IS 3025, Part 40: 1991 R 2019 EDTA Method
4	Chloride (as Cl), mg/l, Max	36	24	68	2	250	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.03	<0.03	<0.03	0.03	0.05	IS 3025 Part 42 : 1992 R : 2019, AAS-Flame APHA,23 rd Edition, AAS-GTA
6	Fluoride (as F) mg/l, Max	0.46	0.76	0.58	0.2	1.0	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
7	Free Residual Chlorine, mg/l, Min	<0.04	<0.04	<0.04	0.04	0.2	APHA, 23 rd Edition, , 4500-Cl ⁻ B. (Iodometric Method-I)
8	Iron (as Fe), mg/l, Max	<0.2	<0.2	<0.2	0.2	1.0	IS 3025 Part 53 : 2003, R : 2019 , AAS-Flame Method
9	Lead (as Pb), mg/l, Max	<0.005	<0.005	<0.005	0.005	0.01	IS:3025(Part 47):1994 (Reaffirmed 2019) APHA, 23 rd Edition, AAS-GTA
10	Manganese (as Mn), mg/l, Max	<0.02	<0.02	<0.02	0.02	0.1	APHA, 23 rd Edition, 3111B, Direct Air Acetylene Flame AAS-GTA
11	Nitrate (as NO ₃), mg/l, Max	16.28	8.92	28.42	0.5	45	APHA, 23 rd Edition, P-4-127, 4500 - NO ₃ ⁻ B , UV-Spectrophotometric Screening Method
12	Odour	Agreeable	Agreeable	Agreeable	Qualitative	Agreeable	APHA, 23 rd Edition, , 2150-C
13	pH value	7.88	8.12	8.15	0.2	6.5-8.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
14	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.001	<0.001	<0.001	0.001	0.002	APHA, 22 nd Edition,4-Amino Autipyrine
15	Selenium, mg/l, Max	<0.007	<0.007	<0.007	0.007	0.01	IS -3025,part 56:2003,R-2019/APHA 23 rd Edition, AAS-VGA
16	Sulphate (as SO ₄) mg/l, Max	62	38	174	2	200	APHA –23 rd Edition. P-4-199, 4500 SO ₄ ²⁻ E
17	Taste	Acceptable	Acceptable	Acceptable	Qualitative	Acceptable	APHA,23 rd Edition, 2160-C Flavour Rating Assesment
18	Total Alkalinity (CaCO ₃), mg/l, Max	76	132	96	4	200	IS 3025, Part 23: 1986 R 2019 Titration Method
19	Total Arsenic (as As), mg/l,Max	<0.006	<0.006	<0.006	0.006	0.01	IS-3025, part 37:1988,R-2019/APHA23 rd Edition AAS-VGA
20	Total Chromium (as Cr), mg/l, Max	<0.04	<0.04	<0.04	0.04	0.05	IS-3025 Part 52:2003, R:2019,AAS-Flame APHA, 23 rd Edition, AAS-GTA
21	Total Dissolved Solids, mg/l, Max	244	196	744	25	500	IS 3025, Part 16: 1984 R 2017 Gravimetric method
22	Total Hardness (CaCO ₃), mg/l, Max	172	148	636	4	200	IS 3025, Part 21, 2009 R 2019 EDTA Method
23	Turbidity, NTU, Max	1	1	2	1	5	IS 3025, Part 10 : 1984 R 2017 Nephelometric Method
24	Zinc (as Zn), mg/l, Max	<0.1	<0.1	<0.1	0.1	5	IS 3025 Part 49 : 1994,R : 2019, AAS-Flame
25	Nickel as Ni, mg/l Max	<0.01	<0.01	<0.01	0.01	0.02	IS 3025 Pat 54 : 2003,R : 2019, AAS-Flame APHA 23 rd Edition, AAS-GTA

WATER QUALITY

(GROUND WATER- ALL PARAMETERS)

Year: 2020-21

Sl. No	Parameter	Sampling Stations			Detection Limit	IS:10500 Drinking Water Standards	Standard / Test Method
		GW-10 02.06.2020	GW-11 01.06.2020	GW-13 01.06.2020			
1	Boron (as B), mg/l, Max	<0.2	<0.2	<0.2	0.2	0.5	APHA, 23 rd Edition ,Carmine
2	Colour,in Hazen Units	3	3	2	1	5	APHA, 23 rd Edition ,Pt.-Co. Method
3	Calcium (as Ca), mg/l, Max	52	32	164	1.6	75	IS 3025, Part 40: 1991 R 2019 EDTA Method
4	Chloride (as Cl), mg/l, Max	46	26	104	2	250	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.03	<0.03	<0.03	0.03	0.05	IS 3025 Part 42 : 1992 R : 2019, AAS-Flame APHA,23 rd Edition, AAS-GTA
6	Fluoride (as F) mg/l, Max	0.82	0.56	0.76	0.2	1.0	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
7	Free Residual Chlorine, mg/l, Min	<0.04	<0.04	<0.04	0.04	0.2	APHA, 23 rd Edition, , 4500-Cl ⁻ B. (Iodometric Method-I)
8	Iron (as Fe), mg/l, Max	<0.2	<0.2	<0.2	0.2	1.0	IS 3025 Part 53 : 2003, R : 2019 , AAS-Flame Method
9	Lead (as Pb), mg/l, Max	<0.005	<0.005	<0.005	0.005	0.01	IS:3025(Part 47):1994 (Reaffirmed 2019) APHA, 23 rd Edition, AAS-GTA
10	Manganese (as Mn), mg/l, Max	<0.02	<0.02	<0.02	0.02	0.1	APHA, 23 rd Edition, 3111B, Direct Air Acetylene Flame AAS-GTA
11	Nitrate (as NO ₃), mg/l, Max	18.42	12.48	7.88	0.5	45	APHA, 23 rd Edition, P-4-127, 4500 - NO ₃ ⁻ B , UV-Spectrophotometric Screening Method
12	Odour	Agreeable	Agreeable	Agreeable	Qualitative	Agreeable	APHA, 23 rd Edition, , 2150-C
13	pH value	8.21	7.96	8.03	0.2	6.5-8.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
14	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.001	<0.001	<0.001	0.001	0.002	APHA, 22 nd Edition,4-Amino Autipyrine
15	Selenium, mg/l, Max	<0.007	<0.007	<0.007	0.007	0.01	IS -3025,part 56:2003,R-2019/APHA 23 rd Edition, AAS-VGA
16	Sulphate (as SO ₄) mg/l, Max	88	44	178	2	200	APHA -23 rd Edition. P-4-199, 4500 SO ₄ ²⁻ E
17	Taste	Acceptabl e	Acceptabl e	Acceptabl e	Qualitative	Acceptable	APHA,23 rd Edition, 2160-C Flavour Rating Assesment
18	Total Alkalinity (CaCO ₃),, mg/l, Max	98	152	88	4	200	IS 3025, Part 23: 1986 R 2019 Titration Method
19	Total Arsenic (as As), mg/l,Max	<0.006	<0.006	<0.006	0.006	0.01	IS-3025, part 37:1988,R-2019/APHA23 rd Edition AAS-VGA
20	Total Chromium (as Cr), mg/l, Max	<0.04	<0.04	<0.04	0.04	0.05	IS-3025 Part 52:2003, R:2019,AAS-Flame APHA, 23 rd Edition, AAS-GTA
21	Total Dissolved Solids, mg/l, Max	248	178	756	25	500	IS 3025, Part 16: 1984 R 2017 Gravimetric method
22	Total Hardness (CaCO ₃), mg/l, Max	192	164	680	4	200	IS 3025, Part 21, 2009 R 2019 EDTA Method
23	Turbidity, NTU, Max	2	1	2	1	5	IS 3025, Part 10 : 1984 R 2017 Nephelometric Method
24	Zinc (as Zn), mg/l, Max	<0.1	<0.1	<0.1	0.1	5	IS 3025 Part 49 : 1994,R : 2019, AAS-Flame
25	Nickel as Ni, mg/l Max	<0.01	<0.01	<0.01	0.01	0.02	IS 3025 Pat 54 : 2003,R : 2019, AAS-Flame APHA 23 rd Edition, AAS-GTA

WATER QUALITY **(GROUND WATER- ALL PARAMETERS)**

Year: 2020-21

Sl. No	Parameter	Sampling Stations			Detection Limit	IS:10500 Drinking Water Standards	Standard / Test Method
		GW 14 01.06.2020	GW15 01.06.2020	GW16 02.06.2020			
1	Boron (as B), mg/l, Max	<0.2	<0.2	<0.2	0.2	0.5	APHA, 23 rd Edition ,Carminc
2	Colour,in Hazen Units	1	1	3	1	5	APHA, 23 rd Edition ,Pt.-Co. Method
3	Calcium (as Ca), mg/l, Max	44	180	122	1.6	75	IS 3025, Part 40: 1991 R 2019 EDTA Method
4	Chloride (as Cl), mg/l, Max	56	104	66	2	250	IS-3025/32:1988, R-2019 Argentometric
5	Copper (as Cu), mg/l, Max	<0.03	<0.03	<0.03	0.03	0.05	IS 3025 Part 42 : 1992 R : 2019, AAS-Flame APHA, 23 rd Edition, AAS-GTA
6	Fluoride (as F) mg/l, Max	0.52	0.44	0.66	0.2	1.0	APHA, 23 rd Edition, Page 4-90 to , 4500 -F- D (SPADNS Method)
7	Free Residual Chlorine, mg/l, Min	<0.04	<0.04	<0.04	0.04	0.2	APHA, 23 rd Edition, , 4500-Cl ⁻ B. (Iodometric Method-I)
8	Iron (as Fe), mg/l, Max	<0.2	<0.2	<0.2	0.2	1.0	IS 3025 Part 53 : 2003, R : 2019 , AAS-Flame Method
9	Lead (as Pb), mg/l, Max	<0.005	<0.005	<0.005	0.005	0.01	IS:3025(Part 47):1994 (Reaffirmed 2019) APHA, 23 rd Edition, AAS-GTA
10	Manganese (as Mn), mg/l, Max	<0.02	<0.02	<0.02	0.02	0.1	APHA, 23 rd Edition, 3111B, Direct Air Acetylene Flame AAS-GTA
11	Nitrate (as NO ₃), mg/l, Max	11.48	7.58	14.76	0.5	45	APHA, 23 rd Edition, P-4-127, 4500 - NO ₃ ⁻ B , UV-Spectrophotometric Screening Method
12	Odour	Agreeable	Agreeable	Agreeable	Qualitative	Agreeable	APHA, 23 rd Edition, , 2150-C
13	pH value	8.08	7.83	7.89	0.2	6.5-8.5	IS 3025, Part 11 : 1983 R 2017 Electrometric method
14	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max	<0.001	<0.001	<0.001	0.001	0.002	APHA, 22 nd Edition, 4-Amino Autipyrine
15	Selenium, mg/l, Max	<0.007	<0.007	<0.007	0.007	0.01	IS -3025,part 56:2003,R-2019/APHA 23 rd Edition, AAS-VGA
16	Sulphate (as SO ₄) mg/l, Max	40	152	128	2	200	APHA -23 rd Edition. P-4-199, 4500 SO ₄ ²⁻ E
17	Taste	Acceptable	Acceptable	Acceptable	Qualitative	Acceptable	APHA, 23 rd Edition, 2160-C Flavour Rating Assessment
18	Total Alkalinity (CaCO ₃), mg/l, Max	110	98	116	4	200	IS 3025, Part 23: 1986 R 2019 Titration Method
19	Total Arsenic (as As), mg/l,Max	<0.006	<0.006	<0.006	0.006	0.01	IS-3025, part 37:1988,R-2019/APHA23 rd Edition AAS-VGA
20	Total Chromium (as Cr), mg/l, Max	<0.04	<0.04	<0.04	0.04	0.05	IS-3025 Part 52:2003, R:2019,AAS-Flame APHA, 23 rd Edition, AAS-GTA
21	Total Dissolved Solids, mg/l, Max	204	756	512	25	500	IS 3025, Part 16: 1984 R 2017 Gravimetric method
22	Total Hardness (CaCO ₃), mg/l, Max	194	666	472	4	200	IS 3025, Part 21, 2009 R 2019 EDTA Method
23	Turbidity, NTU, Max	1	1	1	1	5	IS 3025, Part 10 : 1984 R 2017 Nephelometric Method
24	Zinc (as Zn), mg/l, Max	<0.1	<0.1	<0.1	0.1	5	IS 3025 Part 49 : 1994,R : 2019, AAS-Flame
25	Nickel as Ni, mg/l Max	<0.01	<0.01	<0.01	0.01	0.02	IS 3025 Pat 54 : 2003,R : 2019, AAS-Flame APHA 23 rd Edition, AAS-GTA

Abbreviations

AMSL: Above mean sea level

Avg.: Average

APT: Aquifer Pumping Test

BCCL: Bharat Coking Coal Ltd.

bgl: Below Ground Level

Buffer zone: periphery of the 10 km radius from the project boundary

Core zone: Project / mine / colliery boundary (leasehold area)

CMPDI: Central Mine Plan & Design Institute

DVC: Damodar Valley Corporation

DTW: Depth to water level

GW: Groundwater

IMD: Indian Meteorological Division

JCF: Jharia Coalfield

RCF: Raniganj Coalfield

MADA: Mineral Area Development Authority

MCM: Million Cubic Meter

MGD: Million Gallon per day

NTU: Nephelometric Turbidity unit

OC / UG: Opencast / Underground

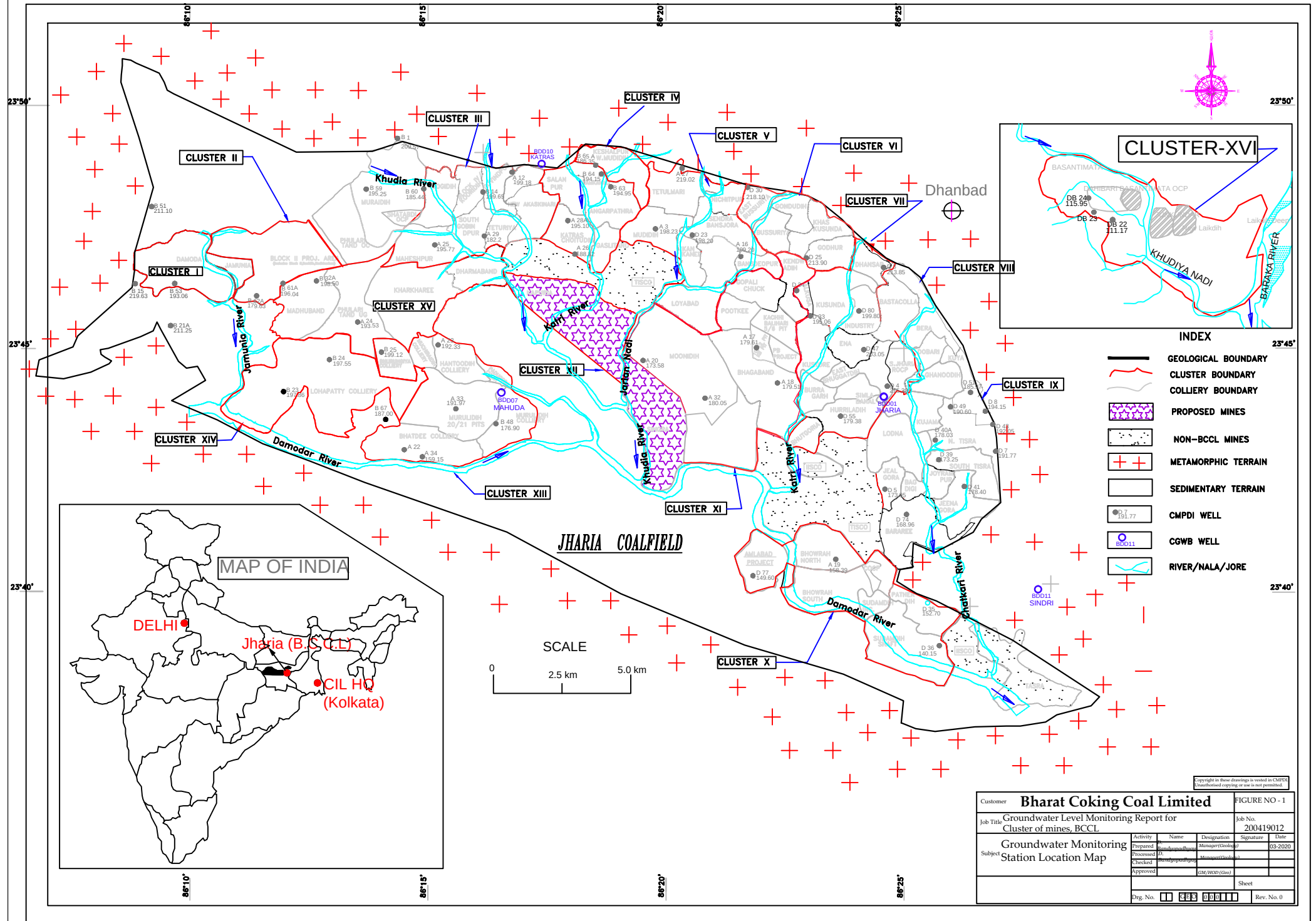
OCP / UGP: Opencast Project / Underground Project

RL: Reduced Level

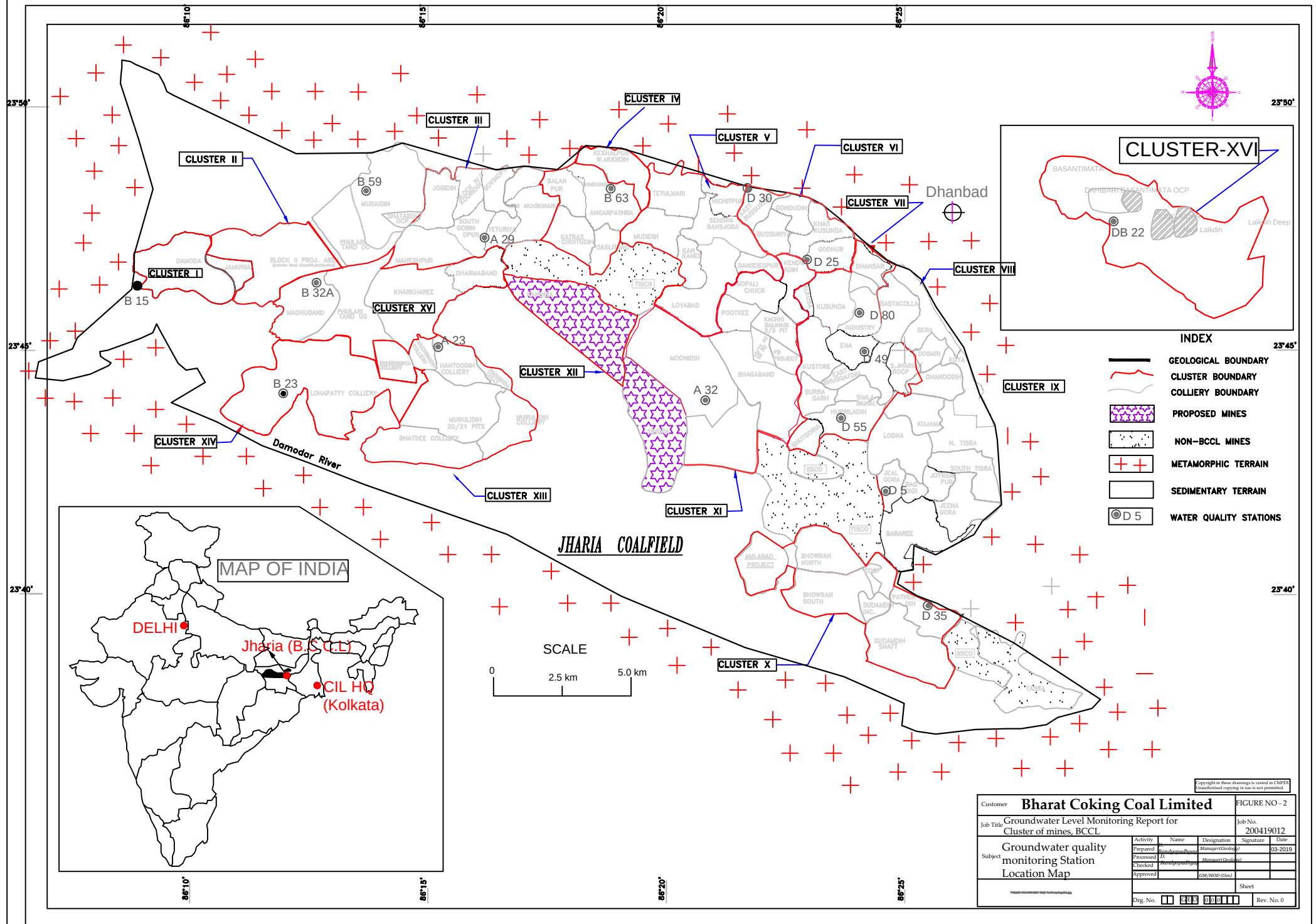
RWH: Rainwater Harvesting

FF: Fire Fighting

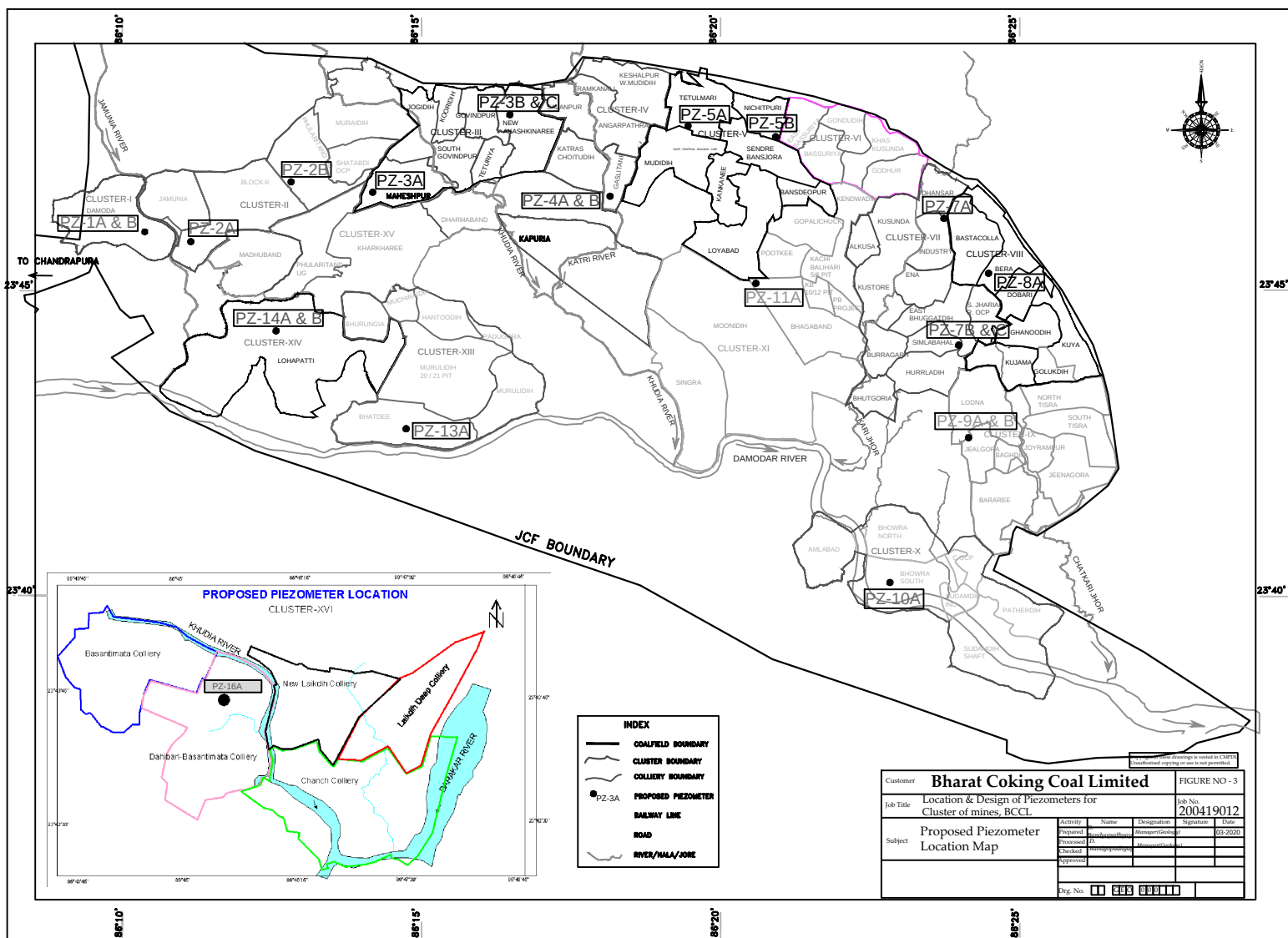
GROUNDWATER MONITORING STATION LOCATION MAP



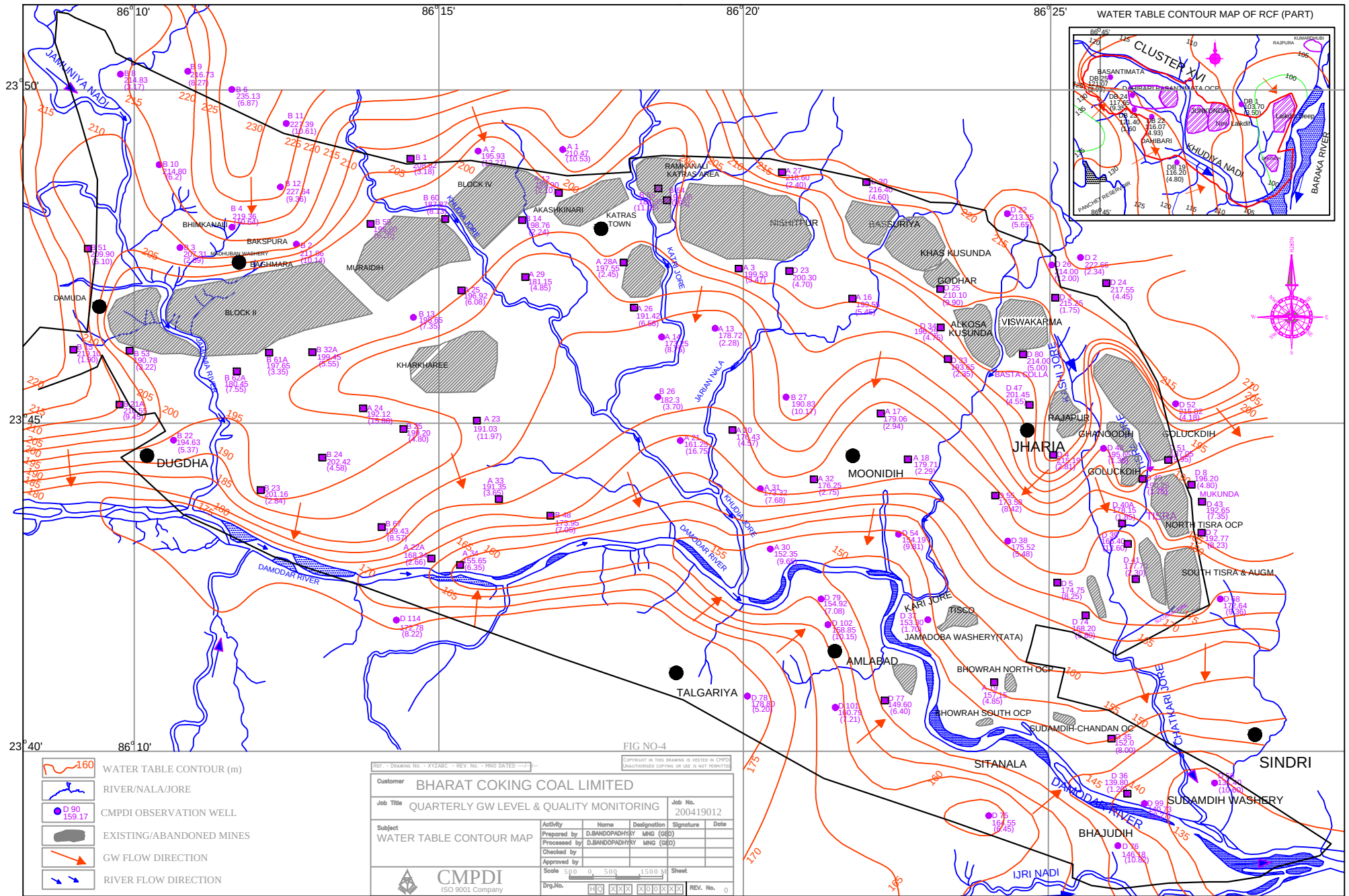
GROUNDWATER QUALITY MONITORING STATION LOCATION MAP



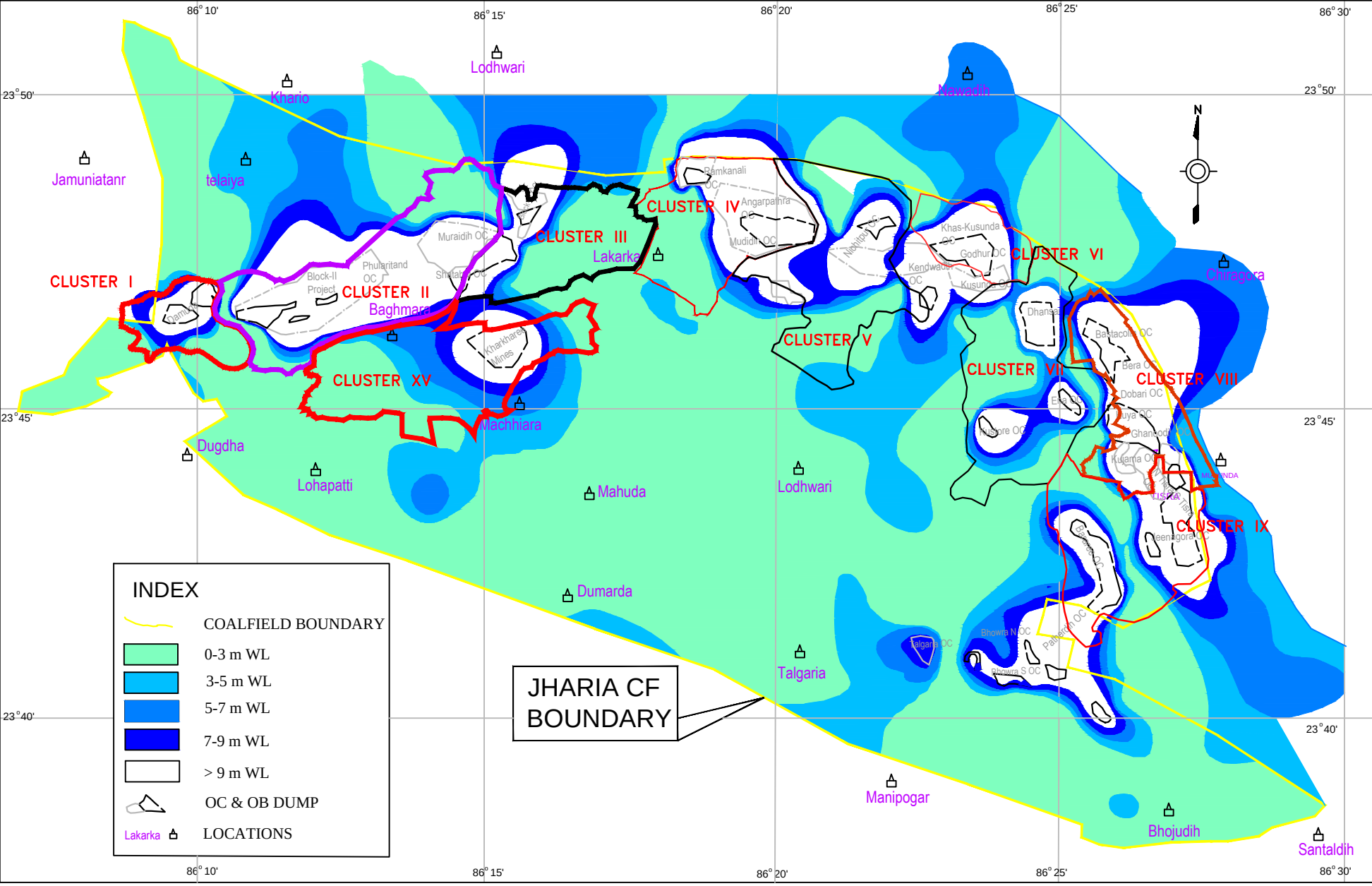
PROPOSED PIEZOMETER LOCATION MAP, JCF & RCF (part)



WATER TABLE CONTOUR MAP OF PRE-MONSOON 2020



DEPTH TO WATER LEVEL MAP OF JHARIA COALFIELD



INDEX

COALFIELD BOUNDARY

0-3 m WL

3-5 m WL

5-7 m WL

7-9 m WL

> 9 m WL

OC & OB DUMP

Lakarka

LOCATIONS

Customer
BHARAT COKING COAL LIMITED

Job Title
HYDROGEOLOGICAL STUDIES FOR BCCL CLUSTERS

Subject
DEPTH TO WATER LEVEL MAP

Activity
Prepared by
Checked by
Approved by

Name
Designation
Signature
Date

Scale
500 1000 1500

Sheet
15000

Rev. No. 0

CMPDI
ISO 9001 Company

Result of the Interaction held between the Accreditation Board and Individuals / Institutions
(Accreditation Validity Period 15/2/2021 to 14/2/2026)

Accredited Individual				
S.No	Name	Qualified for Impact Assessment Report	Qualified for Modelling Studies	Qualified for Hydrogeological Report for min projects
1	Dr.Narendra Kumar Rana	Yes	NO	NO
2	Dr. Arijit Dey	Yes	NO	NO
3	Upendra Shrivastava	Yes	Yes	NO
4	Y.B.Kaushik	Yes	NO	NO
5	Sunil Kumar Saigal	yes	NO	NO
6	T.Rajendran	Yes	NO	NO
7	Dr. Nallathambi Varadaraj	Yes	Yes	Yes
8	Awani Kumar Budhaulia	Yes	NO	NO
9	Diwaspati Jamloki	Yes	NO	NO
10	Mohammed Khaja Rafiuddin	Yes	NO	NO
11	Shreeram Paranjpe	Yes	NO	NO
12	V. Pugazhendi	Yes	NO	NO
13	Ganji Sudarshan	Yes	NO	Yes
14	Durga Pada Pati	Yes	NO	NO
15	Tapan talukdar	Yes	Yes	NO
16	Gulab Prasad	Yes	NO	NO
17	Nawal Kishore Prasad	Yes	NO	Yes
18	Asis Kumar Chattopadhyay	Yes	NO	NO
19	Baddela Jaya Kumar	Yes	Yes	Yes
20	K.Balakrishnan	Yes	NO	NO
21	Vinod Sharma	Yes	NO	NO
22	Shailendra Nath Sinha	Yes	NO	NO
23	Gurinder Paul Singh	Yes	NO	NO
24	Dr.Dilip Singh Chundawat	Yes	NO	NO
25	Dr. Muhammad Ali Farooqi	Yes	NO	NO
26	Dr. Muhammad Najeeb.K	Yes	NO	NO
27	Prakash Ramchandra Gupte	Yes	NO	NO
28	M.C.Reddy	Yes	Yes	Yes
29	C.P.Srivastava	Yes	NO	NO
30	R. Chakrapani	Yes	NO	NO
31	Alaparthi Sreenivas	Yes	NO	NO
32	Raj Pal Singh	Yes	Yes	No
33	K.Kumaresan	Yes	NO	NO
34	Gyanchand Bohra	Yes	NO	NO
35	Vijay Rajkumar Yadav	Yes	NO	NO
37	Dr. M. Sriiman Narayana	Yes	NO	NO
38	Mukesh Suroliya	Yes	NO	NO
Accredited Institution				
S.No	Name	Qualified for Impact Assessment Report	Qualified for Modelling Studies	Qualified for Hydrogeological Report for min projects
1	Environ Techno Consultants	YES	YES	YES
2	NEER	YES	NO	YES
3	Vardan Environet	YES	NO	YES
4	Vimta Labs Limited	YES	NO	YES
5	Geoclimate Risk solutions	YES	YES	YES
6	S R K Mining Services (India)	YES	NO	YES
7	Ground Water & Mineral Investigation Consultancy centre	YES	NO	NO
8	Thrust geoconsultants Private Limited	YES	NO	NO
9	Hydrominviron Consultancy Pvt. Ltd.	Yes	NO	YES
10	Associate Engineers & Consultants	YES	YES	YES
11	Water Solutions	YES	No	YES
12	Royal Environment Auditing & Consultancy Services	NO	NO	YES
13	Central Mine Planning and Design Institute Limited (CMPDIL)	NO	NO	YES

Following have been Accredited for 5 years as mentioned above. However, they will be able to use the accreditation for CGWA purposes after they quit/completion of the present assignment.

1	Sh A.K.Bhatia
2	Dr. Anil Kumar Jain
3	Dr Ratan Chand Jain
4	Dr. K.R.Soorayanarayana
5	Dr Pradeep Kumar Parchure
6	Dr. P.N.Rao
7	Sh Nirad Chandra Nayak



**National Accreditation Board for
Testing and Calibration Laboratories**

CERTIFICATE OF ACCREDITATION

**ENVIRONMENT LABORATORY, CENTRAL MINE
PLANNING AND DESIGN INSTITUTE LIMITED**

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

**"General Requirements for the Competence of Testing &
Calibration Laboratories"**

for its facilities at

GONDWANA PLACE, KANKE ROAD, RANCHI, JHARKHAND, INDIA

in the field of

TESTING

Certificate Number: TC-7470

Issue Date: 08/09/2020

Valid Until:

07/09/2022

**This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued
satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)**

Name of Legal Identity : Registered under Companies act

Signed for and on behalf of NABL



**N. Venkateswaran
Chief Executive Officer**



National Accreditation Board for Testing and Calibration Laboratories

SCOPE OF ACCREDITATION

Laboratory Name :

ENVIRONMENT LABORATORY, CENTRAL MINE PLANNING AND DESIGN INSTITUTE LIMITED,
GONDWANA PLACE, KANKE ROAD, RANCHI, JHARKHAND, INDIA

Accreditation Standard

ISO/IEC 17025:2017

Certificate Number

TC-7470

Page No

1 of 10

Validity

08/09/2020 to 07/09/2022

Last Amended on

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S.No	Discipline / Group	Materials or Products tested	Component, parameter or characteristic tested / Specific Test Performed / Tests or type of tests performed	Test Method Specification against which tests are performed and / or the techniques / equipment used
Permanent Facility				
1	CHEMICAL-ATMOSPHERIC POLLUTION	Ambient Air	NOX	IS 5182 (Part - 6) : 2006
2	CHEMICAL-ATMOSPHERIC POLLUTION	Ambient Air	PM2.5	USEPA Quality Assurance Guidance Document Volume-II (Part- II) - 2.12
3	CHEMICAL-ATMOSPHERIC POLLUTION	Ambient Air	RPM(PM10)	IS 5182 (Part -23):2006
4	CHEMICAL-ATMOSPHERIC POLLUTION	Ambient Air	SO2	IS 5182 (Part-2) : 2001, (RA 2012)
5	CHEMICAL-ATMOSPHERIC POLLUTION	Ambient Noise Level	Noise Level (Leq)	CMPDI/RN/LSOP 06: July-2015
6	CHEMICAL-ATMOSPHERIC POLLUTION	Metal in Particulate Matter	As	USEPA IO-3.2
7	CHEMICAL-ATMOSPHERIC POLLUTION	Metal in Particulate Matter	Cd	USEPA IO-3.2
8	CHEMICAL-ATMOSPHERIC POLLUTION	Metal in Particulate Matter	Cr	USEPA IO-3.2
9	CHEMICAL-ATMOSPHERIC POLLUTION	Metal in Particulate Matter	Cu	USEPA IO-3.2



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Accreditation Standard

ISO/IEC 17025:2017

Certificate Number

TC-7470

Page No

2 of 10

Validity

08/09/2020 to 07/09/2022

Last Amended on

-

S.No	Discipline / Group	Materials or Products tested	Component, parameter or characteristic tested / Specific Test Performed / Tests or type of tests performed	Test Method Specification against which tests are performed and / or the techniques / equipment used
10	CHEMICAL-ATMOSPHERIC POLLUTION	Metal in Particulate Matter	Ni	USEPA IO-3.2
11	CHEMICAL-ATMOSPHERIC POLLUTION	Metal in Particulate Matter	Pb	USEPA IO-3.2
12	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Fluoride	APHA(23rd Edition), SPANDS Method
13	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Ammonical Nitrogen / Free Ammonia	IS 3025(Part 34):1988, (RA : 2009), Nessler's Method
14	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	B.O.D (3 days 27oC)	IS 3025 (Part 44): 1993, (RA2003) 3 day incubation at 27°C
15	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Cadmium	APHA (23rd Edition) Yr.: 2017 [Method: 3120 B (ICP Method)] & AAS-GTA Method
16	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	COD	APHA(23rd Edition), Closed Reflux, Titrimetric Method
17	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Colour	APHA(23rd Edition)
18	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Dissolved Phosphate, as PO ₄ -3	APHA(23rd Edition), Molybdovanadate Method
19	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Hexavalent Chromium	APHA(23rd Edition), 1,5-Diphenylcarbohydrazide Method



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GONDWANA PLACE, KANKE ROAD, RANCHI, JHARKHAND, INDIA

Accreditation Standard

ISO/IEC 17025:2017

Certificate Number

TC-7470

Page No

3 of 10

Validity

08/09/2020 to 07/09/2022

Last Amended on

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S.No	Discipline / Group	Materials or Products tested	Component, parameter or characteristic tested / Specific Test Performed / Tests or type of tests performed	Test Method Specification against which tests are performed and / or the techniques / equipment used
20	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Lead	APHA (23rd Edition) Yr.: 2017 [Method: 3120 B (ICP Method)] & AAS-GTA Method
21	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Nitrate Nitrogen	APHA(23rd Edition), UV-Spectrophotometric Method
22	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Odour	IS 3025 (Part 5):1983
23	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Oil & Grease	IS 3025(Part 39):1991, (RA 2003), Partition Gravimetric Method
24	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	pH value	IS 3025(Part11):1983, (RA 1996), Electrometric Method
25	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Phenolic Compounds	APHA(23rd Edition), 4-Amino antipyrine Method
26	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Sulphide	APHA(23 rd Edition), Methylene Blue Method
27	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Temperature	IS 3025 (Part 9):1984, (RA 2002), Thermometric
28	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Total Dissolved Solids	IS 3025 (Part 16):1984
29	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Total Kjeldahl Nitrogen	APHA(23rd Edition), Kjeldahl Method
30	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Total Residual Chlorine	APHA(23rd Edition), DPD Method



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GONDWANA PLACE, KANKE ROAD, RANCHI, JHARKHAND, INDIA

Accreditation Standard

ISO/IEC 17025:2017

Certificate Number

TC-7470

Page No

4 of 10

Validity

08/09/2020 to 07/09/2022

Last Amended on

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S.No	Discipline / Group	Materials or Products tested	Component, parameter or characteristic tested / Specific Test Performed / Tests or type of tests performed	Test Method Specification against which tests are performed and / or the techniques / equipment used
31	CHEMICAL- POLLUTION & ENVIRONMENT	Effluent	Total Suspended Solids	IS 3025 (Part 17):1984, (RA 1996), Gravimetric Method
32	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Arsenic	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
33	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Arsenic	IS 3025(Part 37):1988 (RA 2003) AAS-VGA Method
34	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Boron	APHA (23rd Edition) Carmine Method
35	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Boron	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
36	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Cadmium	APHA (23rd Edition) AAS-GTA Method
37	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Cadmium	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
38	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Copper	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
39	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Copper	IS 3025 (Part 42) 1992 (RA 2009), AAS-Flame:
40	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Iron	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
41	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Iron	IS 3025 (Part 53) : 2003, (RA 2009) , AAS-Flame Method



National Accreditation Board for Testing and Calibration Laboratories

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ENVIRONMENT LABORATORY, CENTRAL MINE PLANNING AND DESIGN INSTITUTE LIMITED,
GONDWANA PLACE, KANKE ROAD, RANCHI, JHARKHAND, INDIA

Accreditation Standard

ISO/IEC 17025:2017

Certificate Number

TC-7470

Page No

5 of 10

Validity

08/09/2020 to 07/09/2022

Last Amended on

-

S.No	Discipline / Group	Materials or Products tested	Component, parameter or characteristic tested / Specific Test Performed / Tests or type of tests performed	Test Method Specification against which tests are performed and / or the techniques / equipment used
42	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Lead	APHA (23rd Edition) AAS-GTA Method
43	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Lead	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
44	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Manganese	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
45	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Manganese	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
46	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Nickel	IS 3025 (Part 54) : 2003, AAS-Flame Method
47	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Nickel	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
48	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Selenium	IS 3025(Part 56):2003, AAS-VGA Method
49	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Selenium	APHA (23rd Edition) Yr.: [Method: 3120 B (ICP Method)]
50	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Zinc	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
51	CHEMICAL- POLLUTION & ENVIRONMENT	Trace Metal Elements	Zinc	IS 3025 (Part 49) : 1994, (RA 2009), AAS-Flame Method
52	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Arsenic	IS 3025(Part 37):1988 (RA 2003) AAS-VGA Method



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53	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Arsenic	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
54	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Boron	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
55	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Boron	APHA (23rd Edition) Carmine Method
56	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Cadmium	APHA (23rd Edition) AAS-GTA Method
57	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Cadmium	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
58	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Copper	IS 3025 (Part 42) : 1992 (RA 2009), AAS-Flame
59	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Copper	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
60	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Iron	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
61	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Iron	IS 3025 (Part 53) : 2003, (RA 2009) , AAS-Flame Method
62	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Lead	APHA (23rd Edition) AAS-GTA Method



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TC-7470

Page No

7 of 10

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Last Amended on

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63	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Lead	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
64	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Manganese	IS 3025 (Part 59) AAS-Flame Method
65	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Manganese	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
66	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Nickel	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
67	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Nickel	IS 3025 (Part 54) : 2003, AAS-Flame Method
68	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Selenium	APHA (23rd Edition) Yr.: [Method: 3120 B (ICP Method)]
69	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Selenium	IS 3025(Part 56):2003, AAS-VGA Method
70	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Total Chromium	IS 3025 (Part 52) : 2003 AAS-Flame
71	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Total Chromium	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
72	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Total Hexavalent Chromium	APHA(23rd Edition), 1,5-Diphenylcarbohydrazide Method



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73	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Zinc	APHA (23rd Edition) [Method: 3120 B (ICP Method)]
74	CHEMICAL- RESIDUES IN WATER	Ground water/Drinking water/Surface water	Zinc	IS 3025 (Part 49) : 1994, (RA 2009), AAS-Flame Method
75	CHEMICAL- WATER	Drinking Water	Alkalinity	IS 3025(Part 23):1986, (RA 2009) Titration Method
76	CHEMICAL- WATER	Drinking Water	Calcium	IS 3025 (Part 40): 1991, (RA 2009) EDTA Method
77	CHEMICAL- WATER	Drinking Water	Chlorides	IS 3025(Part 32):1988 , (RA 2007), Argentometric Method
78	CHEMICAL- WATER	Drinking Water	Colour	APHA(23rd Edition), Platinum Cobalt Method
79	CHEMICAL- WATER	Drinking Water	Fluoride	APHA(23rd Edition), SPANDS Methodmg/L
80	CHEMICAL- WATER	Drinking Water	Magnesium	IS 3025 (Part 46):1994 &APHA (23rd Ed.) 3500 B, Calculation Method
81	CHEMICAL- WATER	Drinking Water	Nitrate	APHA(23rd Edition), UV-Spectrophotometric Method
82	CHEMICAL- WATER	Drinking Water	Odour	IS 3025 (Part 5):1983, R : 2012 ,
83	CHEMICAL- WATER	Drinking Water	pH value	IS 3025 (Part 11):1983, (RA 1996), Electrometric Method



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ISO/IEC 17025:2017

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TC-7470

Page No

9 of 10

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S.No	Discipline / Group	Materials or Products tested	Component, parameter or characteristic tested / Specific Test Performed / Tests or type of tests performed	Test Method Specification against which tests are performed and / or the techniques / equipment used
84	CHEMICAL- WATER	Drinking Water	Phenolic	APHA(23rd Edition), 4-Amino antipyrine Method
85	CHEMICAL- WATER	Drinking Water	Sulphate	APHA(23rd Edition), Turbidity Method
86	CHEMICAL- WATER	Drinking Water	Total Dissolved Solids	IS 3025 (Part 16):1984 (RA2006), Gravimetric Method
87	CHEMICAL- WATER	Drinking Water	Total Free Residual Chlorine	APHA(23rd Edition), DPD Method
88	CHEMICAL- WATER	Drinking Water	Total Hardness (cacO ₃)	IS 3025 (Part 21):2009, EDTA Method
89	CHEMICAL- WATER	Drinking Water	Turbidity	IS 3025 (Part 10):1984, (RA 1996) Nephelometric Method
90	CHEMICAL- WATER	surface water	Fluoride	APHA(23rd Edition), SPANDS Method
91	CHEMICAL- WATER	surface water	Nitrate	APHA(23rd Edition), UV-Spectrophotometric Method
92	CHEMICAL- WATER	surface water	pH value	IS 3025 (Part 11):1983, (RA 1996), Electrometric Method
93	CHEMICAL- WATER	Surface Water	BOD (3 days 27°C)	IS 3025 (Part 44): 1993, (RA 2003) 3 day incubation at 27°C
94	CHEMICAL- WATER	surface water	Chlorides	IS 3025(Part 32):1988 , (RA 2007), Argentometric Method



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95	CHEMICAL- WATER	Surface water	Colour	APHA(23rd Edition), Platinum Cobalt Method
96	CHEMICAL- WATER	surface water	Dissolved Oxygen	IS 3025 (Part 38):1989, (RA2003), Winkler Azide Method
97	CHEMICAL- WATER	surface water	Phenolic	APHA(23rd Edition), 4-Amino antipyrine Method
98	CHEMICAL- WATER	surface water	Sulphate	APHA(23rd Edition), Turbidity Method
99	CHEMICAL- WATER	surface water	Total Dissolved Solids	IS 3025 (Part 16):1984 (RA2006), Gravimetric Method
100	CHEMICAL- WATER	surface water	Total Suspended Solids	IS 3025 (Part 17):1984, (RA1996) , Gravimetric Method



Quality Council of India

National Accreditation Board for
Education & Training



Certificate of Accreditation

Central Mine Planning and Design Institute Limited

Gondwana Place, Kanke Road, Ranchi-834008, Jharkhand

Accredited as Category - A organization under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations: Version 3 for preparing EIA-EMP reports in the following Sectors:

Sl.No	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1	Mining of minerals including opencast / underground mining	1	1 (a) (i)	A
2	Offshore and onshore oil and gas exploration, development & production	2	1 (b)	A
3	Thermal power plants	4	1 (d)	A
4	Coal Washeries	6	2 (a)	A

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in SA AC minutes dated Feb. 14, 2020 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/20/1431 dated August 14, 2020. The accreditation needs to be renewed before the expiry date by Central Mine Planning and Design Institute Limited, Ranchi following due process of assessment.



Sr. Director, NABET
Dated: Aug. 14, 2020

Certificate No.
NABET/EIA/1720/ SA 0108

Valid up to
22.08.2021

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET website.



REGISTERED OFFICE

Gondwana Place, Kanke Road
Ranchi -834 031
(Jharkhand)

REGIONAL INSTITUTES

क्षेत्रीय संस्थान-I

वेस्ट एंड, जी.टी.रोड
आसनसोल-713 301
(पश्चिम बंगाल)

क्षेत्रीय संस्थान-II

कोयला भवन, कोयला नगर
धनबाद- 826 005
(झारखंड)

क्षेत्रीय संस्थान-III

गोंदवाना प्लेस,कांके रोड
राँची- 834 031
(झारखंड)

क्षेत्रीय संस्थान-IV

जरीपटका, कस्तूरबा नगर
नागपुर-440 014
(महाराष्ट्र)

क्षेत्रीय संस्थान-V

सीपत रोड
बिलासपुर-495 001
(छत्तीसगढ़)

क्षेत्रीय संस्थान-VI

पोस्ट :जयंत कॉलरी,
जिला : सिंगरौली
पिन नं०- 486 890
(मध्य प्रदेश)

क्षेत्रीय संस्थान-VII

गृह निर्माण भवन
सचिवालय मार्ग
भुवनेश्वर-751001
(उड़ीसा)

Regional Institute - I

West End, G.T Road
Asansol - 713 301
(West Bengal)

Regional Institute - II

Koyla Bhawan, Koyla Nagar
Dhanbad - 826 005
(Jharkhand)

Regional Institute - III

Gondwana Place, Kanke Road
Ranchi- 834 031
(Jharkhand)

Regional Institute - IV

Jaripathka, Kasturba Nagar
Nagpur - 440 014
(Maharashtra)

Regional Institute - V

Seepat Road
Bilaspur - 495 001
(Chattisgarh)

Regional Institute - VI

P.O Jayant Colliery
Dist. - Singrauli
PIN - 486 890
Madhya Pradesh

Regional Institute - VII

Grih Nirman Bhawan
Sachivalaya Marg
Bhubneswar - 751 001
(Orissa)

सेन्ट्रल माईन प्लानिंग एंड डिजाइन इन्स्टीच्यूट लिमिटेड

(कोल इंडिया की अनुषंगी कम्पनी)
एक मिनी रत्न कम्पनी

Central Mine Planning & Design Institute Limited

(A Subsidiary of Coal India Limited)

A Mini Ratna Company

गोंदवाना प्लेस, कांके रोड, राँची - 834 031, भारत

दूरभाष : (91-0651) 2230002, 2230483

फैक्स : (91-0651) 2231447

वेबसाईट : www.cmpdi.co.in



Gondwana Place, Kanke Road, Ranchi - 834 031, INDIA

Phone : (91 - 0651) 2230002, 2230483

Fax : (91 - 0651) 2231447

website : www.cmpdi.co.in

REGISTERED OFFICE

Gondwana Place, Kanke Road
Ranchi -834 031
(Jharkhand)

REGIONAL INSTITUTES

क्षेत्रीय संस्थान-I

वेस्ट एंड, जी.टी.रोड
आसनसोल-713 301
(पश्चिम बंगाल)

क्षेत्रीय संस्थान-II

कोयला भवन, कोयला नगर
धनबाद- 826 005
(झारखंड)

क्षेत्रीय संस्थान-III

गोंदवाना प्लेस,कांके रोड
राँची- 834 031
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नागपुर-440 014
(महाराष्ट्र)

क्षेत्रीय संस्थान-V

सीपत रोड
बिलासपुर-495 001
(छत्तीसगढ़)

क्षेत्रीय संस्थान-VI

पोस्ट :जयंत कॉलरी,
जिला : सिंगरौली
पिन नं०- 486 890
(मध्य प्रदेश)

क्षेत्रीय संस्थान-VII

गृह निर्माण भवन
सचिवालय मार्ग
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(Jharkhand)

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Jaripathka, Kasturba Nagar
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Central Mine Planning & Design Institute Limited

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A Mini Ratna Company

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ANNEXURE- XV



BHARAT COKING COAL LIMITED
(A Subsidiary of Coal India Limited – A Maharatna Company)

CORPORATE ENVIRONMENTAL POLICY

Bharat Coking Coal Limited (BCCL), a subsidiary of Coal India Limited, is a Public Sector Undertaking engaged in mining of coal and allied activities. It is the only producer of Prime Coking Coal in India. BCCL was incorporated in 1972 to operate coking coal mines operating in the Jharia and Raniganj Coalfields. Currently, the Company operates 66 coal mines and 8 Coal Washeries.

Our mission is to produce the planned quantity of coal efficiently and economically with due regard to safety, conservation and quality. BCCL affirms its commitment for environment friendly mining with right mitigation of pollution, reclamation of the degraded land, preservation of biodiversity and proper disposal of waste following the best environmental practices including judicious use of the non-renewable energy on the path of continual improvement. Towards this commitment, BCCL shall endeavor to:

- ❖ Conduct mining and associated operations in an environmentally responsible manner to comply with applicable laws and other requirements related to environmental aspects.
- ❖ Design projects with due consideration of Sustainable Development by integrating sound environmental management practices in all our activities.
- ❖ Prevent pollution of surrounding habitation by continuous monitoring and adopting suitable measures for environment protection.
- ❖ Ensure compliance of all applicable Environmental and Forest Clearance conditions and other statutory conditions issued by regulatory agencies.
- ❖ Implement the Environmental Management Plans in all our mines effectively to mitigate pollutions on air, water and noise; proper disposal of wastes and reclamation and ecological restoration of degraded land; and by also dovetailing the Jharia action/ Master Plan for dealing with Fires, Subsidence and Rehabilitation of affected people with the Environmental Management Plans under the Cluster Concept.
- ❖ Strive to conserve Bio-Diversity through Ecological restoration methods.
- ❖ Conserve natural resources through recycling of wastes on the principle of Reduce, Recycle and Reuse. Put special thrusts on efficient energy utilization as a measure to reduce carbon foot-print.
- ❖ Strive for continual improvement in our environmental performances by setting targets, measuring progress and taking corrective action.
- ❖ Create environmental awareness among the employees and the local communities through pro-active communication and training and encourage our business associates to adopt similar approach for environmental protection.

Place: Dhanbad
Date: 25.5.12


Chairman-cum-Managing Director

Chairman-cum-Mg. Director
BHARAT COKING COAL LIMITED
Keya Bhawan, Dhanbad - 826 005

STRICTLY RESTRICTED
FOR COMPANY USE ONLY RESTRICTED

The information given in this report is not to be communicated either directly or indirectly to the press or to any person not holding an official position in the CIL /GOVERNMENT.

**ENVIRONMENTAL MONITORING REPORT
OF
BHARAT COKING COAL LIMITED,
CLUSTER –XI
(FOR THE MONTH APRIL, 2021)**

E. C. no. J-11015/77/2011-IA.II (M) dated 26.07.2019-

CMPDI

ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

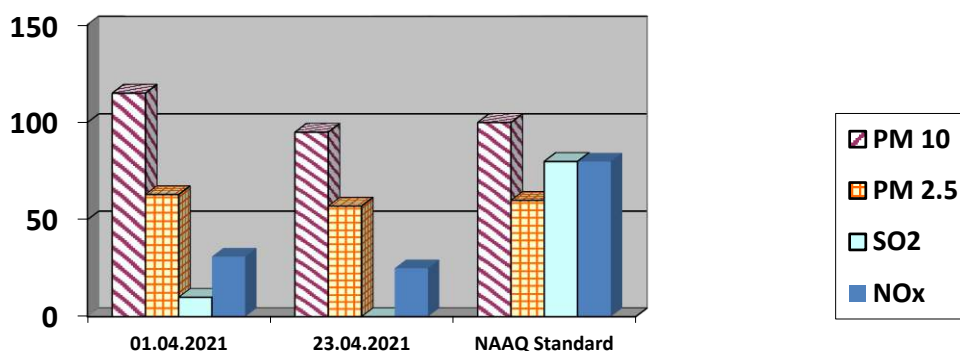
AMBIENT AIR QUALITY DATA

Cluster –XI, Bharat Coking Coal limited

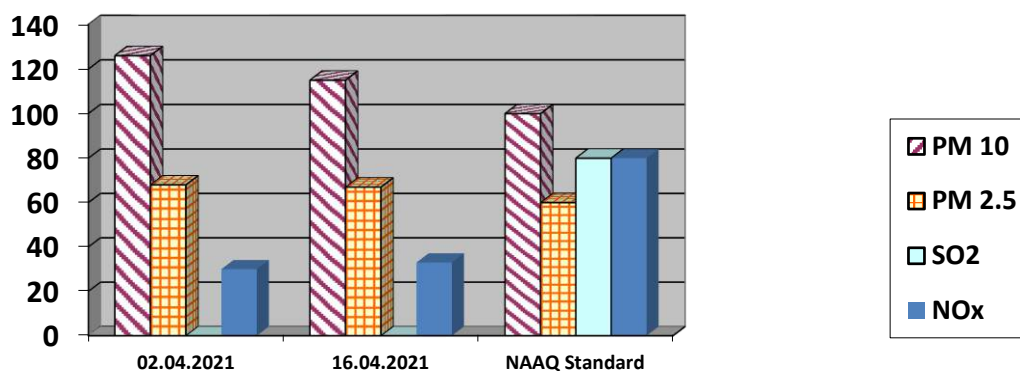
Month: APRIL 2021

Year: 2021-22.

StationNameA16-Pootkee Balihari office		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	01.04.2021	115	63	10	31
2	23.04.2021	95	57	<10	25
	NAAQ Standard	100	60	80	80



Station Name: A17- Moonidih UGP		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	02.04.2021	126	68	<10	30
2	16.04.2021	115	67	<10	33
	NAAQ Standard	100	60	80	80

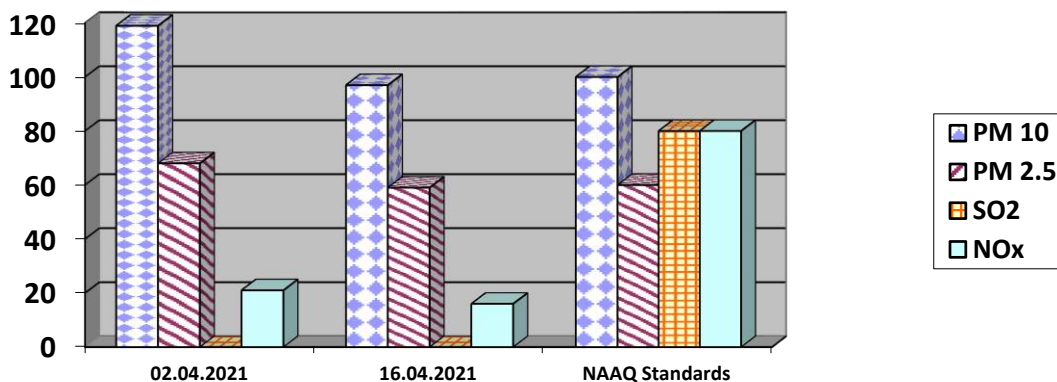


Analysed By
 JSA/SA/SSA

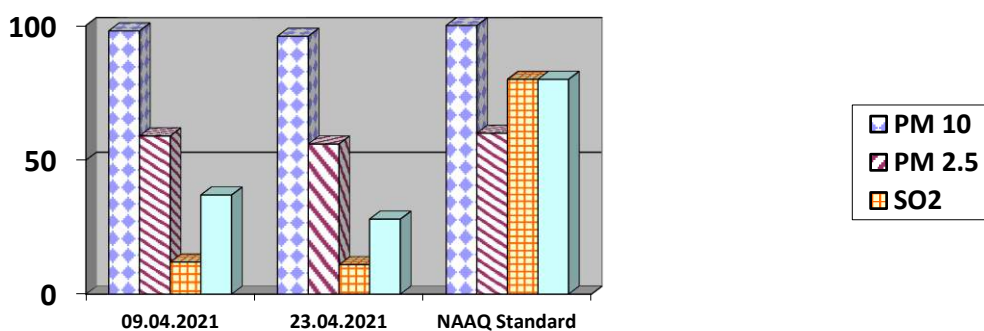
Checked By
 Lab In Charge
 RI-2, CMPDI, Dhanbad

Approved By
 HOD(In-charge) Environment
 RI-2, CMPDI, Dhanbad

Station Name: A29-Moonidih Washery		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	02.04.2021	119	68	<10	21
2	16.04.2021	97	59	<10	16
	NAAQ Standards	100	60	80	80



StationName: Kusunda OCP (A10)		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	09.04.2021	98	59	12	37
2	23.04.2021	96	56	11	28
	NAAQ Standard	100	60	80	80



- All values are expressed in microgram per cubic meter.
➤ 24 hours duration

अमान खन्ना रावत

Analysed By
JSA/SA/SSA

Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

Approved By
HOD(In-charge) Environment
RI-2, CMPDI, Dhanbad

WATER QUALITY MONITORING

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) **Mine Discharge of Bhagabandh (MW11)**

A sampling point is fixed to assess the effluent quality of Mine discharge. This location is selected to monitor effluent discharge in to Kari jore.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analyzed for four parameters on fortnightly basis at the Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.3 Results & Interpretations

The results are given in tabular form along with the applicable standards. Results are compared with Schedule - VI, effluent prescribed by MoEF&CC. Results show that most of the parameters are within the permissible limits.

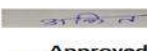
WATER QUALITY DATA (EFFLUENT WATER- FOUR PARAMETERS)

Name of the Cluster: Cluster-XI		Month: APRIL,2021	Name of the Station: Mine Discharge of Bhagabandh	
Sl. No.	Parameters	MW11 First Fortnight 05.04.2021	MW11 Second Fortnight 19.04.2021	As per MOEF General Standards for schedule VI
1	Total Suspended Solids	35	37	100 (Max)
2	pH	8.11	8.05	5.5 - 9.0
3	Oil & Grease	<2.0	<2.0	10 (Max)
4	COD	20	16	250 (Max)

All values are expressed in mg/lit except pH.


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 RI-2, CMPDI, Dhanbad


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 HOD(In-charge) Environment
 RI-2, CMPDI, Dhanbad

NOISE LEVEL QUALITY MONITORING

4.1 Location of sampling sites

1. Pootkee Balihari Office (N16)
2. Moonidih UGP (N17)
3. Moonidih Washery (N29)
4. Kusunda OCP (N10)

Methodology of sampling and analysis

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter (NL-52 OF RION CO. Ltd. Make) during day time. Noise levels were measured for about one hour time in day time. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB (A).

4.2 Results & Interpretations

Ambient noise levels were recorded during day time and the observed values were compared with standards prescribed by MoEF&CC. The results of Noise levels recorded during day time on fortnightly basis are presented in tabular form along with the applicable standard permissible limits. The observed values in terms of L_{EQ} are presented. The observed values at all the monitoring locations are found to be within permissible limits.

NOISE LEVEL DATA

Name of the Project: Cluster -XI			Month: APRIL 2021		
Sl. No.	Station Name/Code	Category of area	Date	Noise level dB(A)LEQ	*Permissible Limit of Noise level in dB(A)
1	Pootkee Balihari Office (N16)	Industrial area	01.04.2021	60.3	75
2	Pootkee Balihari Office (N16)	Industrial area	23.04.2021	59.7	75
3	Moonidih UGP (N17)	Industrial area	02.04.2021	61.3	75
4	Moonidih UGP (N17)	Industrial area	16.04.2021	59.6	75
5	Moonidih Washery (N29)	Industrial area	02.04.2021	57.6	75
6	Moonidih Washery (N29)	Industrial area	16.04.2021	58.4	75
7	Kusunda OCP (N10)	Industrial area	09.04.2021	64.7	75
8	Kusunda OCP (N10)	Industrial area	23.04.2021	63.3	75

*Permissible limits of Noise Level as per MOEF Gazette Notification No. GSR 742(E) dt. 25.09.2000 Standards for Coal Mines and Noise Pollution (Regulation and Control) Rules, 2000.

* Day Time: 6.00 AM to 10.00 PM.


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**ENVIRONMENTAL MONITORING REPORT
OF
BHARAT COKING COAL LIMITED,
CLUSTER –XI
(FOR THE MONTH MAY, 2021)**

E. C. no. J-11015/77/2011-IA.II (M) dated 26.07.2019-

CMPDI

ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

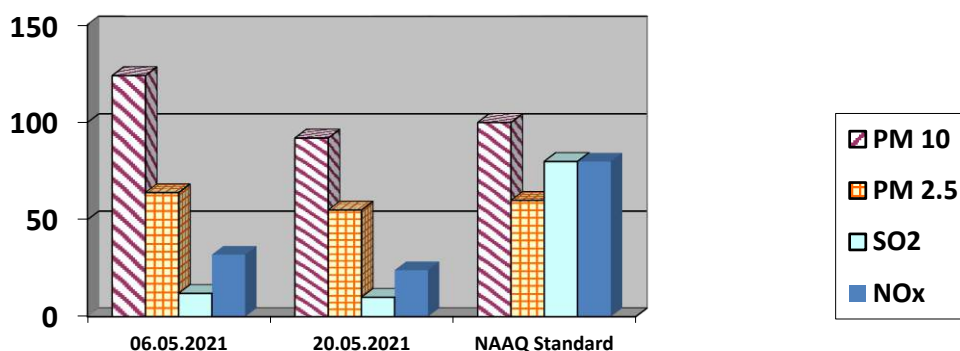
AMBIENT AIR QUALITY DATA

Cluster –XI, Bharat Coking Coal limited

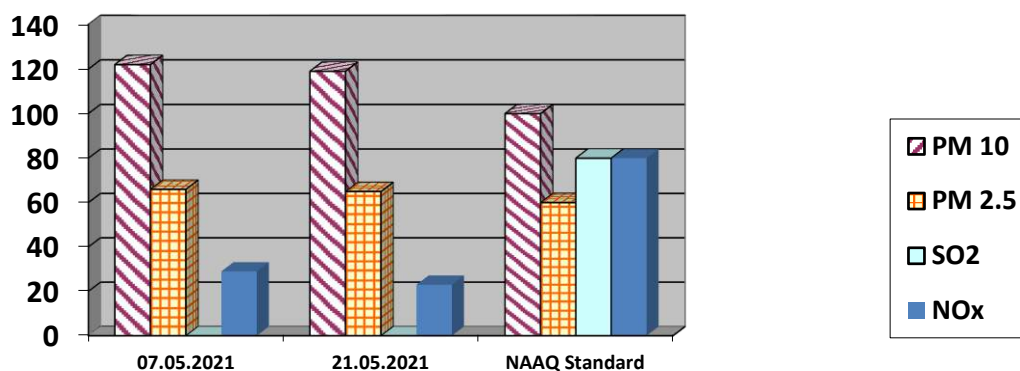
Month: MAY 2021

Year: 2021-22.

StationNameA16-Pootkee Balihari office		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	06.05.2021	124	64	12	32
2	20.05.2021	92	55	10	24
	NAAQ Standard	100	60	80	80



Station Name: A17- Moonidih UGP		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	07.05.2021	122	66	<10	29
2	21.05.2021	119	65	<10	23
	NAAQ Standard	100	60	80	80

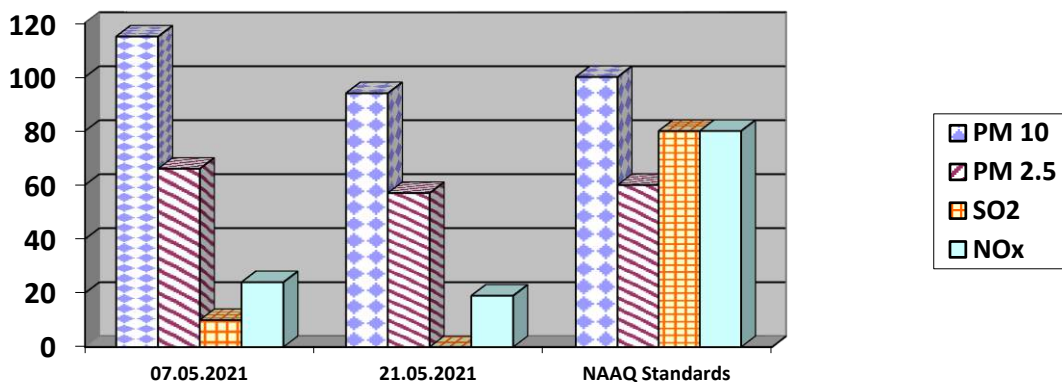


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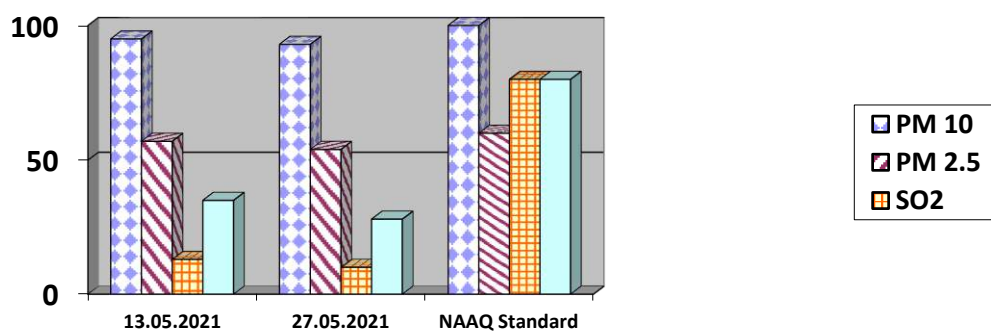
Checked By
 Lab In Charge
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Station Name: A29-Moonidih Washery		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	07.05.2021	115	66	10	24
2	21.05.2021	94	57	<10	19
	NAAQ Standards	100	60	80	80



StationName: Kusunda OCP (A10)		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	13.05.2021	95	57	13	35
2	27.05.2021	93	54	10	28
	NAAQ Standard	100	60	80	80



- All values are expressed in microgram per cubic meter.
➤ 24 hours duration

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HOD(In-charge) Environment
RI-2, CMPDI, Dhanbad

WATER QUALITY MONITORING

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) **Mine Discharge of Bhagabandh (MW11)**

A sampling point is fixed to assess the effluent quality of Mine discharge. This location is selected to monitor effluent discharge in to Kari jore.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analyzed for four parameters on fortnightly basis at the Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.3 Results & Interpretations

The results are given in tabular form along with the applicable standards. Results are compared with Schedule - VI, effluent prescribed by MoEF&CC. Results show that most of the parameters are within the permissible limits.

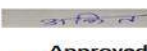
WATER QUALITY DATA (EFFLUENT WATER- FOUR PARAMETERS)

Name of the Cluster: Cluster-XI		Month: MAY,2021	Name of the Station: Mine Discharge of Bhagabandh	
Sl. No.	Parameters	MW11 First Fortnight 03.05.2021	MW11 Second Fortnight 31.05.2021	As per MOEF General Standards for schedule VI
1	Total Suspended Solids	58	44	100 (Max)
2	pH	7.84	7.96	5.5 - 9.0
3	Oil & Grease	<2.0	<2.0	10 (Max)
4	COD	24	20	250 (Max)

All values are expressed in mg/lit except pH.


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NOISE LEVEL QUALITY MONITORING

4.1 Location of sampling sites

1. Pootkee Balihari Office (N16)
2. Moonidih UGP (N17)
3. Moonidih Washery (N29)
4. Kusunda OCP (N10)

Methodology of sampling and analysis

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter (NL-52 OF RION CO. Ltd. Make) during day time. Noise levels were measured for about one hour time in day time. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB (A).

4.2 Results & Interpretations

Ambient noise levels were recorded during day time and the observed values were compared with standards prescribed by MoEF&CC. The results of Noise levels recorded during day time on fortnightly basis are presented in tabular form along with the applicable standard permissible limits. The observed values in terms of L_{EQ} are presented. The observed values at all the monitoring locations are found to be within permissible limits.

NOISE LEVEL DATA

Name of the Project: Cluster -XI			Month: MAY 2021		
Sl. No.	Station Name/Code	Category of area	Date	Noise level dB(A)LEQ	*Permissible Limit of Noise level in dB(A)
1	Pootkee Balihari Office (N16)	Industrial area	06.05.2021	57.1	75
2	Pootkee Balihari Office (N16)	Industrial area	20.05.2021	55.8	75
3	Moonidih UGP (N17)	Industrial area	07.05.2021	62.5	75
4	Moonidih UGP (N17)	Industrial area	21.05.2021	54.4	75
5	Moonidih Washery (N29)	Industrial area	07.05.2021	60.3	75
6	Moonidih Washery (N29)	Industrial area	21.05.2021	59.7	75
7	Kusunda OCP (N10)	Industrial area	13.05.2021	60.1	75
8	Kusunda OCP (N10)	Industrial area	27.05.2021	60.4	75

*Permissible limits of Noise Level as per MOEF Gazette Notification No. GSR 742(E) dt. 25.09.2000 Standards for Coal Mines and Noise Pollution (Regulation and Control) Rules, 2000.

* Day Time: 6.00 AM to 10.00 PM.


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**ENVIRONMENTAL MONITORING REPORT
OF
BHARAT COKING COAL LIMITED,
CLUSTER –XI
(FOR THE MONTH JUNE, 2021)**

E. C. no. J-11015/77/2011-IA.II (M) dated 26.07.2019-

CMPDI

ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

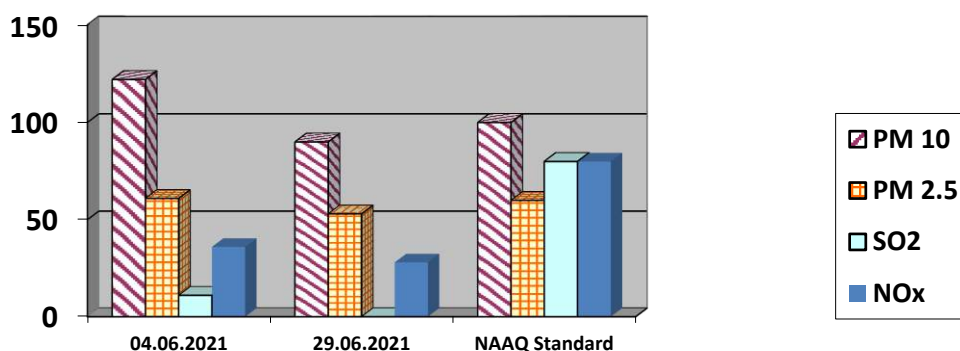
AMBIENT AIR QUALITY DATA

Cluster –XI, Bharat Coking Coal limited

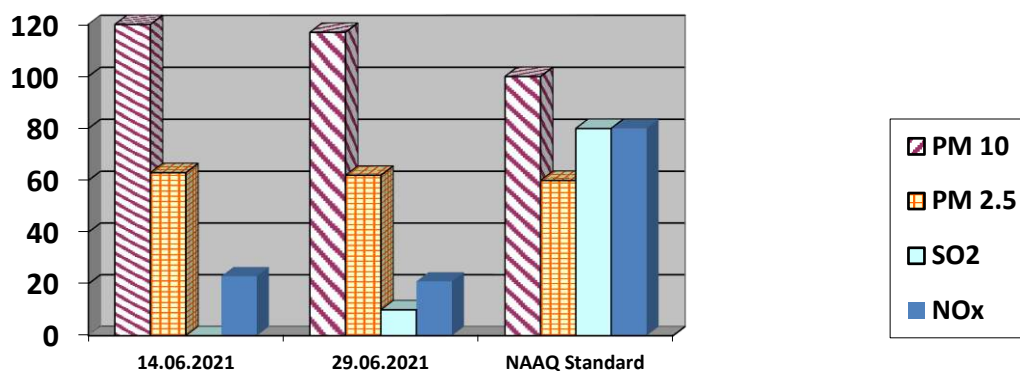
Month: JUNE 2021

Year: 2021-22.

StationNameA16-Pootkee Balihari office		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	04.06.2021	122	61	11	36
2	29.06.2021	90	53	<10	28
	NAAQ Standard	100	60	80	80



Station Name: A17- Moonidih UGP		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	14.06.2021	120	63	<10	23
2	29.06.2021	117	62	10	21
	NAAQ Standard	100	60	80	80

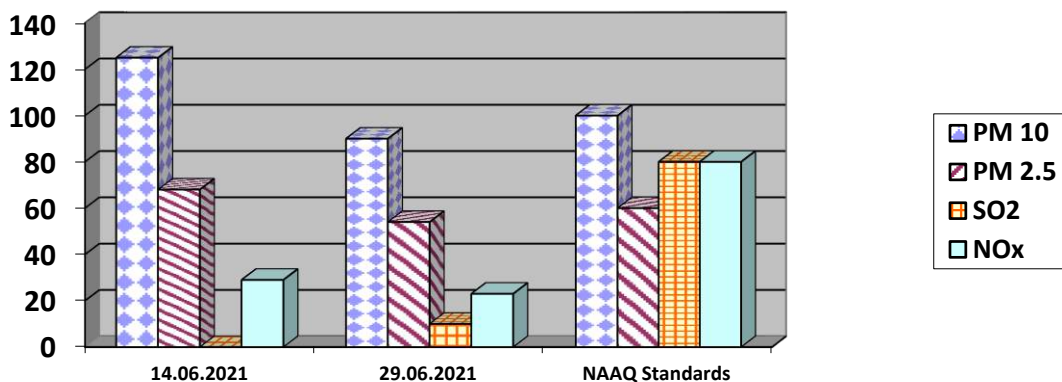


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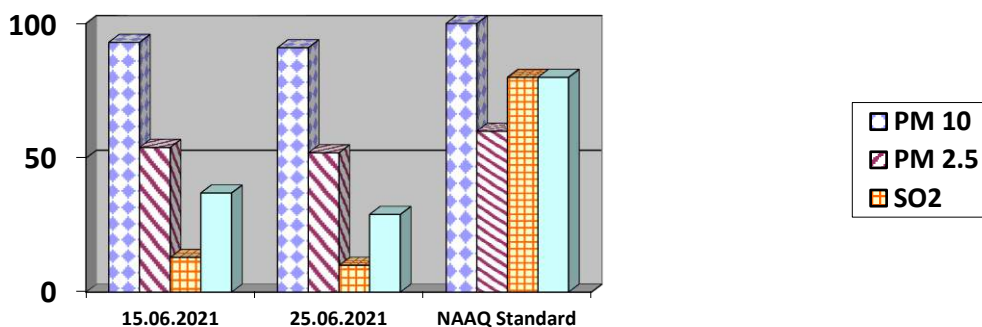
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Station Name: A29-Moonidih		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	14.06.2021	125	68	<10	29
2	29.06.2021	90	54	10	23
	NAAQ Standards	100	60	80	80



StationName: Kusunda OCP (A10)		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	15.06.2021	93	54	13	37
2	25.06.2021	91	52	10	29
	NAAQ Standard	100	60	80	80



- All values are expressed in microgram per cubic meter.
- 24 hours duration

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HOD(In-charge) Environment
RI-2, CMPDI, Dhanbad

WATER QUALITY MONITORING

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) **Mine Discharge of Bhagabandh (MW11)**

A sampling point is fixed to assess the effluent quality of Mine discharge. This location is selected to monitor effluent discharge in to Kari jore.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analyzed for four parameters on fortnightly basis at the Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.3 Results & Interpretations

The results are given in tabular form along with the applicable standards. Results are compared with Schedule - VI, effluent prescribed by MoEF&CC. Results show that most of the parameters are within the permissible limits.

WATER QUALITY DATA (EFFLUENT WATER- FOUR PARAMETERS)

Name of the Cluster: Cluster-XI		Month: JUNE,2021	Name of the Station: Mine Discharge of Bhagabandh	
Sl. No.	Parameters	MW11 First Fortnight 07.06.2021	MW11 Second Fortnight 28.06.2021	As per MOEF General Standards for schedule VI
1	Total Suspended Solids	42	37	100 (Max)
2	pH	7.81	7.99	5.5 - 9.0
3	Oil & Grease	<2.0	<2.0	10 (Max)
4	COD	28	24	250 (Max)

All values are expressed in mg/lit except pH.


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NOISE LEVEL QUALITY MONITORING

4.1 Location of sampling sites

1. Pootkee Balihari Office (N16)
2. Moonidih UGP (N17)
3. Moonidih Washery (N29)
4. Kusunda OCP (N10)

Methodology of sampling and analysis

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter (NL-52 OF RION CO. Ltd. Make) during day time. Noise levels were measured for about one hour time in day time. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB (A).

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Ambient noise levels were recorded during day time and the observed values were compared with standards prescribed by MoEF&CC. The results of Noise levels recorded during day time on fortnightly basis are presented in tabular form along with the applicable standard permissible limits. The observed values in terms of L_{EQ} are presented. The observed values at all the monitoring locations are found to be within permissible limits.

NOISE LEVEL DATA

Name of the Project: Cluster -XI			Month: JUNE 2021		
Sl. No.	Station Name/Code	Category of area	Date	Noise level dB(A)LEQ	*Permissible Limit of Noise level in dB(A)
1	Pootkee Balihari Office (N16)	Industrial area	04.06.2021	59.6	75
2	Pootkee Balihari Office (N16)	Industrial area	29.06.2021	58.5	75
3	Moonidih UGP (N17)	Industrial area	14.06.2021	62.6	75
4	Moonidih UGP (N17)	Industrial area	29.06.2021	63.1	75
5	Moonidih Washery (N29)	Industrial area	14.06.2021	56.2	75
6	Moonidih Washery (N29)	Industrial area	29.06.2021	55.3	75
7	Kusunda OCP (N10)	Industrial area	15.06.2021	63.6	75
8	Kusunda OCP (N10)	Industrial area	25.06.2021	60.7	75

*Permissible limits of Noise Level as per MOEF Gazette Notification No. GSR 742(E) dt. 25.09.2000 Standards for Coal Mines and Noise Pollution (Regulation and Control) Rules, 2000.

* Day Time: 6.00 AM to 10.00 PM.


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**ENVIRONMENTAL MONITORING REPORT
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(FOR THE MONTH JULY, 2020)**

E. C. no. J-11015/77/2011-IA.II (M) dated 26.07.2019-

CMPDI

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Dhanbad, Jharkhand

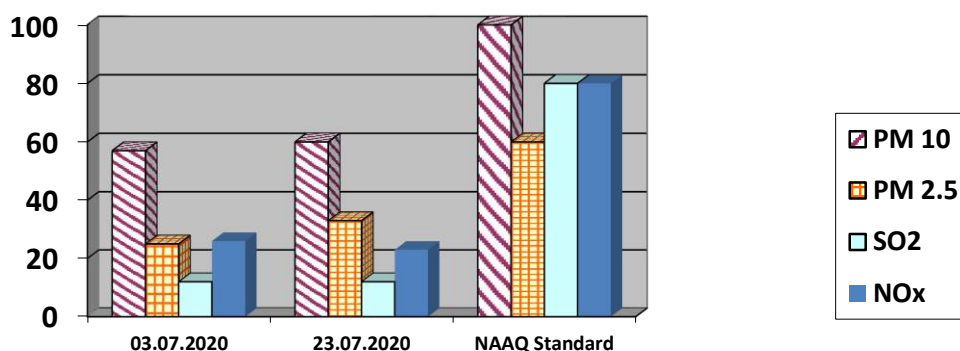
AMBIENT AIR QUALITY DATA

Cluster –XI, Bharat Coking Coal limited

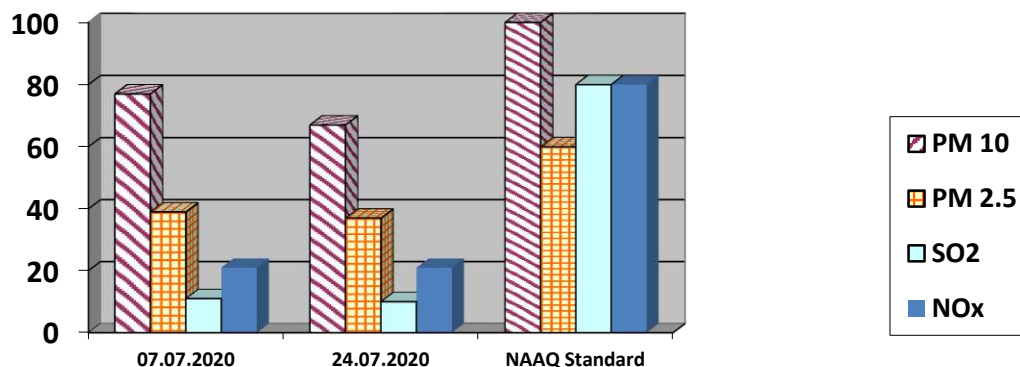
Month: JULY ,2020

Year: 2020-21.

StationNameA16-Pootkee Balihari office		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	03.07.2020	57	25	12	26
2	23.07.2020	60	33	12	23
	NAAQ Standard	100	60	80	80



Station Name: A17- Moonidih UGP		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	07.07.2020	77	39	11	21
2	24.07.2020	67	37	10	21
	NAAQ Standard	100	60	80	80

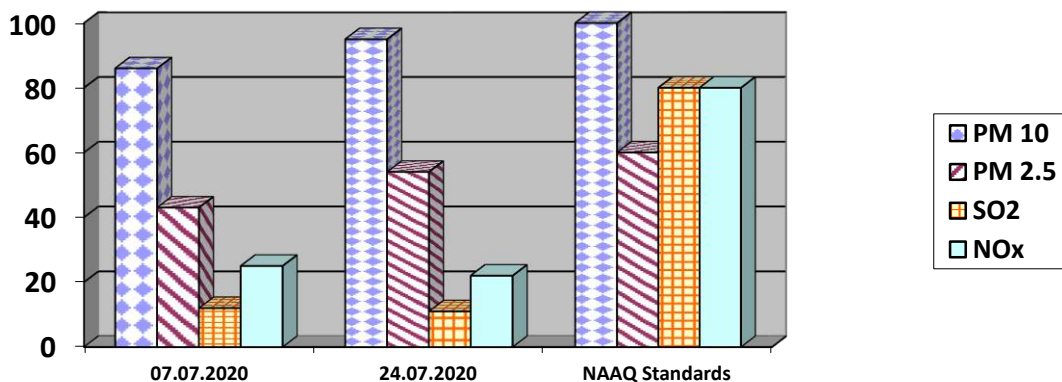


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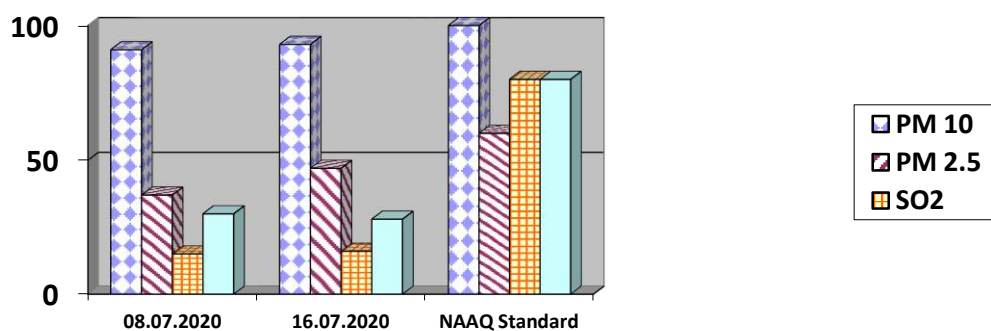
Checked By
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 HOD(In-charge) Environment
 RI-2, CMPDI, Dhanbad

Station Name: A29-Moonidih Washery		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	07.07.2020	86	43	12	25
2	24.07.2020	95	54	11	22
	NAAQ Standards	100	60	80	80



StationName: Kusunda OCP (A10)		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	08.07.2020	91	37	15	30
2	16.07.2020	93	47	16	28
	NAAQ Standard	100	60	80	80



- All values are expressed in microgram per cubic meter.
 ➤ 24 hours duration

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Analysed By
JSA/SA/SSA

Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

अतिरिक्त
Approved By
HOD(In-charge) Environment
RI-2, CMPDI, Dhanbad

WATER quality monitoring

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) **Mine Discharge of Bhagabandh (MW11)**

A sampling point is fixed to assess the effluent quality of Mine discharge. This location is selected to monitor effluent discharge in to Kari jore.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analyzed for four parameters on fortnightly basis at the Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.3 Results & Interpretations

The results are given in tabular form along with the applicable standards. Results are compared with Schedule - VI, effluent prescribed by MoEF&CC. Results show that most of the parameters are within the permissible limits.

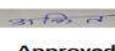
WATER QUALITY DATA (EFFLUENT WATER- FOUR PARAMETERS)

Name of the Cluster: Cluster-XI		Month: JULY, 2020	Name of the Station: Mine Discharge of Bhagabandh	
Sl. No.	Parameters	MW11 First Fortnight	MW11 Second Fortnight	As per MOEF General Standards for schedule VI
		06.07.2020	20.07.2020	
1	Total Suspended Solids	54	61	100 (Max)
2	pH	7.59	7.67	5.5 - 9.0
3	Oil & Grease	<2.0	<2.0	10 (Max)
4	COD	28	32	250 (Max)

All values are expressed in mg/lit except pH.


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 Lab In Charge
 RI-2, CMPDI, Dhanbad


 Approved By
 HOD(In-charge) Environment
 RI-2, CMPDI, Dhanbad

NOISE LEVEL QUALITY MONITORING

4.1 Location of sampling sites

1. Pootkee Balihari Office (N16)
2. Moonidih UGP (N17)
3. Moonidih Washery (N29)
4. Kusunda OCP (N10)

Methodology of sampling and analysis

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter (NL-52 OF RION CO. Ltd. Make) during day time. Noise levels were measured for about one hour time in day time. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB (A).

4.2 Results & Interpretations

Ambient noise levels were recorded during day time and the observed values were compared with standards prescribed by MoEF&CC. The results of Noise levels recorded during day time on fortnightly basis are presented in tabular form along with the applicable standard permissible limits. The observed values in terms of L_{EQ} are presented. The observed values at all the monitoring locations are found to be within permissible limits.

NOISE LEVEL DATA

Name of the Project: Cluster -XI			Month: JULY, 2020		
Sl. No.	Station Name/Code	Category of area	Date	Noise level dB(A)LEQ	*Permissible Limit of Noise level in dB(A)
1	Pootkee Balihari Office (N16)	Industrial area	03.07.2020	64.6	75
2	PootkeeBalihari Office (N16)	Industrial area	23.07.2020	62.3	75
3	MoonidihUGP (N17)	Industrial area	07.07.2020	63.2	75
4	MoonidihUGP (N17)	Industrial area	24.07.2020	60.1	75
5	Moonidih Washery (N29)	Industrial area	07.07.2020	62.3	75
6	Moonidih Washery (N29)	Industrial area	24.07.2020	59.5	75
7	KusundaOCP (N10)	Industrial area	08.07.2020	59.2	75
8	KusundaOCP (N10)	Industrial area	16.07.2020	60.3	75

*Permissible limits of Noise Level as per MOEF Gazette Notification No. GSR 742(E) dt. 25.09.2000 Standards for Coal Mines and Noise Pollution (Regulation and Control) Rules, 2000.

* Day Time: 6.00 AM to 10.00 PM.

अनुमान रंजन राय

Analysed By
JSA/SA/SSA



Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

अमित

Approved By
HOD(In-charge) Environment
RI-2, CMPDI, Dhanbad

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FOR COMPANY USE ONLY RESTRICTED

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**ENVIRONMENTAL MONITORING REPORT
OF
BHARAT COKING COAL LIMITED,
CLUSTER –XI
(FOR THE MONTH AUGUST, 2021)**

E. C. no. J-11015/77/2011-IA.II (M) dated 26.07.2019-

CMPDI

ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

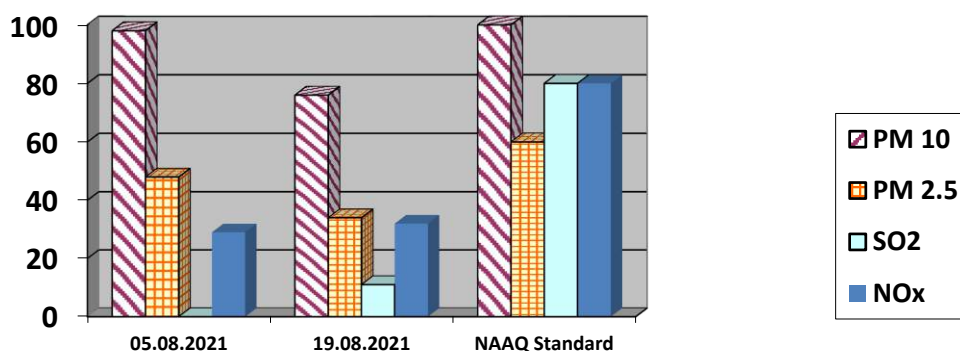
AMBIENT AIR QUALITY DATA

Cluster –XI, Bharat Coking Coal limited

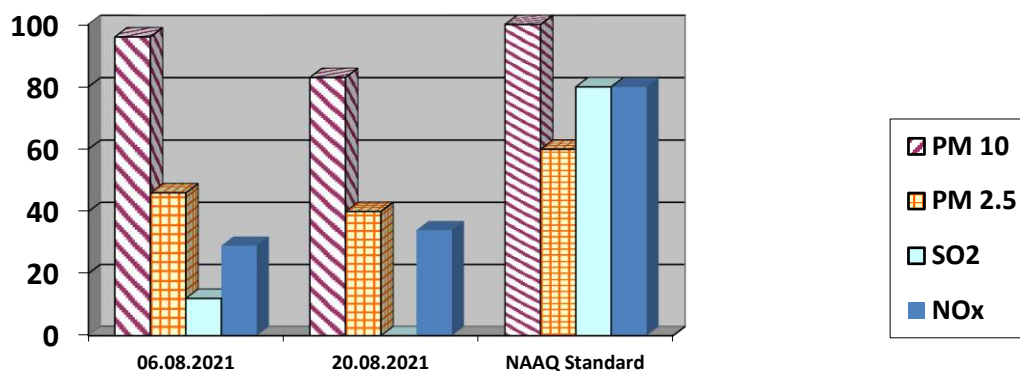
Month: AUGUST 2021

Year: 2021-22.

StationNameA16-Pootkee Balihari office		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	05.08.2021	98	48	<10	29
2	19.08.2021	76	34	11	32
	NAAQ Standard	100	60	80	80

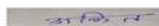


Station Name: A17- Moonidih UGP		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	06.08.2021	96	46	12	29
2	20.08.2021	83	40	<10	34
	NAAQ Standard	100	60	80	80

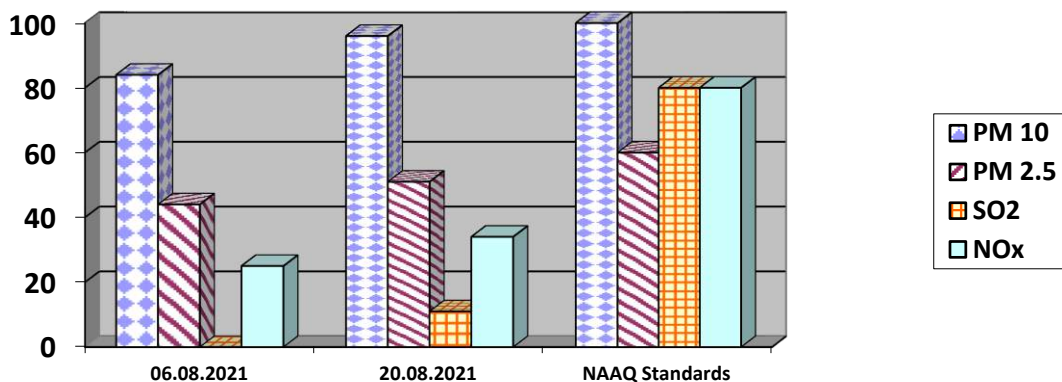



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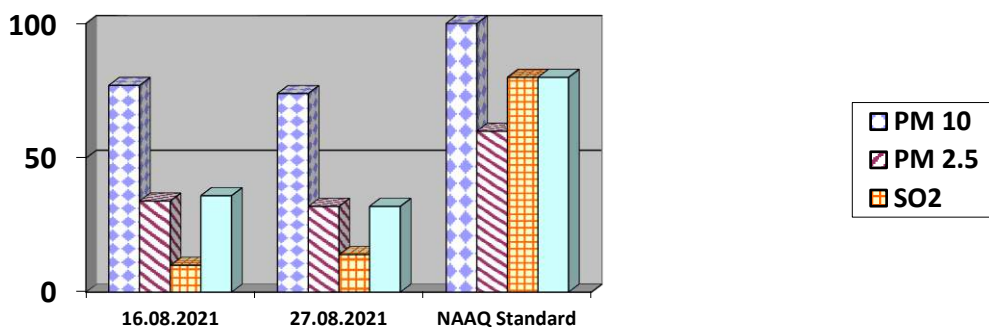

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Station Name: A29-Moonidih		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	06.08.2021	84	44	<10	25
2	20.08.2021	96	51	11	34
	NAAQ Standards	100	60	80	80



StationName: Kusunda OCP (A10)		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	16.08.2021	77	34	10	36
2	27.08.2021	74	32	14	32
	NAAQ Standard	100	60	80	80



- All values are expressed in microgram per cubic meter.
- 24 hours duration

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WATER QUALITY MONITORING

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) **Mine Discharge of Bhagabandh (MW11)**

A sampling point is fixed to assess the effluent quality of Mine discharge. This location is selected to monitor effluent discharge in to Kari jore.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analyzed for four parameters on fortnightly basis at the Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.3 Results & Interpretations

The results are given in tabular form along with the applicable standards. Results are compared with Schedule - VI, effluent prescribed by MoEF&CC. Results show that most of the parameters are within the permissible limits.

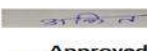
WATER QUALITY DATA (EFFLUENT WATER- FOUR PARAMETERS)

Name of the Cluster: Cluster-XI		Month: AUGUST,2021	Name of the Station: Mine Discharge of Bhagabandh	
Sl. No.	Parameters	MW11 First Fortnight 02.08.2021	MW11 Second Fortnight 30.08.2021	As per MOEF General Standards for schedule VI
1	Total Suspended Solids	39	45	100 (Max)
2	pH	8.29	8.12	5.5 - 9.0
3	Oil & Grease	<2.0	<2.0	10 (Max)
4	COD	16	16	250 (Max)

All values are expressed in mg/lit except pH.


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NOISE LEVEL QUALITY MONITORING

4.1 Location of sampling sites

1. Pootkee Balihari Office (N16)
2. Moonidih UGP (N17)
3. Moonidih Washery (N29)
4. Kusunda OCP (N10)

Methodology of sampling and analysis

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter (NL-52 OF RION CO. Ltd. Make) during day time. Noise levels were measured for about one hour time in day time. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB (A).

4.2 Results & Interpretations

Ambient noise levels were recorded during day time and the observed values were compared with standards prescribed by MoEF&CC. The results of Noise levels recorded during day time on fortnightly basis are presented in tabular form along with the applicable standard permissible limits. The observed values in terms of L_{EQ} are presented. The observed values at all the monitoring locations are found to be within permissible limits.

NOISE LEVEL DATA

Name of the Project: Cluster -XI			Month: AUGUST 2021		
Sl. No.	Station Name/Code	Category of area	Date	Noise level dB(A)LEQ	*Permissible Limit of Noise level in dB(A)
1	Pootkee Balihari Office (N16)	Industrial area	06.08.2021	64.5	75
2	Pootkee Balihari Office (N16)	Industrial area	19.08.2021	58.7	75
3	Moonidih UGP (N17)	Industrial area	06.08.2021	63.1	75
4	Moonidih UGP (N17)	Industrial area	19.08.2021	57.1	75
5	Moonidih Washery (N29)	Industrial area	06.08.2021	62.3	75
6	Moonidih Washery (N29)	Industrial area	20.08.2021	60.5	75
7	Kusunda OCP (N10)	Industrial area	16.08.2021	61.2	75
8	Kusunda OCP (N10)	Industrial area	27.08.2021	61.3	75

*Permissible limits of Noise Level as per MOEF Gazette Notification No. GSR 742(E) dt. 25.09.2000 Standards for Coal Mines and Noise Pollution (Regulation and Control) Rules, 2000.

* Day Time: 6.00 AM to 10.00 PM.


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ANNEXURE - XVII

A. Training from April'2021 – September'2021

No. of employees (Department & Contractual) received training in Cluster XI (April'2021 – September'2021)		
Colliery	Types of Training	Number
Moonidih	Initial training	55
	Refresher training	285
	Special	385
Gopalichuck, Pootkee, Bhagabandh, KB 10-12, PBP colliery, P.B. Area Office, etc.	Training of Contractual workers	24
	Refresher training	209
	Special	185
Total		1,143

B. IME & PME report for Cluster XI from April'2021 to September'2021

IME & PME of Cluster XI	
Area Covered	Beneficiary
Moonidih Colliery	999
Gopalichuck, Pootkee, Bhagabandh, KB 10-12, PBP colliery, P.B. Area Office, etc.	231
Total	1,230