बीसीसीएल BCCL
वसुधैव कुटुम्बकम
ONE EARTH • ONE FAMILY • ONE FUTURE
भारत कोकिंग कोल लिमिटेड
(कोल इण्डिया लिमिटेड की एक अनुषंगी कंपनी)
Bharat Coking Coal Limited
(A Subsidiary of Coal India Limited)
(एक मिनीरत्न कंपनी / A Miniratna Company)
(भारत सरकार का उपक्रम / A Government of India Undertaking)

Ref. No. BCCL/GM/Ar. III/Envt./2023-24/ 123

Dated: 28.11.2023

To
The Director
Ministry of Environment, Forest& CC
Regional Office (ECZ), Bungalow No.-2
Shyamali Colony
Ranchi- 834002

Subject: Six monthly compliance report on implementation of Environmental measures for the period from April 2023 to September 2023 in respect of Cluster – III groups of mines.

Ref:-EC Order No. J-11015/213/2010-IA.II (M) dated 06.02.2013

Dear Sir,

Kindly find herewith the enclosed six-monthly compliance report on implementation of Environmental measures for the period from **April 2023 to September 2023** in respect of Cluster –III groups of mines, BCCL.

This is for your kind information.

Encl: As above

Yours faithfully

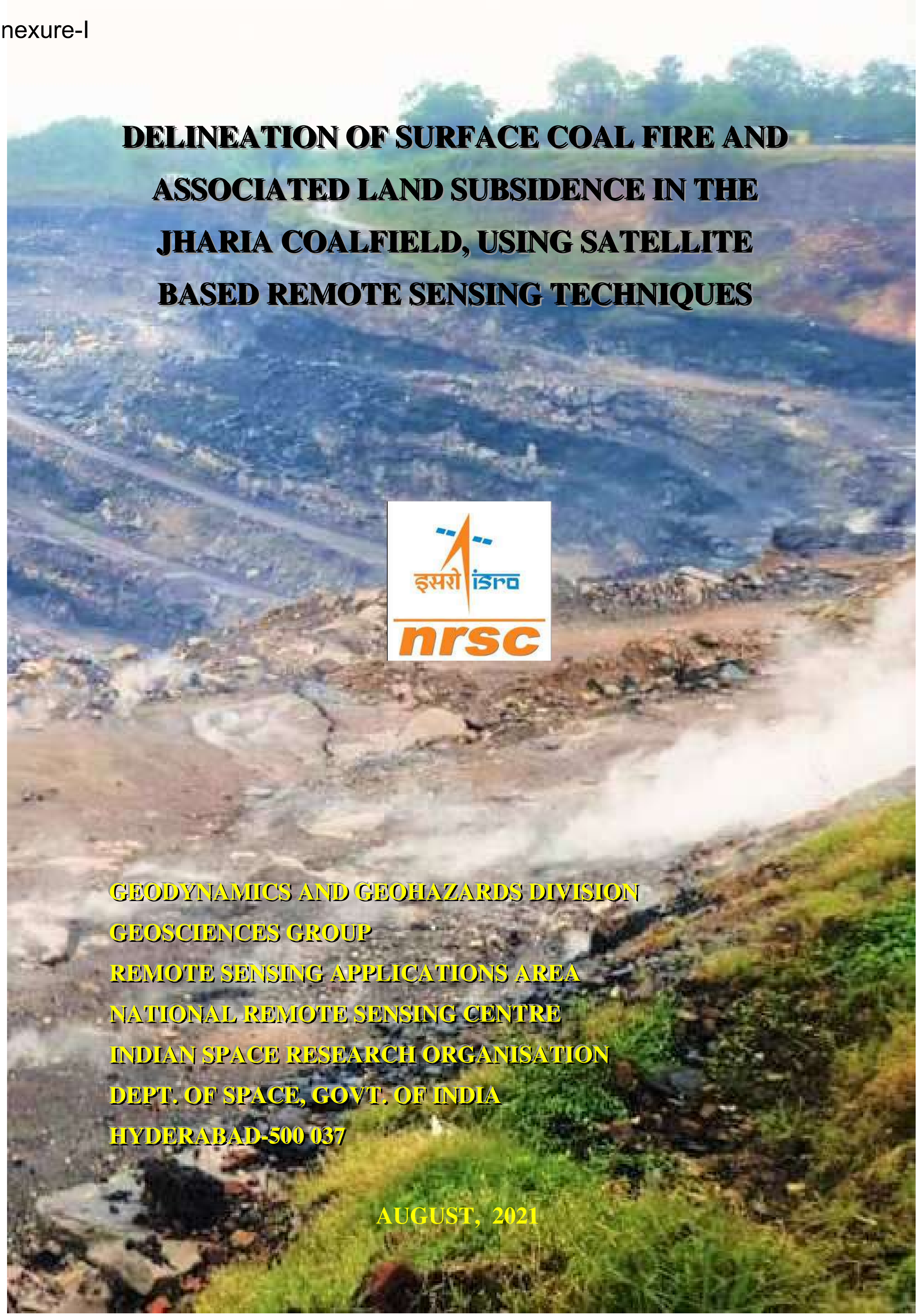
29/11/23

Addl. General Manager
Govindpur Area

Add. General Manager
Govindpur Area-III

C.C to (Through e-mail)
1. Regional officer, JSPCB, Housing colony, Dhanbad
2. CPCB Zonal office, Kolkata
3. GM (Min/Env), BCCL Koyla Bhawan, Dhanbad
4. Area Manager (Env), Govindpur Area.

Annexure-I



DELINEATION OF SURFACE COAL FIRE AND ASSOCIATED LAND SUBSIDENCE IN THE JHARIA COALFIELD, USING SATELLITE BASED REMOTE SENSING TECHNIQUES

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nrsc

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

AUGUST, 2021

Annexure-II

Deposit in Escrow Accounts with Bank of Baroda/Union Bank of India

Rs. In lakhs

Sr No	ESCROW ACCOUNT AT BOB	A/C No	Deposit											Interest											G Total	Less: Received from CCO in FY 2020-	Less: Received from CCO in FY 2021-22	Balance
			2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	Total	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	Total				
1	MAHESHPUR COLLIERY	00150100008836	38.40	15.84	16.63	17.46	18.34	19.25	20.22	21.23	22.29	23.40	**213.06**	1.46	3.73	5.09	5.47	6.46	8.18	10.16	12.47	7.36	9.14	**69.51**	**282.57**			**282.57**
2	JOGIDIH COLLIERY	00150100008823	39.85	8.58	9.01	9.46	9.94	10.43	10.96	11.50	12.08	12.68	**134.49**	1.52	3.87	4.61	4.55	5.05	6.12	7.34	8.77	6.79	8.44	**57.06**	**191.55**			**191.55**
3	GOVINDPUR UG	00150100008835	20.58	21.61	22.68	23.82	25.01	26.26	27.58	28.96	30.40	31.93	**258.83**	0.78	2.00	3.85	4.82	6.21	8.34	10.79	13.65	8.24	10.44	**69.12**	**327.95**			**327.95**
4	BLOCK IV /KOORIDIH MINE	00150100008834	100.83	105.87	111.16	116.72	122.56	128.68	135.12	141.88	148.97	156.42	**1,268.21**	3.84	9.80	18.85	23.62	30.45	40.85	52.86	60.69	34.82	56.62	**332.40**	**1,600.61**	160.92451		**1,439.68**
5	NAKC	00150100008831	60.59	63.62	66.80	70.14	73.65	77.34	81.19	85.26	89.52	94.00	**762.11**	2.31	5.89	11.33	14.19	18.30	24.55	31.77	36.47	20.93	26.94	**192.66**	**954.77**	96.70365		**858.07**
	TOTAL		**260.25**	**215.52**	**226.28**	**237.60**	**249.50**	**261.96**	**275.07**	**288.83**	**303.26**	**318.43**	**2,636.70**	**9.90**	**25.29**	**43.73**	**52.65**	**66.47**	**88.02**	**112.92**	**132.05**	**78.14**	**111.57**	**720.74**	**3,357.44**	**257.63**	**-**	**3,099.81**

Annexure-III

Stone Pitching along the water body

Annexure-IV

Biological Reclamation on stabilized OB dumps at Chaitudih, New Akashkinaree Colliery (Plantation year 2021-22, area 23 Ha)

Biological Reclamation on stabilized OB dumps at Block-IV Colliery (Plantation year 2020-21, area 4.5 Ha)

Biological Reclamation on stabilized OB dumps at NAK Colliery (Plantation year 2020-21, area 5 Ha)

Biological reclamation of stabilized OB dumps in New Akashkinaree Colliery (Plantation year FY 2014-15 to 2017-18)


Network:28-Aug-2021 at 12:25:49 PM IST
Local:28-Aug-2021 at 12:25:49 PM IST
N 23° 47' 12.896", E 86° 15' 43.413"
Sahnidih Main Road
Sahnidih 828125
JH
India


GPS Map Camera
Katras,JH,India
Baghmara Cum Katras, Katras, 828306, JH, India
Lat 23.805139, Long 86.274568
05/29/2023 12:43 PM GMT+05:30


GPS Map Camera
Kharkhari, JH, India

Development of Eco-restoration Parks/Recreational Parks in Cluster-III

Eco-Park at Maheshpur Colliery

Netaji Subhash Chandra Bose Eco-Park at NAKC

Annexure-V

Details of OB generated

Colliery Name	OB generated (Lakh cum)									
	FY 2013-14	**FY 2014-15**	**FY 2015-16**	**FY 2016-17**	**FY 2017-18**	**FY 2018-19**	**FY 2019-20**	**FY 2020-21**	**FY 2021-22**	**FY 2022-23**
New Akashkinaree Colliery	10.01014	28.10951	59.42051	36.15412	38.11560	17.26961	27.54293	13.04	10.94	9.50461
Block-IV/Kooridih Colliery	17.25116	18.37296	17.80795	43.19287	34.79501	20.72033	27.89974	27.96	3.73	8.24221

Details of Backfilling

Colliery Name	Backfilled Area (Ha)									
	FY 2013-14	**FY 2014-15**	**FY 2015-16**	**FY 2016-17**	**FY 2017-18**	**FY 2018-19**	**FY 2019-20**	**FY 2020-21**	**FY 2021-22**	**FY 2022-23**
New Akashkinaree Colliery	3.6	3.8	13	8	4	4	5	2.53	2.5	1.46
Block-IV/Kooridih Colliery	7.38	5.23	7.54	2.5	3.7	2.7	4.9	6	1.5	4.0

Annexure-VI

Proposed Coal Production, OB generation for FY 2023-24

FY 2023-24	New Akashkinaree Colliery (Mixed)	Block-IV Colliery (Mixed)	Maheshpur Colliery (UG)	Jogidih Colliery (UG)
Coal Production (Te)	0.95 MTe (OCP); 0.035 MTe(UG)	0.50 MTe	40000 Te	30000 Te
OB (cum)	41,00,000	25,00,000	NA	NA

Annexure-VII

Details of Block Plantation/Biological Reclamation done up to 30.09.2023

Year of Plantation	Total Area Covered (Ha)	Species	Survival Rate
FY 2014-15	4	Gamhar, Siris, Subabool, Bel, Kachnar, Kher, Amaltas, Mehandi, Sheesham, Chakundi etc.	80 %
FY 2015-16	4.5		
FY 2016-17	5		
FY 2017-18	4		
FY 2018-19	5		
FY 2019-20	1		
FY 2020-21	9.5		
FY 2021-22	23		
FY 2023-24	5		

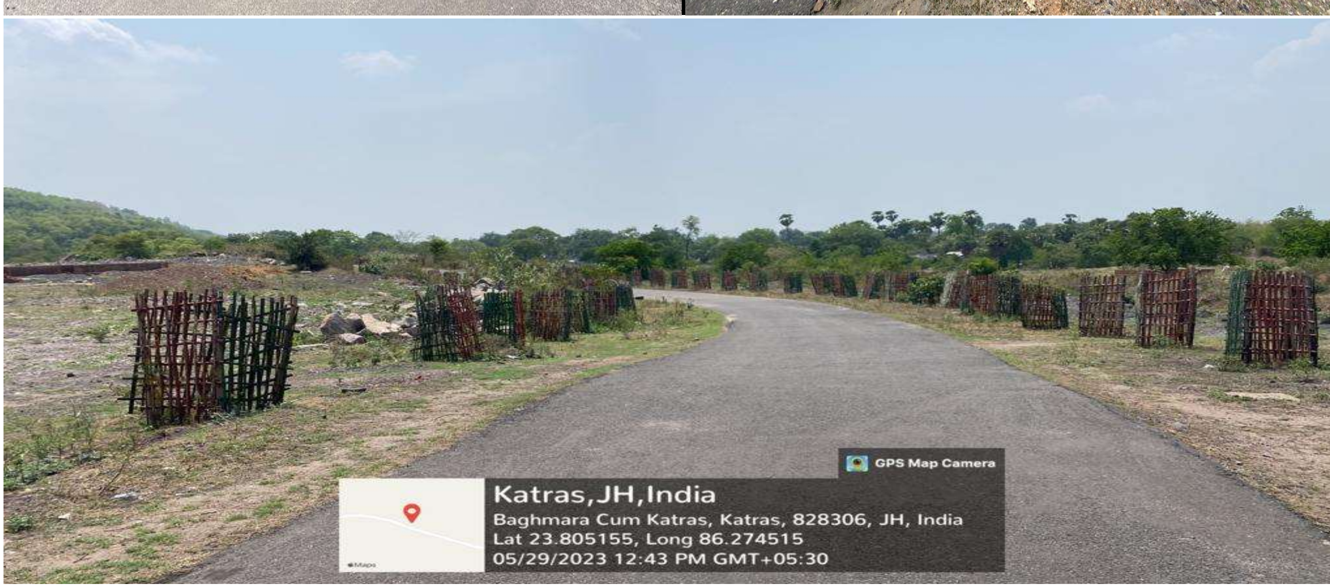
Details of Avenue/Block Plantation/Biological Reclamation done up to 30.09.2023

Year of Plantation	Type of Plantation	Nos.	Executing Agency
FY 2020-21	Block	388 Nos.	DFO, Dhanbad
FY 2022-23	Avenue/ Block	1978 Nos.	
FY 2023-24	Avenue	150 nos.	

Annexure-VIII

Sedimentation ponds and settling tanks for mine water utilization

Roads constructed within colliery premises



<u>Bamboo gabion plantations along roads.</u>

Trolley mounted fog cannon at railway siding

Water Sprinkling on Haul roads within mines through Mist type water tanker (28 KL Capacity)

PM10 Online Analyzers installed at Collieries

Truck Mounted Fog Cannon System

Annexure-IX

"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

April 2022

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Chapter 1 Introduction

Jharia Coalfield (JCF) is one of the oldest coalfields of India and has been subjected to coal exploitation for more than 100 years. JCF is one of the significant coal-producing areas in the country and occupies an important place in India's industrial and energy scenario by virtue of prime coking coal and is an essential source of coal. Jharia coalfield is crucial and a large coalfield situated in Dhanbad and Bokaro district, Jharkhand. Geographically the JCF is bounded by latitude 23°38' N to 23°49' N and longitude 86°09'E to 86°30'E and encompassing a total area of about 450sq km (Figure 1.1). Jharia is the largest coal producer in India and has an estimated reserved of 19.4 billion tonnes of coking coal. The coalfield contributes to the local economy and directly or indirectly employs the local population.

Bharat Coking Coal Limited, a subsidiary of Coal India Limited, has been operating the majority of the coal mines in the Jharia coalfield regions since its inception in 1972. Jharia, one of the eight blocks in Dhanbad and the main source of metallurgical coal in India can be termed as the country powerhouse since its mines are the only source for the best quality coking coal required by the steel industries and others in the country.

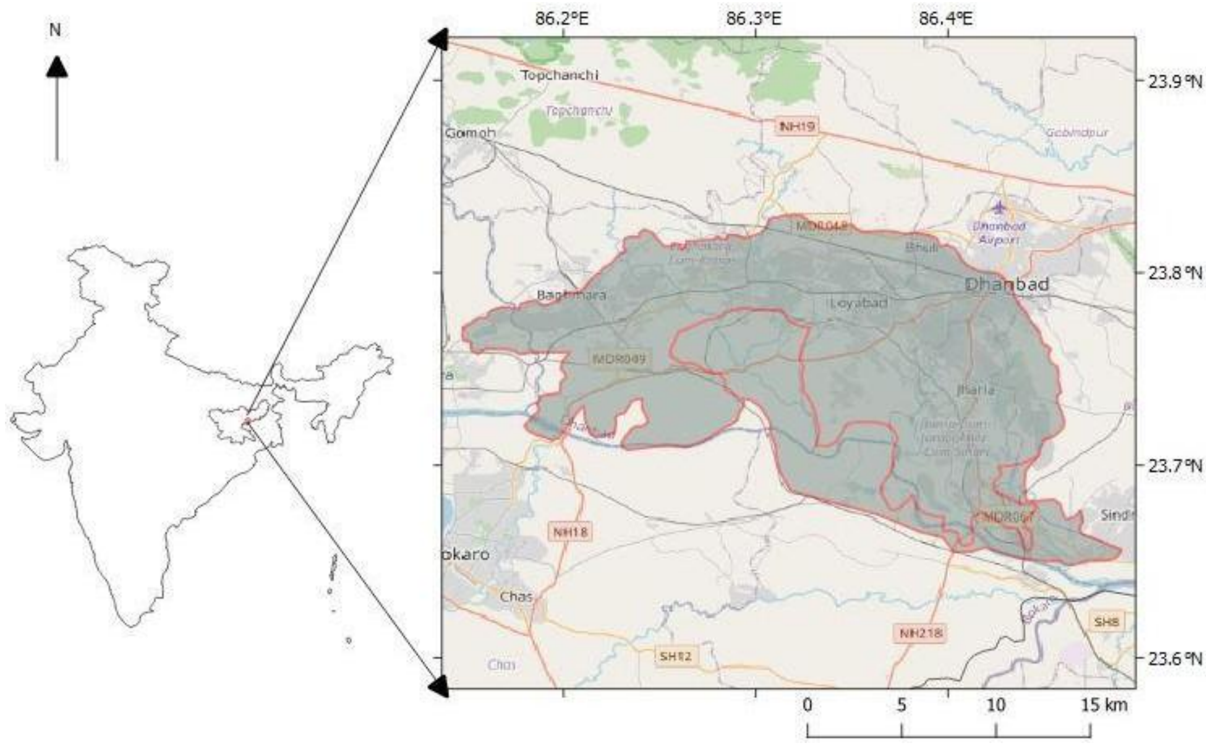


Figure 1.1: Geographical location of Jharia Coalfield in India

1.1. Climate

Dhanbad lies 236 m above the mean sea level and experiences the tropical climate. When compared with the winter, the summers have much more rainfall. The Köppen-Geiger climate classification is Aw (Tropical wet-dry climate) and experiences an average temperature of 25.9 °C and 1203 mm of precipitation falls annually. The driest month is December. There is 3 mm of precipitation in December. In July, the precipitation reaches its peak, with an average of 321 mm. With an average of 32.5 °C, May is the warmest month. At 18.4 °C on average, January is the coldest month of the year. The windrose for the March-June months is presented in Figure 1.2.

1.2. Land use & Land cover

In the present investigation, the Jharia coalfield area (2827.43 sq km) has been undertaken to study the Land use land cover (LULC), For this study, Sentinel-2A satellite image is used in the month of 17 February 2019 having a minimum cloud. These images were downloaded from the United States Geological Survey (USGS) Earth Explorer. Each Sentinel 2A satellite imagery band was geo-referenced to the WGS_84 datum and Universal Transverse Mercator Zone 45 North coordinate system. The Sentinel 2A satellite image stacking of the band-2, band-3, band-4 and band-8 of 10 m resolution was performed on the ArcGIS 10.5 software for studying the LULC of the Jharia coalfield.

For LULC classification, supervised classification was carried out in the study area. Thus allocations of each classified area in sq. km and its percentages are tabulated in Table 1.1. The percentage of areas as classified as; agriculture (74.5%), barren land (7.45%) built-up areas (5.14%), mining (2.64%), vegetation (9.40%) and water body (0.86%) (Figure 1.2).

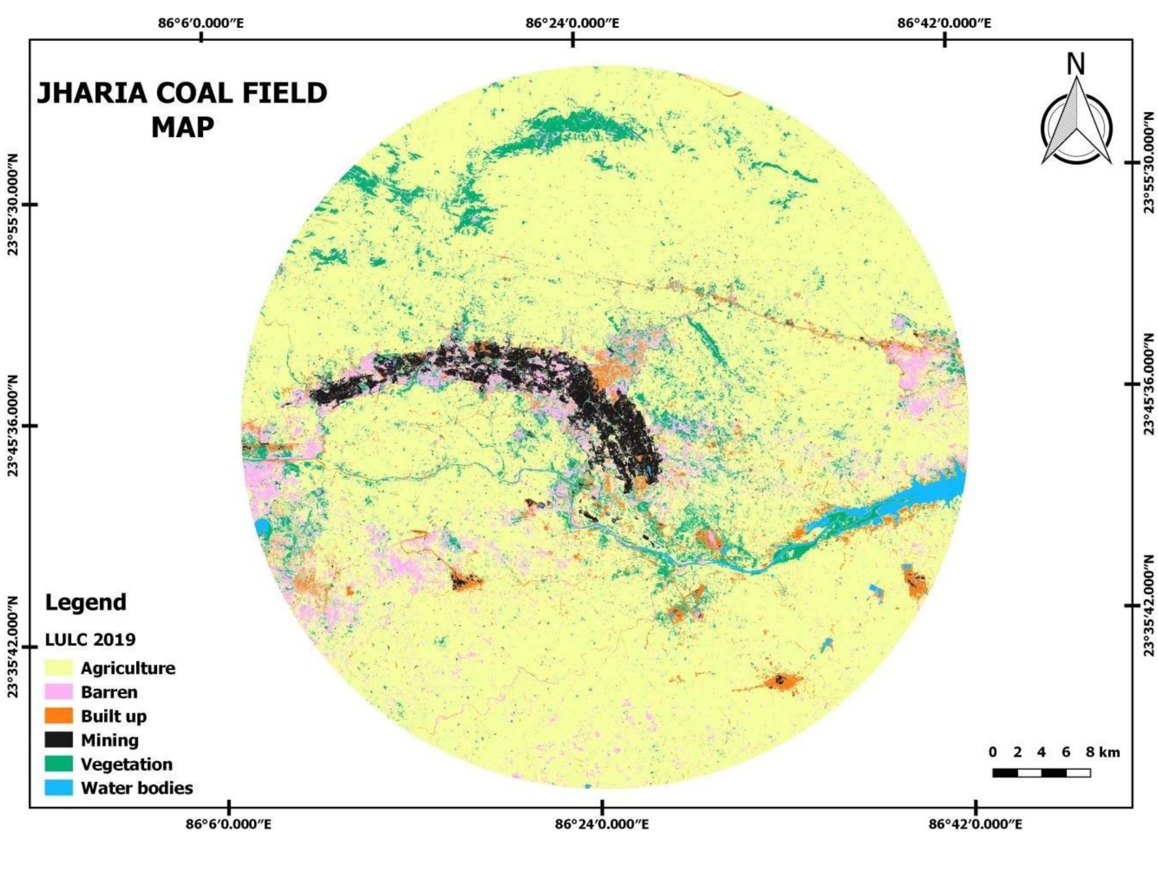


Figure 1.2: Land Use land cover map of Jharia coal field area

Table 1.1: LULC classification of Dhanbad study area

Sr. No	Name	Area in sq. km	Area in %
1.	Agriculture	2106.7	74.51
2.	Barren	210.64	7.45
3.	Built up	145.31	5.14
4.	Mining	74.67	2.64
5.	Vegetation	265.74	9.40
6.	Water bodies	24.37	0.86
Total		**2827.43**	**100**

1.3. Population

The study area covers four district boundaries; namely Dhanbad (1710.2sq km), Bokaro (620.43sq km), Giridih (29.8sq km) in Jharkhand and Puruliya (465.85sq km) district in West Bengal state. The Dhanbad district covers the maximum study area and the population is around 23, 94,434 in the year 2001 and is around 26,84,487 in 2011. The Bokaro district total population is in 2001 is 17, 75,961 and in 2011 it is 20, 62,330. The Giridih district total population is 19, 01,564 in 2001 and is 24,45,474 in 2011. The Puruliya district in West Bengal state total population is in 2001 is 25, 35,233 and in 2011 are 29, 30,115.

Based on the covered study area the total population in the study area is tabulated in Table 1.2. The total population in the study area based on Census book 2001 is 25,32,195 and 2011 is 28,62,600.

Table 1.2: Population in the study area as per 2011 census

District Name	District Area Covered by Study Area	% of Area Covered of District by Study Area	Population of 2001	Population 2001 in Study Area	Population of 2011	Population 2011 in Study Area
Bokaro	620.43	21.50	17,75,961	3,81,791	2,062,330	4,43,353
Dhanbad	1710.2	81.51	23,94,434	19,51,645	2,684,487	21,88,060
Giridih	29.8	0.59	19,01,564	11,275	2,445,474	14,500
Puruliya	465.85	7.40	25,35,233	1,87,484	2,930,115	2,16,686
Total	2826.28		Total Population 2001	25,32,195	Total Population 2011	28,62,600

1.4. Purpose of Study

Urban air pollution is a notable concern across the world. Inferring to the rapid rates of industrialization and urbanization in Indian cities, polluted air quality is considered a key factor in crumbling the quality of life with an adverse effect on the human being. Hence air quality gained a significant role in recent decades since it is worsened by emission from major pollutants including particulate matter (PM_{10} and $PM_{2.5}$), NO_2, SO_2 and O_3 were found to exceed the national ambient air quality standard (NAAQS) limits.

Particulate pollution is a major concern in the field of air pollution. The particulate matter in the air result from dispersion of dust from industrial (mining and non-mining) and allied activities, transportation, local vehicular movement and domestic fuel (Coal, wood-burning etc.) burning. Assessment of the air quality can provide useful insight for the development of the air quality management plan. The database developed on air quality also helps the regulatory agency identify the locations where natural resources and human health could be at risk.

Jharia coal mines having low ash content and high calorific value coals are subjected to intensive mining activities because of the easy availability of coal at shallow depths in thick seams. 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 cause a lot of fugitive gaseous and PM emissions. Hence, the Jharia region has been under scrutiny by various public authorities and the 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 dust, fugitive emissions, fuel oils, household LPG. The percentage contribution of these factors in the ambient depends exclusively on a particular region"s economic activities. To improve the existing ambient air quality, the major sources of PM emissions first need to be identified.

Hence, the environmental clearance committee of MoEFCC 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 the Jharia coalfields region to quantify the various sources of PM emissions and suggest an effective environmental management plan.

The study's major objective 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 includes the entire Jharia Coalfield and an area up to 10 Km from the periphery/boundary of BCCL mines.

The detailed objectives are as follows:

i. Ambient Air Monitoring

- Monitoring of ambient air quality at selected receptor locations for pollutants including PM_{10}, $PM_{2.5}$(limited), SO_x, NO_x, PAHs to establish the status of the air quality in Jharia Coalfields and an area up to 10 K.M 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 validate dispersion modelling predictions using measured air quality parameters
- To draw supportive data through the 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 micrometeorological conditions of the Jharia Coalfields

- Emission Inventory related to Jharia Coalfields along with area up to 10 Km from the periphery/boundary of BCCL mines

ii. 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
- Source apportionment
- To identify and apportion the pollution load at receptor level to various sources in the Jharia Coalfields along with an 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 periods of the day and day-of-the-week.
- Any other item in consensus between both BCCL/CIL & NEERI evolved during the study.

1.5. Approach of study

The study approach has many components, each one of them having its importance and interdependence as shown in Figure 1.3. The ultimate objective is source apportionment of ambient air of JCF that primarily requires knowledge of ambient air quality status, sources and emission load. These three objectives were achieved by monitoring air pollutants at 13 locations in Jharia Coalfield using various instruments and multiple analyses. These locations were selected based on land use and activity profile. All monitoring was carried out using varied instruments and all attributes were analysed using standards methodologies. The study‟s methodology of the study was divided into three parts namely ambient air quality monitoring, sources emission inventory and source apportionment analysis.

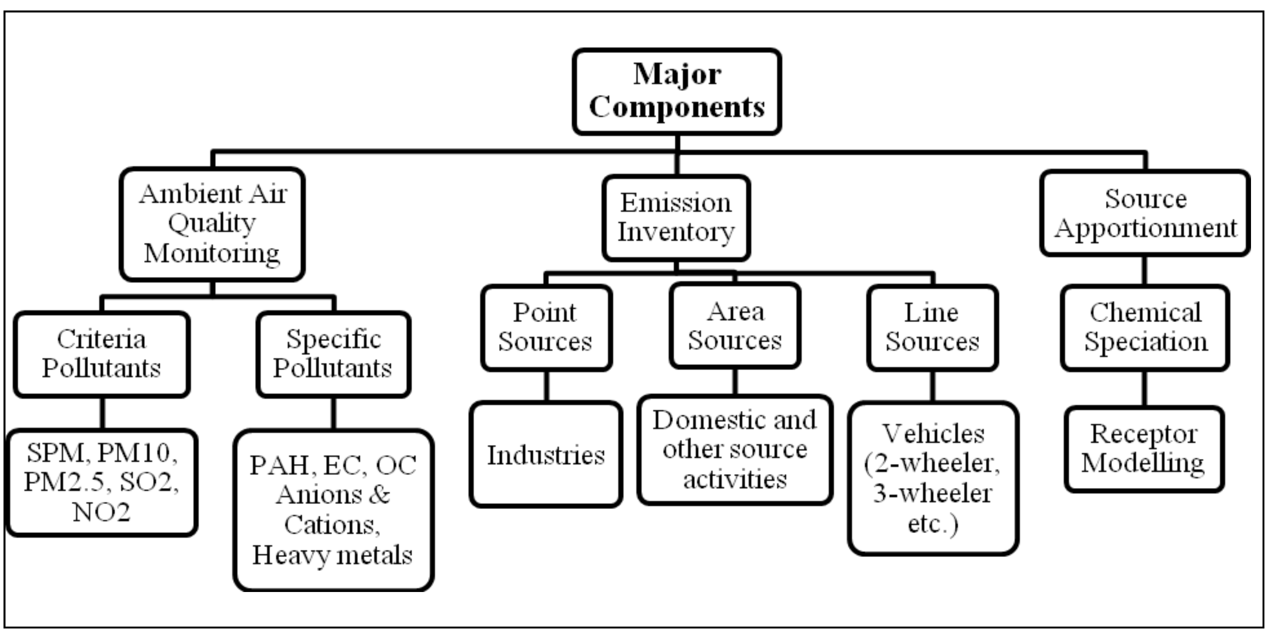


Figure 1.3: Air quality Monitoring & emission source apportionment studies

Chapter 2 Emission Inventory

This section consists of all methodologies that have been applied for the emission inventory and dispersion modelling in the Jharia Coalfield. The emission inventory is the process to identify the possible source and its contribution. Emission inventory and dispersion modelling are based on the primary data collection to calculate emission load from a particular source. It provides fundamental information for air quality modelling and air pollution control strategy development. In the coal mining area, mining, non-mining, industrial, vehicular and other sources are contributing. Air quality monitoring includes the suitable location selected based on the metrological conditions, chemical characterization for identification of the source, CMB model to estimate the source apportionment to $PM_{2.5}$.

Air pollutant emission inventory is a process to identify the possible sources and their contribution. It provides fundamental information for air quality modelling and air pollution control strategy development. Mining, non-mining, industrial, vehicular and other sources are contributing to critical coal mining zone like JCF, India. According to possible emission sources, sources are divided into three categories like point sources, area sources and line sources. The inventory of these sources is important to make a proper source profile.

2.1. Inventory of Point Sources

A point source of pollution is a single identifiable source that is responsible for significant pollution load in the study area, like thermal power stations. A comprehensive list of different point-like industries in the study area was obtained from the regional office of the Jharkhand State Pollution Control Board (JSPCB), at Dhanbad. The industries specific information of includes production capacities, raw material used, manufacturing process, fuel consumption, etc. also collected from the regional office by the CSIR-NEERI team.

2.2. Inventory of Area Sources

Area sources are sources of pollution that emit a substance or radiation from a specified area. Mining activities, domestic/hotel fuel (coal) burning, garbage burning, etc. are the major contributor to area sources. In order to assess the fuel consumption in the study area, the necessary information was collected through surveys at petrol pumps, hotels and restaurants, bakeries, open eat out and crematoria. Also, surveys collected data on the seasonal implication of fuel used particularly wood and coal. The data on trash burning and solid waste generated in the study were collected from Municipal Corporation Dhanbad.

2.3. Inventory of Line Sources

Vehicles contribute a whole range of HCs besides contributing SO_x, NO_x (as NO_2), HC and lead. Diesel vehicles are the primary source of smoke and NO_x in addition to CO and HCs. However, CO and HCs per litre of fuel consumed by diesel vehicles in relatively low compared to gasoline-powered vehicles. In gasoline-powered vehicles, the exhaust is the major source of pollution that contributes 100 % CO and NO_x and 80% of HCs emitted to the atmosphere. The remaining 20% of HCs are emitted from crankcase blow-by and evaporative emissions. In the two-stroke engine, the crankcase blow-by is absent. The exhaust emissions are the principal sources of pollutants emitting about 40% of fuel supplied without burning due to short circulating, contributing high concentration of HCs. In diesel vehicles, practically all pollutants are emitted through exhaust gases and the contribution to crankcase blow-by and evaporative fuel emission are negligible.

Though the quantity of pollutants emitted by the vehicles is directly proportional to the number of vehicles playing on the road, the intensity of pollution potential depends on several contributory factors such as a geographical location, unplanned development of central business areas, inadequate and ill-maintained road as well as the type of vehicle, unplanned traffic management, meteorological conditions, and non-availability of adequate emission control technology.

Vehicle activity data were collected during the field campaign at 12 road networks in the study area, and the daily average vehicular activity is presented in Table 2.1.

Table 2.1a: Daily average vehicle activity on different road network considered during the fieldsurvey

Label	Road Network	HDV	LMV	3W	2W	Total
L1	Jharia to Lodna -5 km	1254	1385	3640	9560	15839
L2	Pathardih to Sindri -7 km	1539	5356	4362	15633	26890
L3	Bastacola to Pathardih -13km	2153	8325	3678	10233	24389
L4	Bhuli to Bankmore - 6km	1475	13832	12965	18241	46513
L5	Katras to Harina–12.5 km	1802	7290	3156	15329	27577
L6	Bankmore to Kusunda -5 km	658	2685	1896	10235	15474
L7	Kusunda to Katras - 10 km	1306	4521	5327	15689	26843
L8	Monidih to Kusunda -7 Km	1208	7659	3985	14698	27550
L9	Lohpiti to Mahuda Area Colony - 8 km	1535	4523	2235	6356	14649
L10	Mahuda to Parasia Chowk -7 km	1223	4023	1759	5623	12628
L11	Parasia Chowk To Moonidih - 3 km	269	2159	236	2347	5011
L12	Bhowra to Parbatpur - 13 Km	2135	7856	4258	14578	28827

Table 2.1b: Average vehicle speed of different categories of vecle in the road network

		Average vehicle speed*			
Label	**Road Network**	**HDV**	**LMV**	**3W**	**2W**
L1	Jharia to Lodna -5 km	20	35	30	40
L2	Pathardih to Sindri -7 km	20	40	35	40
L3	Bastacola to Pathardih -13km	20	40	35	40
L4	Bhuli to Bankmore - 6km	15	30	30	30
L5	Katras to Harina–12.5 km	20	35	30	40
L6	Bankmore to Kusunda -5 km	15	30	20	30
L7	Kusunda to Katras - 10 km	20	40	30	40
L8	Monidih to Kusunda -7 Km	20	35	30	40
L9	Lohpiti to Mahuda Area Colony - 8 km	20	40	30	40
L10	Mahuda to Parasia Chowk -7 km	15	30	20	30

L11	Parasia Chowk To Moonidih - 3 km	20	35	35	40
L12	Bhowra to Parbatpur - 13 Km	20	40	30	40

*** Average travel speed on the road network is considered during traffic surveys and input form Traffic police and vehicle drivers**

The vehicle utilization factors (km travelled per day per vehicle type) were adapted from the Auto Fuel Policy Report (Table 2.2). Two-to-four-wheelers Emission factors were taken from various project reports conducted by CPCB and Indian Clean Air Programmed (ICAP) (CPCB 2010; ARAI 2007). The percentage distribution of various types of vehicles moving on the road network considered during the field survey is presented in Fig 2.1. It shows that major numbers of vehicles moving in the considered Road network are two-wheelers (51%), followed by light motor vehicles (26%), three-wheeler (17%) and heavy-duty diesel vehicles (6%).

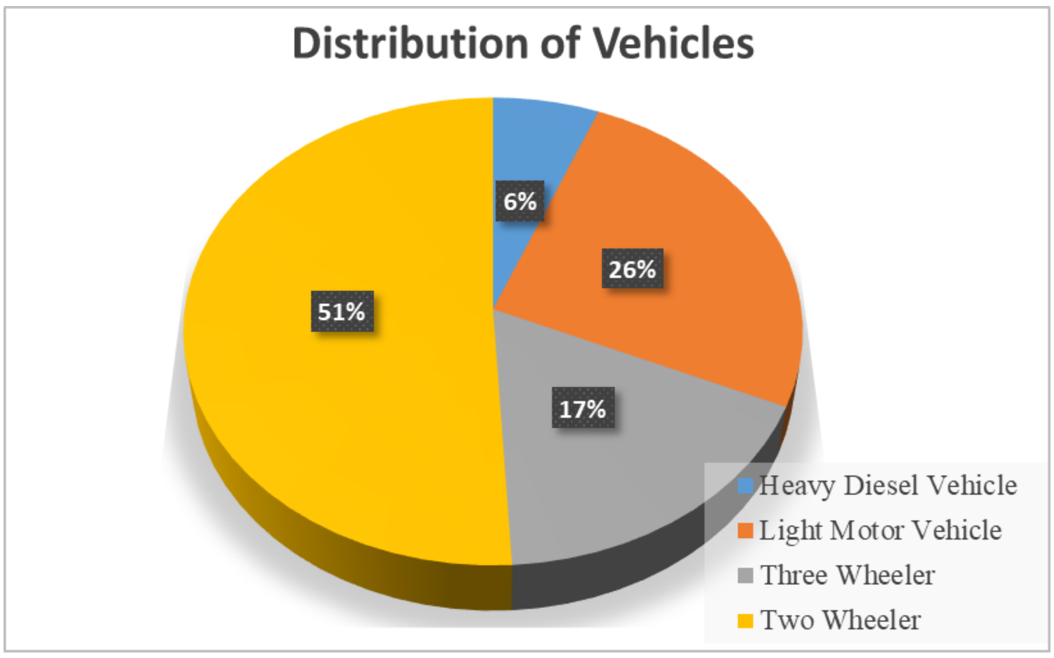


Figure 2.1 Percentage of different types of vehicle surveyed on the road network during the field survey

Table 2.2: Utilization Factors for different types of vehicle

Vehicle Type	km per day
LMV (Car Jeep)	52.6
LMV (Taxi)	77.89
2 Wheeler	25.1
3 Wheeler (Auto)	97.72
HDV	45.5

2.4. Methodology

The following method is adopted to estimate the emission load due to vehicles

$$E_i = N_v \times VKT \times E_f \tag{2.1}$$

Where, E_i is the emission from a particular type of vehicle

N_v is the number of vehicles of a particular type

VKT is the vehicle km travelled

E_i, km is the emission factor for a specific vehicle

Table 2.3a: Emission estimate for road transport

Label	Road Network	Emission (kg/day)	
		PM_{10}	$PM_{2.5}$
L1	Jharia to Lodna -5 km	230.12	113.08
L2	Pathardih to Sindri -7 km	379.07	180.37
L3	Bastacola to Pathardih -13km	632.21	451.98
L4	Bhuli to Bankmore - 6km	331.41	187.69
L5	Katras to Harina–12.5 km	719.42	415.63
L6	Bankmore to Kusunda -5 km	308.69	194.34
L7	Kusunda to Katras - 10 km	576.31	277.95
L8	Monidih to Kusunda -7 Km	317.83	114.25
L9	Lohpiti to Mahuda Area Colony - 8 km	360.24	151.99
L10	Mahuda to Parasia Chowk -7 km	241.56	148.24
L11	Parasia Chowk To Moonidih - 3 km	94.26	57.23
L12	Bhowra to Parbatpur - 13 Km	592.82	379.80

Re-suspension of the unpaved and paved roads depends on the „silt loading" factor and „vehicles weight" roaming on the road (Table 2.4). The silt loading (S_L) is the mass of the silt-sized material per unit area of the road surface. The amount of dust produces by vehicles movement on paved (eq. 2.2a) and unpaved (eq. 2.2b) roads can be appraised by the following equations (adapted from US-EPA, AP-42):

$$E = k. (SL/2)^{0.65} . (W/3)^{1.5} \quad (2.2a)$$

$$E = [k. (SL/12).(S/30)^{0.5} (W/3)^{1.5}]/(M/0.5)^{0.2} \quad (2.2b)$$

Where, „E" = emission rate of PMs (Table 2.3);

SL is silt load (g/m2);

W is the average weight of the vehicle (Tons);
M is the surface moisture content (%)

k is constant (the function of particle size) in g VKT^{-1} (Vehicle Kilometer Travel)

Table 2.3b: Surface silt load in paved and unpaved road

Label	Road Network (Paved: 97.4%; Unpaved: 2.6%)	Surface Silt load (g/m2)	
		unpaved	paved
L1	Jharia to Lodna -5 km	102.3	18.2
L2	Pathardih to Sindri -7 km	--	16.8
L3	Bastacola to Pathardih -13km	63.2	12.1
L4	Bhuli to Bankmore - 6km	--	17.5
L5	Katras to Harina–12.5 km	92.8	12.6
L6	Bankmore to Kusunda -5 km	--	18
L7	Kusunda to Katras - 10 km	--	17.3
L8	Monidih to Kusunda -7 Km	56.5	12.8
L9	Lohpiti to Mahuda Area Colony - 8 km	--	15.5
L10	Mahuda to Parasia Chowk -7 km	--	19

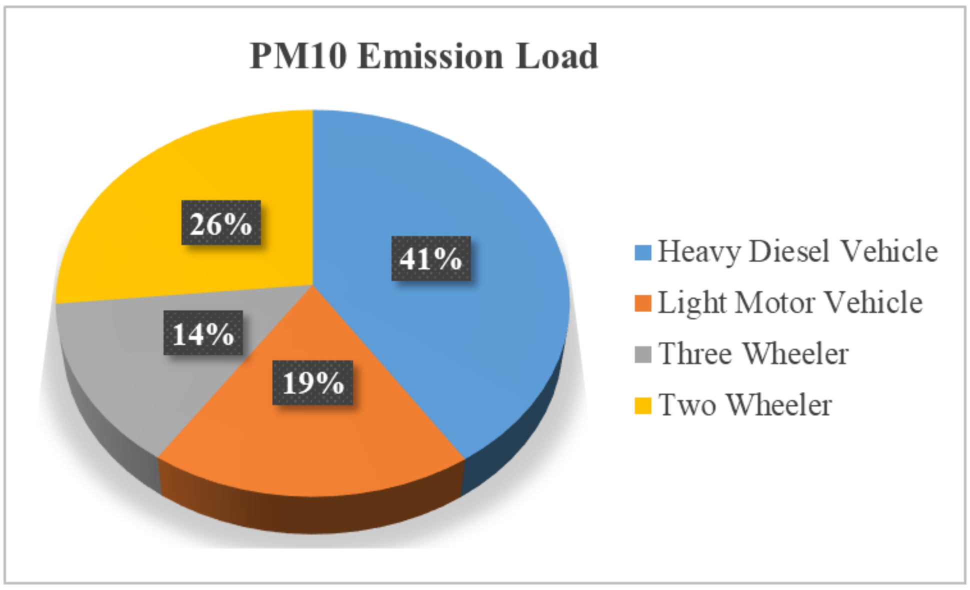


Figure 2.2 PM_{10} emission load for different categories of vehicle

It is observed that 41% of PM10 emission is contributed by the Heavy-duty diesel vehicles followed by two-wheelers (26%), Light motor vehicles (19%) and three-wheelers (14%) in the considered road network during the study period. The particle size multiplier (k) in the equations 2.2a and 2.2b varies with aerodynamic size range as shown in EPA technical document (13.2.1_paved_roads.pdf (epa.gov)).

Table 2.4: Emission rate for the paved and unpaved road

	Emission Rate	
Emission Sector	**PM_{10} (kg/day)**	**$PM_{2.5}$ (kg/day)**
Re-suspension dust from Paved & Unpaved Road	1756	843

2.5. Results

2.5.1. Industrial Emission

Emission inventory estimates are determined based on considering available industrial activity information, emission factors (Table 2.5) and observations. For the current study, industrial and mining information was collected for emission inventory development. Emission inventory information for industries was collected from the regional office of JSPCB. In Dhanbad, the major industries are the power plant and the coking industry. Other than those are coal mines, thus coal as a fuel is majorly used in industries and households. Emission loads by point source are depicted in Table 2.6 as per emission inventory.

Table 2.5: Emission factor for coal mining activities

EF	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2
g/Mg Coal	1914	1864	1176	420	820

Table 2.6: Emission load from Industrial sector in JCF

Sr. No	Name of Industry	Type of Fuel	Fuel consumption	Unit	TSP (Ton/yr)	PM_{10} (Ton/yr)	$PM_{2.5}$ (Ton/yr)	SO_2 (Ton/yr)	NO_2 (Ton/yr)
1	M/s Mahalaxmi Industries	Coal	4	MT/Oven/cycle (24hrs)	2.79	2.72	1.72	0.61	1.20
2	GEETEE Hard Coke Traders	Coal	100	TPD	69.86	68.04	42.92	15.33	29.93
3	M/s Shree Gopal Coke Industries	Coal	77.4	TPD	54.07	52.66	33.22	11.87	23.17
4	M/s Laxmi Hard coke Manufacturing Company	Coal	102	TPD	71.26	69.40	43.78	15.64	30.53
5	M/s - Sanjay Hard Coke Industries	Coal	70	TPD	48.90	47.63	30.05	10.73	20.95
6	M/s Inder Hard Coke Industries	Coal	36	TPD	25.15	24.49	15.45	5.52	10.77
7	M/s Shiv Shakti Coke Industries	Coal	80	TPD	55.89	54.43	34.34	12.26	23.94
8	Khetawat Coke Manufacturing Company	Coal	4.5	MT/Oven/Batch (24hrs)	3.14	3.06	1.93	0.69	1.35
9	M/s Pawan Hard Coke Industries	Coal	100	TPD	69.86	68.04	42.92	15.33	29.93
10	M/s Ganapati Udyog	Coal	135	TPD	94.31	91.85	57.95	20.70	40.41
11	M/s Aman Soft Coke Industries	Coal	29.76	TPD	20.79	20.25	12.77	4.56	8.91

2.5.2. Area/Distributed source

An area source emission inventory estimates the pollutant loads emanating from several small but numerous individual sources in a specific geographic area and which cannot be included underline no point sources.

Area sources considered for emission inventory for JCF region are:

- Cooking operations in households: Slum and non-slum
- Cooking operations in hotels, restaurants, open eat-outs and bakeries
- Crematoria

The following sections will detail the methodology adopted for estimating emissions from each of the above-mentioned sources and the results thusobtained.

- **Emission load from mining activities**

The emission loads from coal mine activities are depicted in Table 2.7. The emission load is calculated based on the secondary data collected from the BCCL mines covered in the study. The data includes coal and overburden quantity handled per day during loading and unloading, transfer from pit to stockyard through haul road and conveyor, vehicular movement frequency and diesel consumption for HEMM and DG sets. Emission factors from EEA air pollutant emission inventory guidebook 2019 were considered for the estimations of TSP and PM load.

Table 2.7: Emission load from coal mine activities in Jharia coalfield region

Mine	Area (m^2)	PM_{10} (Tone/y)	$PM_{2.5}$ (Tone/y)
ABOCP	2355283	156.1	78.0
ADI Colliery	1444818	47.9	23.9
ASP Colliery	19540	27.7	13.8
Bhowra south	78079	26.9	13.4
Block IV Govindpur	432827	22.5	11.2
DBOCP	605747	64.7	32.4
East Bassuriya Colliery	576494	24.3	12.2
Gopalichuck Colliery	37573	3.7	1.9
Jeenagora OCP	2079123	208.0	104.0
Kuya OCP	1134723	90.1	45.1
NAKC	245205	78.3	39.1
NGK	261847	126.0	63.0
Nichitpur colliery	791140	61.4	30.7
Phularitand colliery	335887	84.1	42.1
Rajapur OCP	1170784	90.4	45.2
Sendra Bansjora	472760	63.0	31.5
Shatabdi colliery (Muraidhih)	34270	77.0	38.5
Tetulmari	876320	23.3	11.7
Total		**1275.4**	**637.7**

- **Cooking operations in non-slum household**

A survey of 20 non-slum household areas was conducted in randomly selected areas of Dhanbad to understand which fuels are being used in these households and their quantities. The survey results indicated that Liquefied Petroleum Gas (LPG) was the fuel of choice in all the households and that each household used about 1 cylinder per month on average. It was assumed that LPG use remains the same for all 365 days of the year. The results obtained are presented in Table 2.8.

Table 2.8: Emissions from the use of LPG in non-slum households in Dhanbad

LPG Pollutant	PM_{10}	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	2.1	0.4	1.8	0.25	0.07
Emission (T/Year)	0.00575	0.0011	0.0049	0.0007	0.0002

- **Cooking operations in slum households**

A survey of 15 areas having slum households was conducted, spread in Jharia Coalfield which was known to have significant slum populations, to understand which fuels are being used in these households and their quantities. It was seen that a majority of the slum households use coal as a cooking fuel (Table 2.9).

Table 2.9: Emission from coal as fuel

Pollutant	SPM	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	20	13.3	3.99	24.92	0.5
Emission (T/Year)	28.354	18.856	5.657	35.330	0.709

- **Emissions from crematorium**

In order to calculate emission from crematoria data were obtained from crematoriums in Dhanbad. Emission from the burning of bodies using woods mainly produces PM_{10}, CO and HC majorly as depicted in Table 2.10.

Table 2.10: Emission from Crematoria using Wood as fuel

Pollutant	PM_{10}	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	17.3	0.2	1.3	126.3	114.5
Emission (T/Year)	28.88	0.033	0.216	20.99	19.03

- **Emissions from bakeries**

Data were collected from 34 bakeries operating in Dhanbad in which 12 bakeries were using electrical ovens. The emissions from such bakeries were not considered. All the other bakeries were using coal as fuel. Emissions from such bakeries are given in Table 2.11.

Table 2.11: Emission from Bakeries using Coal as fuel

Pollutant	SPM	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	20	13.3	3.99	24.92	0.5
Emission (T/Year)	6.26	4.16	1.25	7.80	0.16

- **Emissions from hotels and restaurants**

Data were collected from 35 hotels in Dhanbad city. It has been found that most hotels/restaurants were using a combination of coal and LPG as cooking fuel. Emission from coal and LPG were calculated and depicted in Table 2.12 and 2.13.

Table 2.12: Emission from Hotel & Restaurants using Coal

Pollutant	SPM	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	20	13.3	3.99	24.92	0.5
Emission (T/Year)	81.10	5.393	1.618	10.105	0.203

Table 2.13: Emission from Hotel & Restaurants using LPG

Pollutant	PM_{10}	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	2.1	0.4	0.8	0.25	0.07
Emission (T/Year)	0.136	0.026	0.117	0.016	0.005

- **Emission from open eat-outs**

From the survey it has been observed that most of the open eat-outs were using coal as cooking fuel, only a few were using LPG (Table 2.14).

Table 2.14: Emission loads from open eat-outs

Pollutant	SPM	SO_2	NO_2	CO	HC
Emission Factor (g/kg)	20	13.3	3.99	24.92	0.5
Emission (T/Year)	140.7	9.36	2.81	17.54	0.35

2.5.3. Grid wise emission inventory

The grid-wise particulate emission inventory maps were prepared from the primary and secondary data collected during the field surveys and the information received from the open cast mines, respectively. The PM emissions from restaurants, eat-outs, domestic chullahs, vehicles, crematoria, etc. were estimated based on the primary data obtained from the filed campaigns, whereas, the emissions from the mine operations were estimated based on the data received from the mines and the emission factors reported in the literature. Once the emissions rates were estimated, the cumulative emissions (including all types of sources like line, point, and area) were calculated falling under the grid defined (shown in Figure 2.3 and Figure 2.4). From the figures, it can be interpreted that the PM emissions are high on the northeast side of the study area. Whereas, the actual transport and dispersion of these emissions can be interpreted through the dispersion modelling carried out using the AERMOD model.

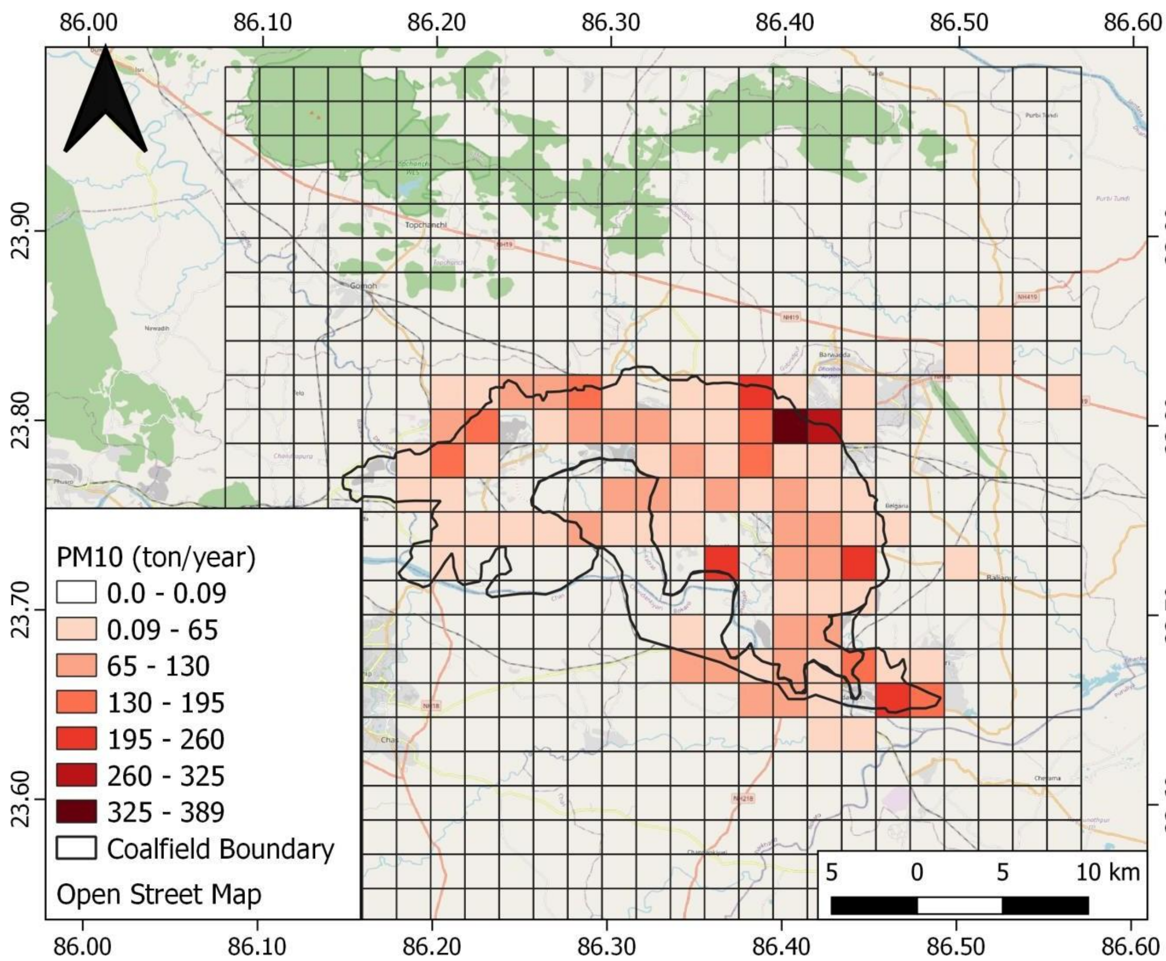


Figure 2.3 Grid-wise emission inventory of PM_{10} in tons/year over the study area

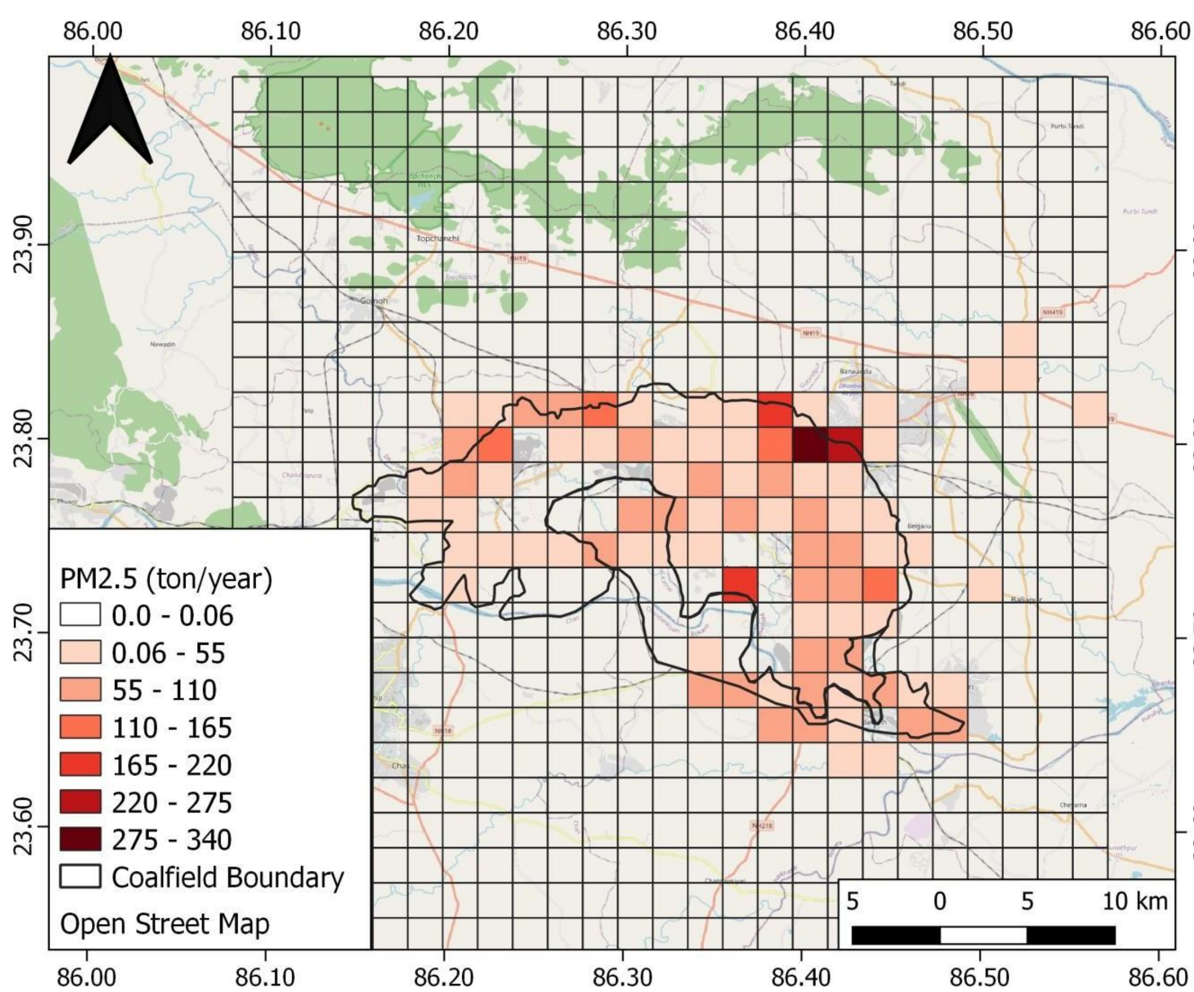
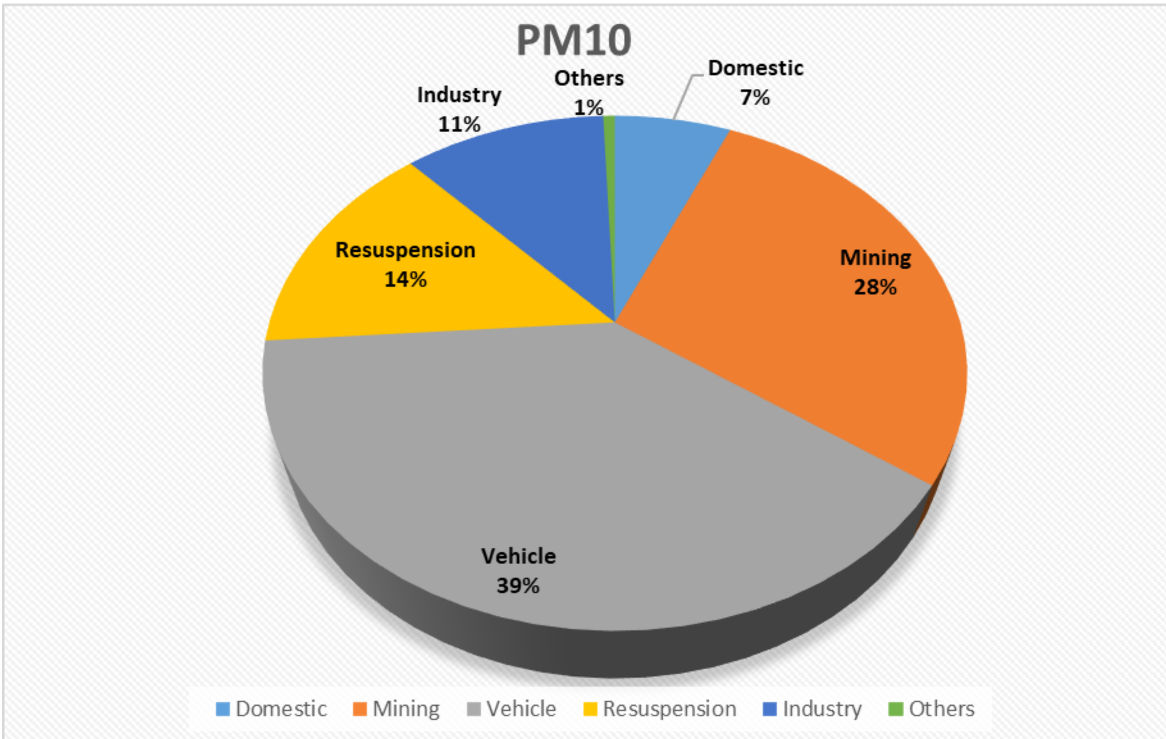
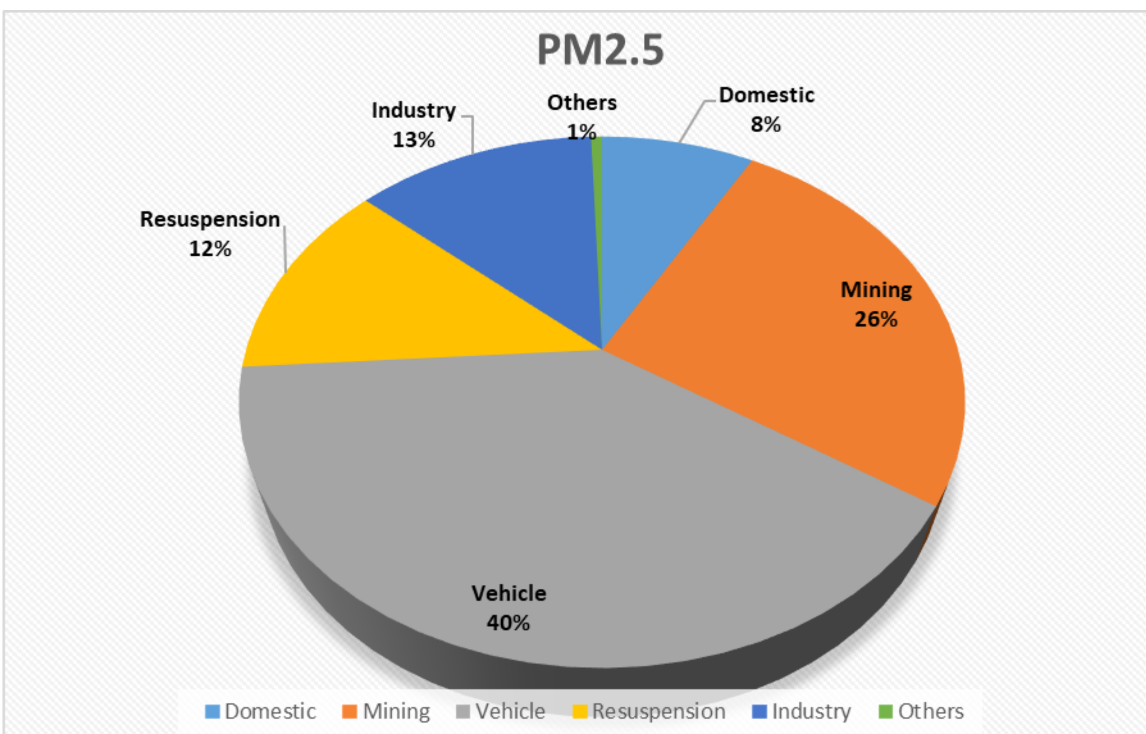


Figure 2.4 Grid-wise emission inventory of PM2.5 in tons/year over the study area

The respective share of various emission sources is represented through pie diagrams shown in Figure 2.5. Data shows that PM_{10} emissions are contributed mostly from vehicular emissions followed by emissions from the mines whereas, $PM_{2.5}$ emissions are contributed mostly from vehicular emissions, domestic burning and mine activities. The grid-wise emission inventory maps and the information on the pollution sources provide the basis for the policymakers to target the hotspots of pollution generation in order to take effective mitigation actions.



(a)



(b)

Figure 2.5 (a) and (b) represents emission load from various sectors over JCF region for PM_{10} and $PM_{2.5}$ respectively

References

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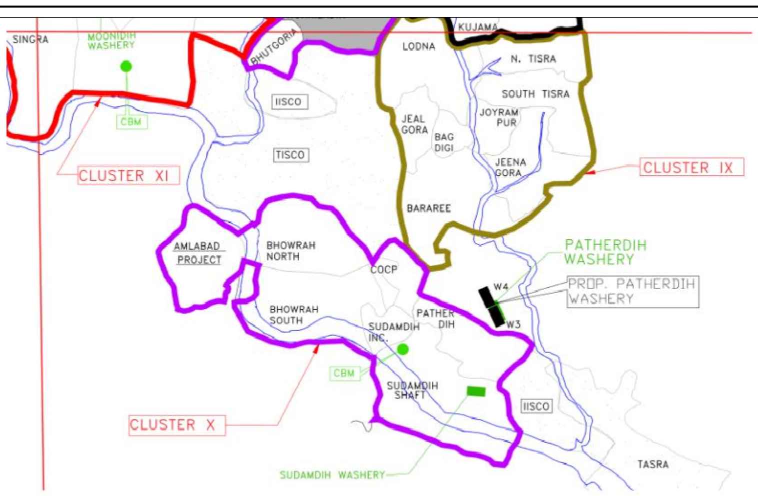
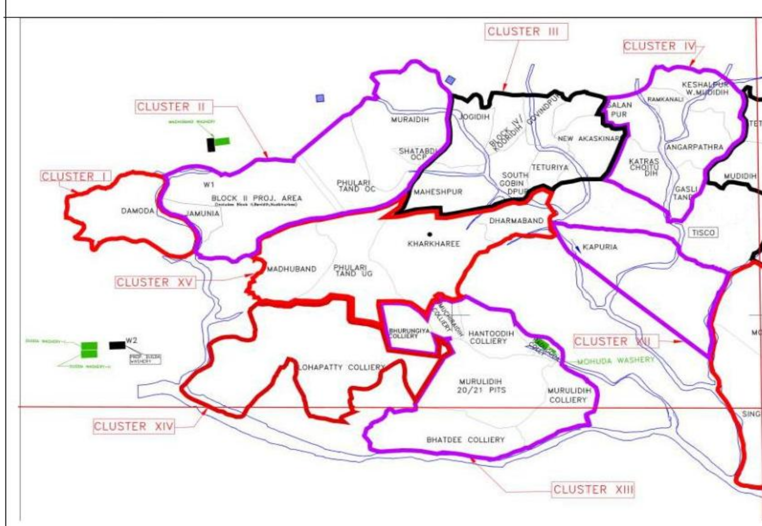
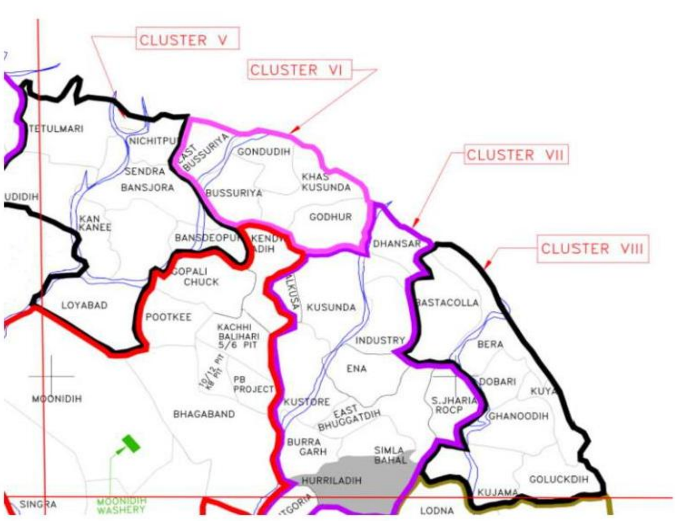
Chapter 3 Air Quality Monitoring and Receptor modelling

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. The details of the visit and mine cluster names are given in Table 3.3.1. The Entire Jharia Coal Field (JCF) is divided into 16 clusters. Both open cast 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 with their 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.

Table 3.3.1: The details of mine cluster in Jharia Coalfield

	Day 1: Cluster I, II, III, IV, XII, XIII, XV and XIV
	Day 2: Cluster V, VI, VII, and VIII
	Day 3: Cluster IX, X and XI

Based on preliminary field visit by NEERI Scientists along with BCCL staffs, the following locations (Figure 3.1) were 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 V- Katras
4. Cluster IX Lodhna
5. Cluster XI Moonidih nearby sources: Coal Mine
6. Cluster X Patherdih: nearby sources: Coal Mine, Steel Industry
7. Cluster VIII Bastacola nearby sources: Coal Mine

- **Buffer Zone**

8. Bank More
9. Harina
10. Bhuli
11. Sindri
12. Parbatpur Electro steel/ Bhaga
13. Background

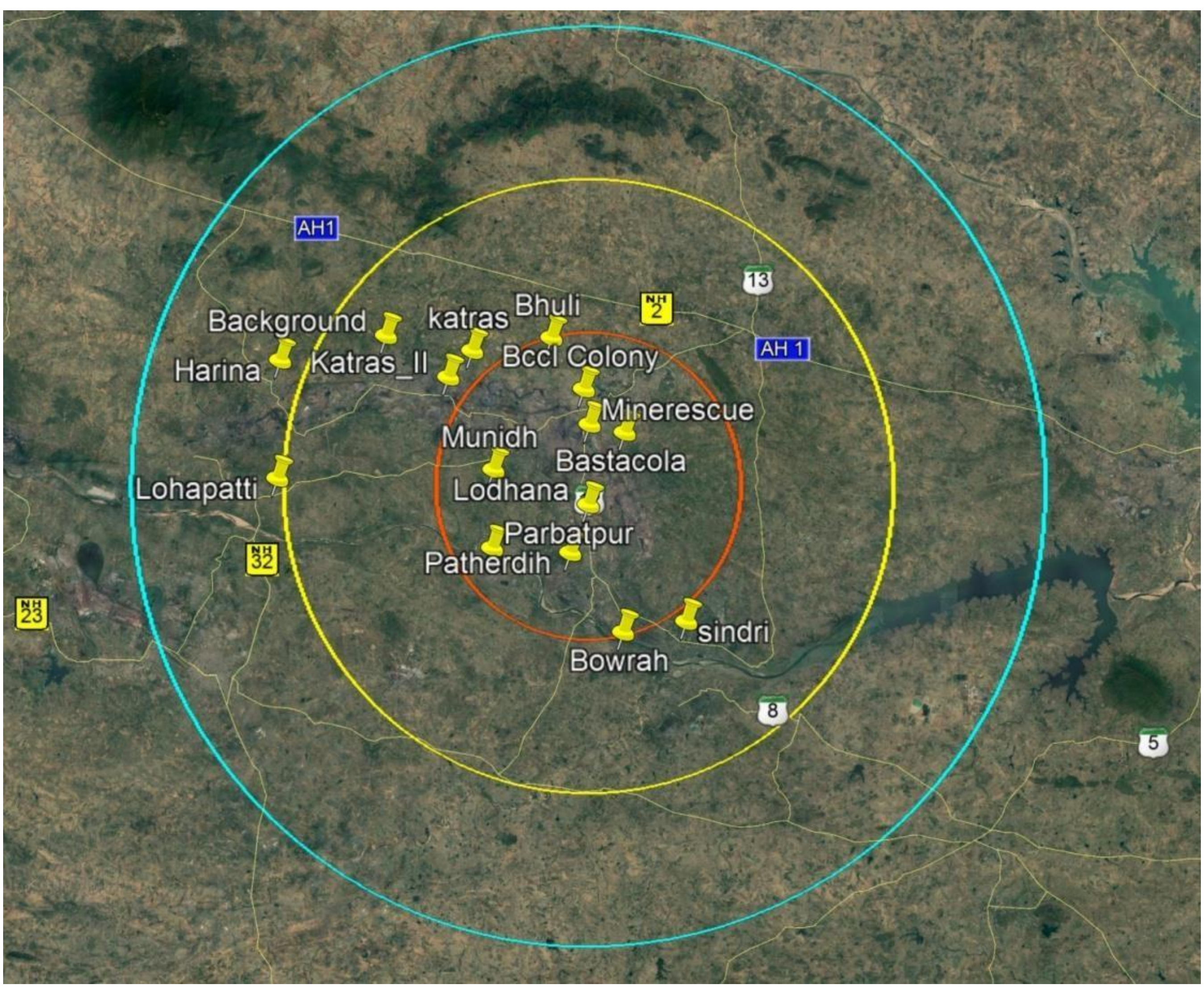


Figure 3.1: Air monitoring sites under 30 km buffer area

3.1. Sampling Method and Schedule

The PM_{10} and $PM_{2.5}$ sampling for Jharia Coalfields was done at all the 13 sampling sites for the period of 24 h using low volume respirable suspended particulate matter samplers (Instrumax, ARA and Envirotech) on Quartz and polytetrafluoroethylene (PTFE) filter paper of 47 mm diameter. Samplers at a flow rate of 16.67 LPM were used. The filter papers were desiccated before and after sampling for 24h at a temperature of 27 ± 3°C and at a relative humidity (RH) of 55 ± 2% to remove the moisture present in them. The PM_{10} and $PM_{2.5}$ field samples were collected periodically throughout the sampling period. The sampling frequency and types of equipment used for monitoring are described in Table 3.3.2 and 3.3.3. The national Ambient quality and Standards for Coal Mines (Stipulated by Ministry of Environment and Forests are depicted in Table 3.3.4. and Table 3.3.5.

Table 3.3.2: Frequency of Air pollutants sampling in Jharia Coalfields

Parameter	Number of Days	Change of Filter/ absorbing media	Reporting
PM_{10}	10	24 hourly, Teflon: 5 Days Quartz: 5 Days	24 hourly
$PM_{2.5}$	10	24 hourly Teflon: 5 Days Quartz: 5 Days	24 hourly
NO_2	10	8 hourly	8 hourly
SO_2	10	8 hourly	8 hourly

Table 3.3.3: Ambient Air Quality Sampling/Analysis Methodology for Target Pollutants

Particulars	Parameters			
	PM_{10}	**$PM_{2.5}$**	**NO_2**	**SO_2**
Sampling Instrument	INSTUMEX and ARA-N-FRM Sampler	INSTUMEX and ARA-N-FRM Sampler	APM sampler	APM sampler
Sampling Principle	Cyclonic Flow Technique	Cyclonic Flow Technique	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	7 days continuous, Teflon and quartz on alternate days	7 days continuous, Teflon and quartz on alternate days	7 days continuous	7 days continuous
Analytical Instrument	Electronic Micro Balance	Electronic Micro Balance	Spectrophotometer	Spectrophotometer
Analytical Method	Gravimetric	Gravimetric	Modified Jacob and Hochheiser method	Colorimetric Improved West & Gaeke Method
Minimum reportable value	$5 \mu g/m^3$	$5 \mu g/m^3$	$9 \mu g/m^3$	$4 \mu g/m^3$

Table 3.3.4: National Ambient Air Quality Standards (2009)

Sr. No.	**Pollutant**	**Time Weighted Average**	**Concentration in ambient Air (in µg/m³) Industrial, Residential Rural & Other Areas**	**Concentration in ambient Air (in µg/m3) Ecologically Sensitive Area**	**Concentration In ambient Air (in µg/m³) Methods of Measurement**
1	Sulphur Dioxide (SO_2)	Annual*	50	20	Improved West & Geake, Ultraviolet fluorescence
		24Hours**	80	80	
2	Nitrogen Dioxide (NO_2)	Annual*	40	30	Modified Jacob & Hochheiser (Na-Arsenite) Chemiluminescence
		24Hours**	80	80	
3	Particulate matter (Size less than 10µm) or PM_{10}	Annual*	60	60	Gravimetric, TOEM, Beta attenuation
		24Hours**	100	100	
4	Particulate matter (Size less than 2.5µm) or $PM_{2.5}$	Annual*	40	40	Gravimetric, TOEM, Beta attenuation
		24Hours**	60	60	
5	Ozone (O_3)	8 Hours*	100	100	UV photometric, Chemiluminescence chemical method
		1 Hour	180	180	
6	Lead (Pb)	Annual*	0.5	0.5	ASS / ISP method after sampling on EPM 2000 or equivalent filter paper ED-XRF using Teflon filter
		24Hours**	1	1	
7	Carbon Monoxide (CO)	Annual*	0.2	0.2	Non-dispersive Infra-Red (NDIR) Spectroscopy
		24Hours**	0.4	0.4	
8	Ammonia (NH_3)	Annual*	100	100	Chemiluminescence, Indo-phenol‟s blue method
		24Hours**	400	400	
9	Benzene (C_6H_6)	Annual*	0.5	0.5	Gas Chromatography based continuous analyzer. Adsorption and description followed by GC analysis
10	Benzo (a) Pyene (BaP)-particulate phase only	Annual*	0.1	0.1	Solvent extraction followed by HPLC / GC analysis
11	Arsenic (As)	Annual*	0.6	0.6	AAS/ ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni)	Annual*	20	20	

Table 3.3.5 Standards for Coal Mines (Stipulated by Ministry of Environment and Forests (MoEF), Vide Notification No. GSR 742(E), Dt: 25.09.2000)

Pollutant	Time weighted Average	Concentration in Ambient Air	
		New Coal Mines (commenced after 25.09.2000)	Existing Coal Mines (commenced prior to 25.09.2000)
Suspended Particulates Matter (SPM)	Annual Average 24 hours	360µg/m3 500µg/m3	430µg/m3 600µg/m3
Respirable Particulate Matter (size less than 10 µm) (RPM)	Annual Average 24 hours	180µg/m3 250µg/m3	215µg/m3 300µg/m3
Sulphur Dioxide (SO_2)	Annual Average 24 hours	80µg/m3 120µg/m3	80µg/m3 120µg/m3
Oxides of Nitrogen as NO_2	Annual Average 24 hours	80µg/m3 120µg/m3	80µg/m3 120µg/m3

3.2. Chemical Analysis

3.2.1. Gravimetric analysis

The exposed filters were analysed by gravimetric technique using a weighing balance for PM_{10} particles and using a microbalance for $PM_{2.5}$ particles with a precision of 5µg with automatic (internal) calibration.

3.2.2. Elemental analysis

PM_{10} samples collected on glass fibre filters were digested in a microwave digester. The samples were made up to 50ml using deionized distilled water. Similarly, the exposed filters containing $PM_{2.5}$ particles were cut equally into 2 halves. A part of the exposed filter was used for ions analysis. Whereas, the other half was cut into tiny fragments and digested and made up to 15mL using distilled deionized water. The obtained samples (both PM_{10} and $PM_{2.5}$) after digestion were stored in vials and refrigerated at 4°C until further analysis. These samples were later subjected to estimate the elemental composition using ICP-OES (Thermo Scientific, USA).

3.2.3. Analysis of SO_2 and NO_2

SO_2 analysis: Modified West and Gaeke method was followed for sampling and analysis of Sulfur dioxide in ambient air. SO_2 from the air is absorbed in a solution of potassium tetracholo-mercute (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air was formed. Once formed, that complex was stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex was made to react with pararosaniline and formaldehyde to form the intensely colored pararosanline methylsulphonic acid. The absorbance of the solution was measured by means of a suitable spectrophotometer.

NO_2 analysis: Modified Jacobs and Hochheiser method was followed for sampling and analysis of NO_2 in ambient air. Ambient NO_2 was collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion produced during sampling was determined calorimetrically by the nitrite ion reaction with phosphoric acid, sulphanilamide, and N-(1-napthyl)-ethlylenediamine di-hydrochloride (NEDA) and the absorbance of the highly colored azo dye was measured at 540nm.

3.2.4. Ion analysis

The filter papers containing both PM_{10} and $PM_{2.5}$ samples were extracted and subjected to ion analysis as per standards. The filter papers were divided into tiny fragments and moistened with isopropanol slightly before extraction since the filters are hydrophobic. Further 25 mL of deionized distilled water was added and sonicated using an ultrasonic bath for 60 min at 60°C. The samples were then kept overnight after sonication. Furthermore, the samples were then filtered using nylon filter discs (25mm, 0.45mm) and were refrigerated at 4°C until further analysis. The extracted samples were subjected to IC to analyse the ions (anions and cations) present in them.

3.2.5. Polycyclic Aromatic Hydrocarbons (PAH) analysis

Filter papers were cut into pieces using scissors and transferred to a 100 ml beaker and 50 ml of Dichloromethane (DCM) (GC/HPLC grade) was added. The samples were extracted with DCM using an ultrasonic bath for about 30 minutes. The extracted samples were filtered with Whatman filter paper containing 2gm Anhydrous Sodium Sulphate. After filtration, the filtrate is concentrated using a rotary vacuum evaporator to 2ml final volume. Solid-phase extraction may be used to clean up the impurities of the sample and re-concentrated in a rotary evaporator. The samples were analyzed through GC with conditions as injector 300°C and FID temperature 320°C.

3.2.6. EC & OC analysis

This is a thermal/optical-transmittance (TOT) method that speciates carbon in particulate matter collected on a quartz-fiber filter into OC, EC, and CC. In the first (or non-oxidizing) heating stage, organic and carbonate carbon is thermally desorbed from the filter under a flow of helium with controlled temperature ramps. The oven is then partially cooled, and the original flow of helium is switched to an oxidizing carrier gas (He/O_2). In the second (or oxidizing) heating stage, the original elemental carbon component plus pyrolyzed organic carbon formed during the first heating stage are oxidized/desorbed from the filter with another series of controlled temperature ramps. All carbon evolved from the sample is converted to CO_2 in an oxidizing oven immediately downstream from the desorption oven, and the CO_2 is converted to methane (CH_4) by a methanator oven before being measured with a flame ionization detector (FID). (https://www3.epa.gov/ttnamti1/files/ambient/pm25/spec/RTIOCECSOP.pdf)

3.3. Results

3.3.1. Mass concentration of PM_{10} and $PM_{2.5}$

In summer monitoring, the mean mass concentrations of PM_{10} particles in all 13 sampling sites were found to be in the range of 74-184µg/m^3 with the highest concentration of 184µg/m^3 at mine rescue site and lowest concentration of 74µg/m^3 at Bastacola site. Also, the mean mass concentration of $PM_{2.5}$ particles was found in the range of 49-117µg/m^3 with the highest concentration of 117µg/m^3 and the lowest concentration of 49µg/m^3 recorded at Harina and Lohapatti site respectively.

The average concentrations of PM_{10} and $PM_{2.5}$ in two seasons are described in Table 3.6 and 3.7. Results revealed that the average concentrations of PM_{10} are within the prescribed limits of MoEF notification guidelines for coal mine areas. In the case of $PM_{2.5}$, there is no Govt. notified standard for mining areas but in the case of buffer zones, National Ambient Air Quality Standard, NAAQS, 2009 may be applicable. The highest PM_{10} and $PM_{2.5}$ concentrations were found in Mine rescue and Harina (Figure 3.2 and 3.3).

Table 3.6: Average concentration of PM_{10} and $PM_{2.5}$ in Summer of Jharia Coalfield

Monitoring Sites		**Average Concentration (µg/m^3)-Summer**	
	Site Description	**PM_{10} (µg/m^3)**	**$PM_{2.5}$ (µg/m^3)**
Lohapatti	Core Zone	133.7	49.42
		(83-203)	(44-83)
Mines Rescue	Core Zone	184.8	83.43
		(124-255)	(55-205)
Katras	Core Zone	141.4	80.01
		(100-216)	(42-150)
Lodhna	Core Zone	156.8	63.98
		(100-303)	(32-99)
Moonidih	Core Zone	118.4	62.84
		(80-153)	(34-94)
Patherdih	Core Zone	94.7	67.22
		(50-119)	(37-91)
Bastacola	Core Zone	104.32	93.27
		(154 -316)	(64-158)
BCCL colony	Buffer Zone	157.35	74.37
		(113-222)	(47-103)
Harina	Buffer Zone	177.7	117.3
		(73-265)	(42-175)
Bhuli	Buffer Zone	141.7	105.89
		(85-243)	(44-161)
Sindri	Buffer Zone	122.2	76.05
		(82-139)	(18-127)
Parabatpur	Buffer Zone	122.4	110.98
		(86-171)	(70-150)
Background	Buffer Zone	144.4	57.13
		(24-255)	(23-97)

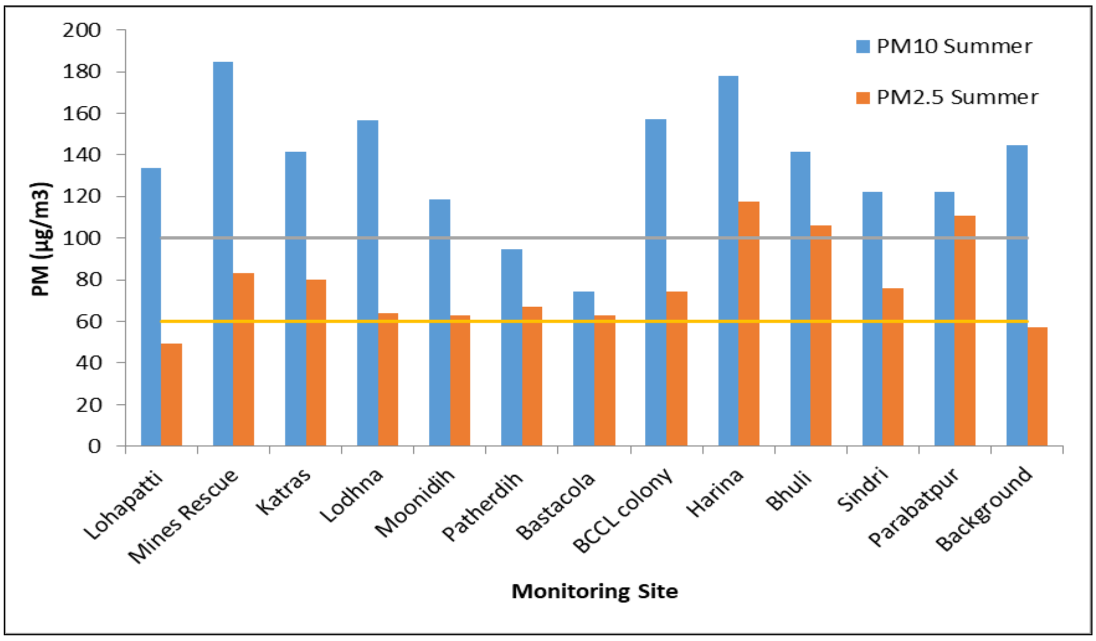


Figure 3.2: Average concentration of PM_{10} and $PM_{2.5}$ in JCF region in summer compared to NAAQS (2009)

Table 3.7: Average concentration of PM_{10} and $PM_{2.5}$ in winter of Jharia Coalfield.

Monitoring Sites	**Site Description**	**Average Concentration (µg/m³)-Winter**	
		PM_{10} (µg/m³)	**$PM_{2.5}$ (µg/m³)**
Lohapatti	Core Zone	174.28	139.59
		(122-241)	(114-236)
Mines Rescue	Core Zone	303.49	176.97
		(175-350)	(114-233)
Katras	Core Zone	230.06	50.87
		(134-332)	(24-78)
Lodhna	Core Zone	322.8	112.17
		(243-412)	(98-209)
Moonidih	Core Zone	300.16	188.27
		(128-728)	(64-600)
Patherdih	Core Zone	222.71	113.23
		(182-246)	(111-167)
Bastacola	Core Zone	332.05	176.48
		(251-663)	(54-425)
BCCL colony	Buffer Zone	219.98	128.79
		(155-300)	(94-175)
Harina	Buffer Zone	130.73	42.93
		(65-215)	(44-98)
Bhuli	Buffer Zone	174.75	151.66
		(150-200)	(89-180)
Sindri	Buffer Zone	171.82	167.07
		(81-210)	(142-184)
Parabatpur	Buffer Zone	228.76	148.16
		(75-660)	(101-192)
Background	Buffer Zone	233	121.18
		(195-254)	(63-170)
Katras II		107.13	98.42
	Core Zone	(128-181)	(94-104)

Whereas in winter monitoring, the highest PM_{10} mass concentration was found to be 332µg/m^3 at Bastacola site (exceeding the prescribed limit of **GSR 742(E)**) along with other core mining zones like Mines Rescue, Moonidih. The lowest average concentration of PM_{10} was found in Katras II (Table 3.7).

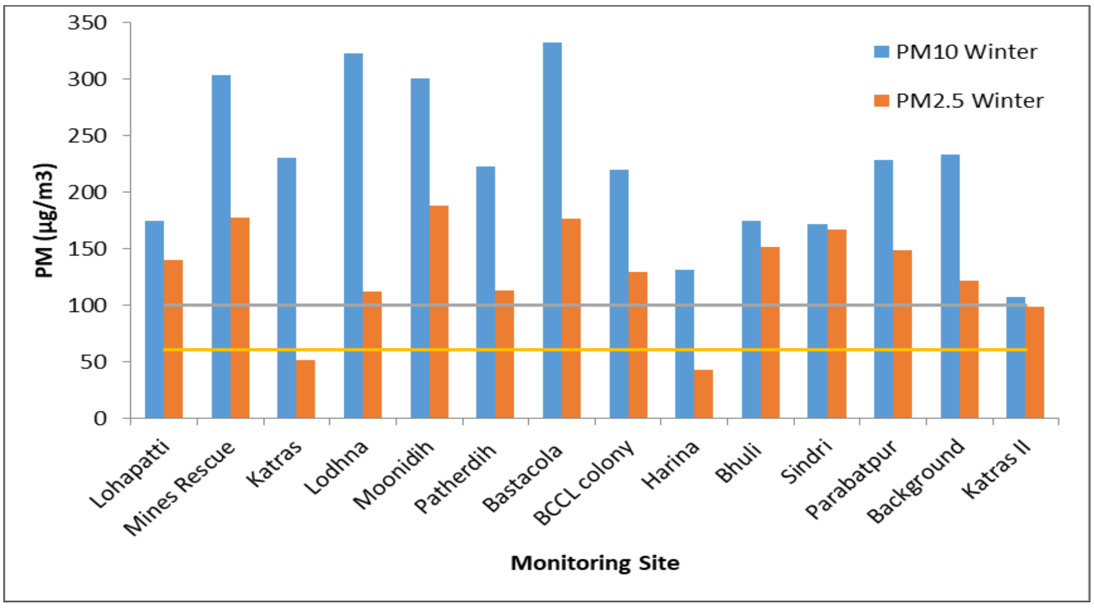


Figure 3.3: Average concentration of PM_{10} and $PM_{2.5}$ in JCF region during Winter compared to NAAQS (2009)

3.3.2. Elemental concentration of PM_{10} and $PM_{2.5}$ in summer

The digested samples of PM_{10} and $PM_{2.5}$ particles from all the 13 sampling sites were subjected to estimate the elemental composition using ICP-OES. The analysis of PM_{10} particles yields 11 different elements such as Al, As, Cd, Co, Cu, M, Ni, Pb, Zn, Fe and Cr. Similarly, the samples containing $PM_{2.5}$ particles revealed the same elements as PM_{10}. It was observed that Al and Fe were found to be higher for both PM_{10} and $PM_{2.5}$ particles. Al is the most abundant element. The concentration of Al was detected in the range of 6.32-14.62µg/m^3. Maximum Al concentrations were found at BCCL colony, Parbatpur, Harina and Background. The concentrations of Fe and Cr were estimated as 0.78-7.74µg/m3 and 0.075-1.32µg/m3 respectively. The highest concentrations of both Fe (7.74µg/m3) & Cr (1.32µg/m3) were found at the Bastacola site Figure **3.4.** Similarly, in the case of PM2.5 particles the concentrations of Al (4.87-14.47µg/m3), Fe (0.44-11.77µg/m3) and Cr (0.066-2.17µg/m3) were found higher than other elements. For PM2.5 particles, maximum concentrations of Fe (11.77µg/m3) and Cr (2.17µg/m3) were obtained at the Mine Rescue site and Al (14.47µg/m3) at Katras. Since, the elements such as Al, Fe and Cr possess higher concentrations in the PM10 elemental composition, Al would have been emitted from road dust, whereas Fe would have been emitted from the re-suspension of dust containing deposits from the emissions of vehicular and other anthropogenic activities Figure 3.5.

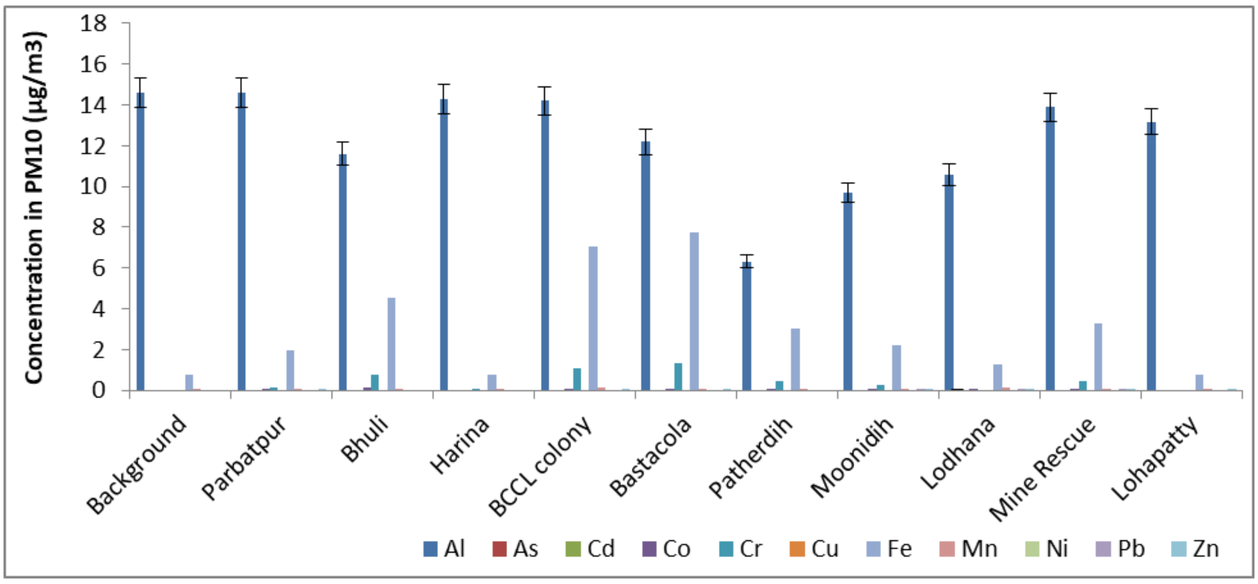


Figure 3.4: Metal concentration of PM_{10} in the summer season

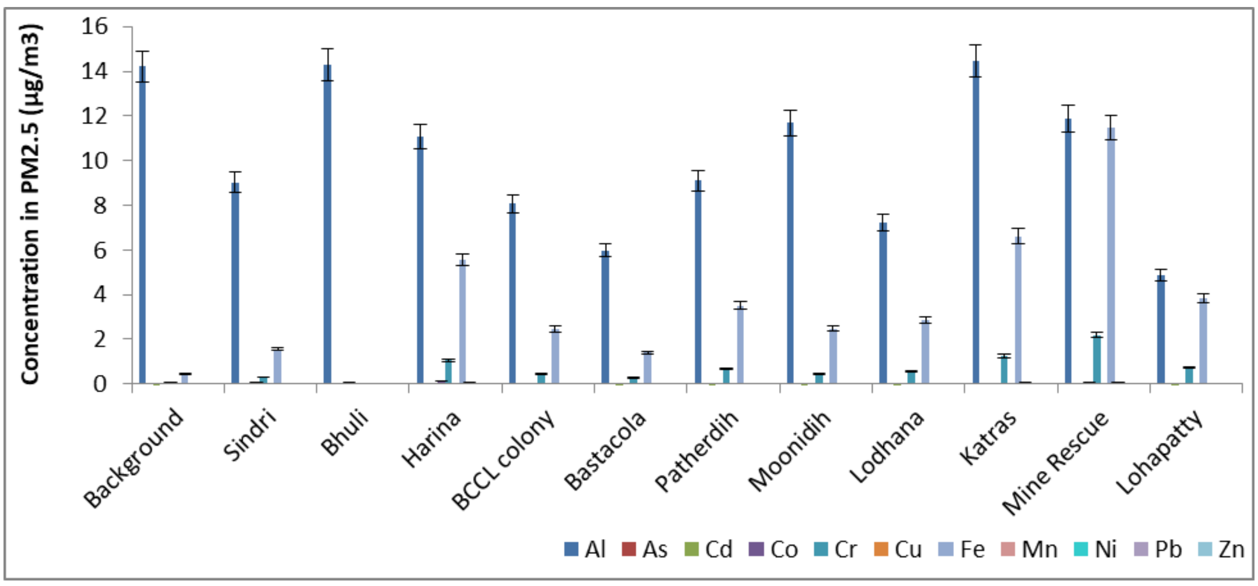


Figure 3.5: Metal concentration of $PM_{2.5}$ in the summer season

3.3.3. Elemental Concentration of PM_{10} and $PM_{2.5}$ in Winter

The elemental analysis was performed using inductively coupled plasma optical emission spectroscopy (ICP-OES). For the air quality assessment, the concentrations of 11 elements i.e. Al, As, Cd, Cr, Cu, Fe, K, Mn, Ni, Pb, and Zn in PM_{10} and $PM_{2.5}$ samples, were measured. Among all the elements, Al, Fe, and K concentrations were found considerably higher for PM_{10} samples in the winter season. Al was observed in the range of 2.02-10.77µg/m3 followed by Fe (0.79-9.26µg/m3) and K (0.90-4.19µg/m3). Maximum Al concentration (10.77µg/m^3) was observed at the BCCL colony, followed by Lodhna (10.29µg/m^3). The Highest Fe concentration (9.26µg/m^3) was observed at Bastacola while K (4.19µg/m^3) at the Lodhna site. This may be due to vehicular emissions, paved roads, construction dust, coal combustion, soil dust, etc. The concentration of As, Ni, Pb was found within the limits of CPCB standards. The remaining elements i.e. Cd, Cr, Cu, Mn, and Zn were found very low (Figure 3.6).

Similarly, in the case of $PM_{2.5}$ samples concentrations of Al, Fe and K were detected higher than other elements. The concentration of Al, Fe, and K was obtained as 0.11-2.91µg/m^3, 0.05-1.93µg/m^3 and 0.08-2.12µg/m^3. For $PM_{2.5}$ particles, maximum Al and K were found at the Munidih site, which were 2.91µg/m^3 and 2.12µg/m^3 respectively. The highest concentration of

Fe i.e. 1.93µg/m^3 was detected at Lodhna site. The concentrations of all other analysed elements were low (Figure 3.7).

From the elemental analysis of the summer and winter seasons, it was observed that the average Al concentration obtained was more in the summer season than in the winter season. In contrast, the average concentration of Cr was more in the winter season.

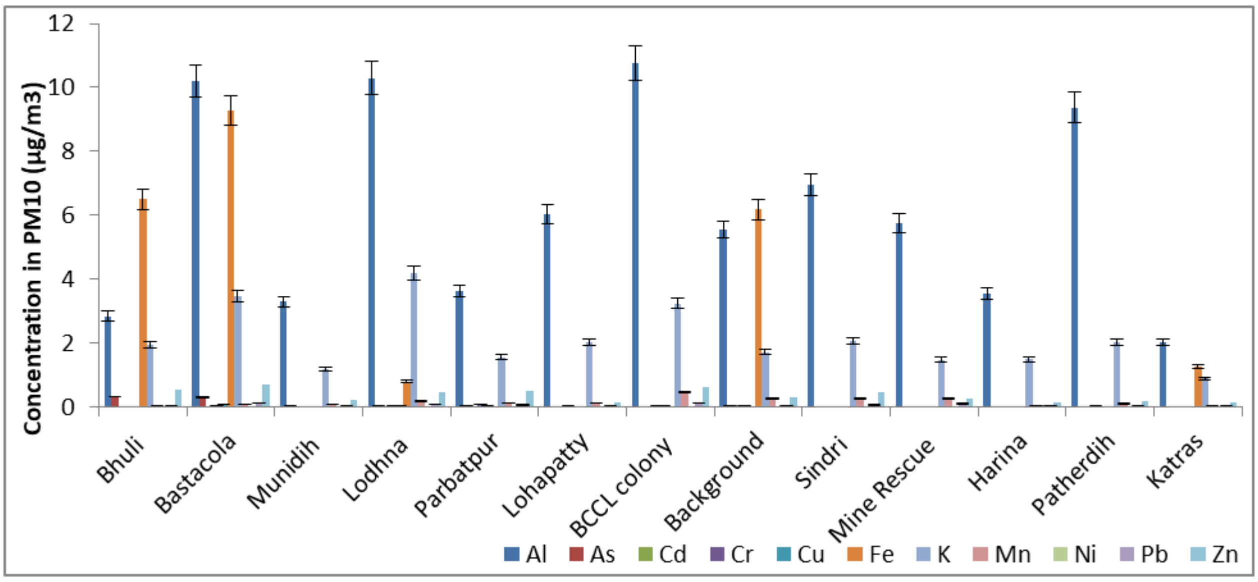


Figure 3.6: Metal concentration of PM_{10} in winter season

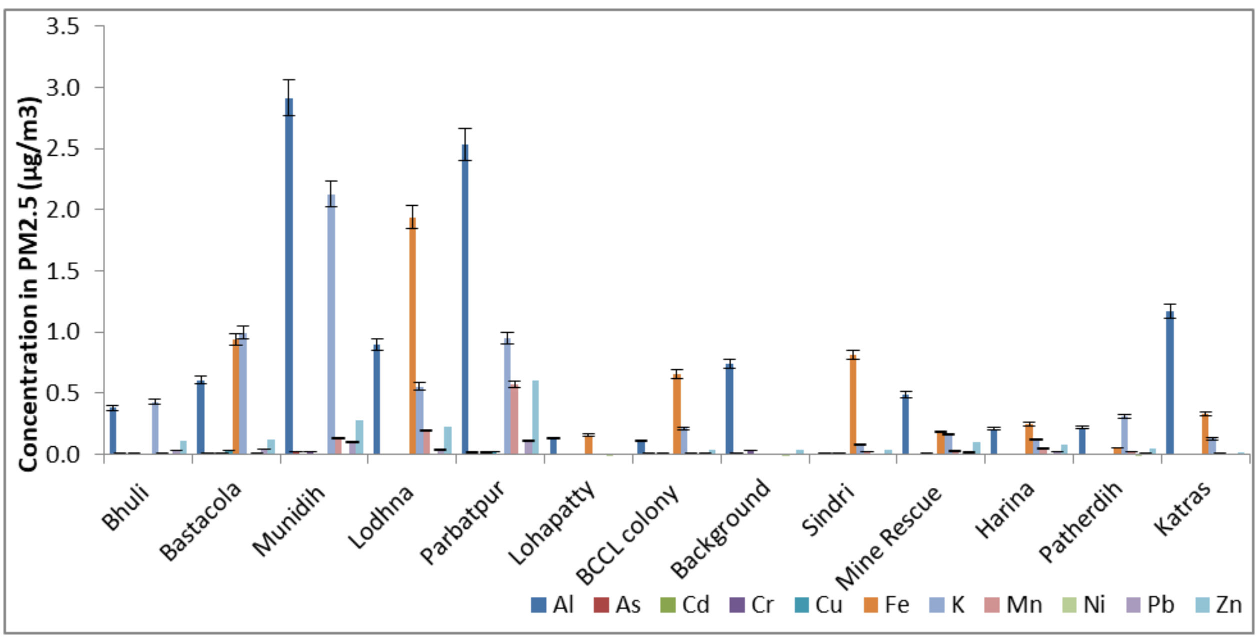
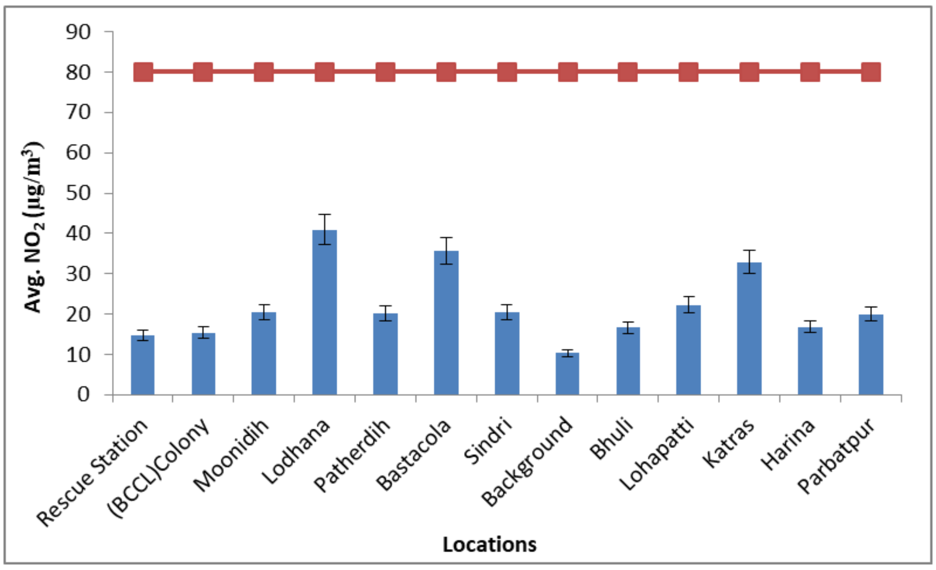


Figure 3.7: Metal concentration of PM 2.5 in winter season

3.3.4. SO_2 and NO_2 concentration in ambient air in the Summer season

The mean average SO_2 concentration in the summer season among all the monitoring stations ranged between 11µg/m^3 (Harina & Bastacola) and 24.5µg/m^3 (Moonidih), being well below the threshold limits of 80µg/m^3 (residential or industrial). The 8-hour average NO_2 concentrations were between 10.3µg/m^3 (Background) and 40.9µg/m^3 (Lodhana), well within the standard limits of 80µg/m^3 (residential or industrial) Figure 3.8. The SO_2 in the residential areas may be received from the open burning of raw coal and other domestic and commercial activities.



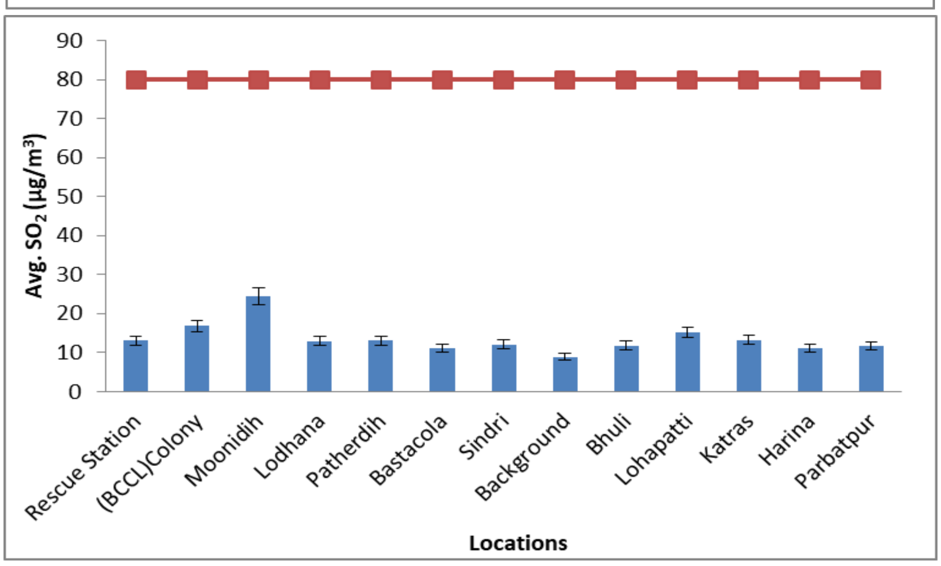
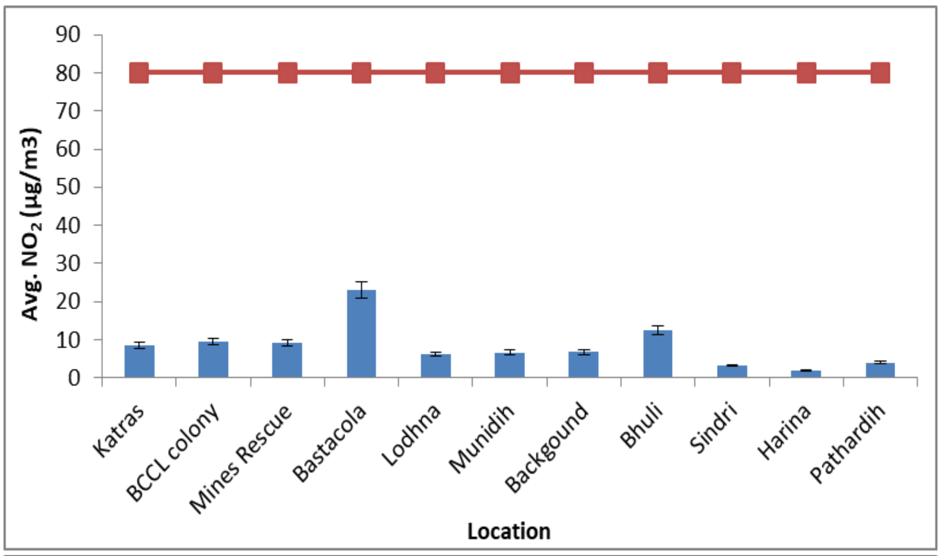


Figure 3.8: NO_2 and SO_2 Concentration of all monitoring sites in summer season

3.3.5. SO_2 and NO_2 concentration in ambient air in Winter season

The mean concentration of NO_2 and SO_2 in the winter season was found below the threshold limit i.e. 80µg/m^3. The concentration of SO_2 was below 10µg/m^3 in Katra, BCCL colony, Mine Rescue, Bastacola, Lodhana and Munidih. Bastacola and Bhuli site has a NO_2 concentration above 10µg/m^3 (Figure 3.9). It has been observed that the concentration of NO_2 and SO_2 in the winter and summer seasons were below the standard limit. But the average concentration of NO_2 and SO_2 in the summer season was higher than in the winter season.



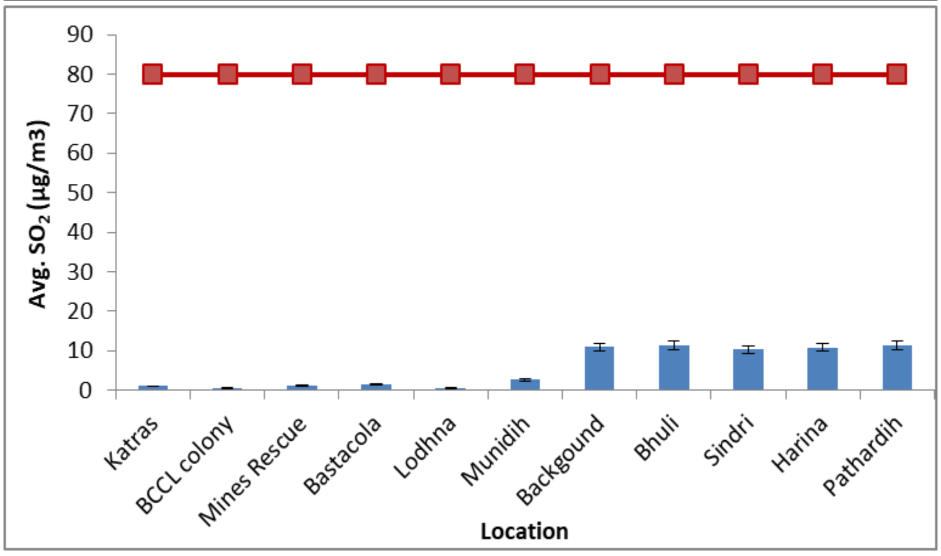


Figure 3.9: NO_2 and SO_2 Concentration of all monitoring sites in Winter season

3.3.6. Carbonaceous Aerosol/EC & OC in Summer

Data were obtained for four OC fractions (OC1, OC2, OC3 and OC4 in He atmosphere at 140, 280, 480 and 580°C, respectively) and three EC fractions (EC1, EC2, and EC3 in a 2% O2/98% He atmosphere at 580, 740 and 840°C, respectively). The IMPROV protocol defines OC as OC1 + OC2 + OC3 + OC4 and EC as EC1 + EC2 + EC3. The mass concentration of organic matter (OM) in the atmosphere was estimated by multiplying OC by 1.6 (conversion factor for urban aerosol). The total carbonaceous aerosol (TCA) was calculated as the sum of OM and EC. The highest concentration of OC and EC in $PM_{2.5}$ was found in the BCCL colony site i.e. 37.85 and 42.33µg/m^3, respectively, and the lowest OC concentration was 15.36µg/m^3 and EC was 13.08µg/m^3 in Sindri site. In comparison, the concentration of OC (67.35µg/m3) and EC (81.67µg/m^3) in PM_{10} were higher in the BCCL colony among all the sites. The lowest OC concentration as 17.95µg/m^3 was in Bastacola and EC in Parbatpur i.e. 15.44µg/m^3 (Figure 3.10).

3.3.7. Carbonaceous Aerosol/EC & OC in winter

The mass concentration of EC and OC in PM_{10} and $PM_{2.5}$ are more significant than 100µg/m^3 and 70µg/m^3, respectively in Bastacola, Katras, Mine Rescue, Background, and Sindri. The highest concentration of EC in PM_{10} and $PM_{2.5}$ was observed in the Sindri site, whereas OC was found higher in Sindri and Bastacola. OC contributing to PM_{10} mass concentration was lowest in

Harina followed by Lohapatti and Patherdih. In the case of $PM_{2.5}$, Parbatpur was found to have the lowest concentration among other sites.

The higher mean concentration of EC and OC in winter were likely related to the influence of emissions from residential heating (in addition to traffic source) and, on the other hand, to the unfavourable meteorological conditions leading to more excellent dispersion of pollutants in the atmosphere during this season. Elemental carbon is emitted directly into the atmosphere during incomplete combustion emissions, such as motor vehicle exhaust, fuel burning, and biomass burning (Figure 3.11).

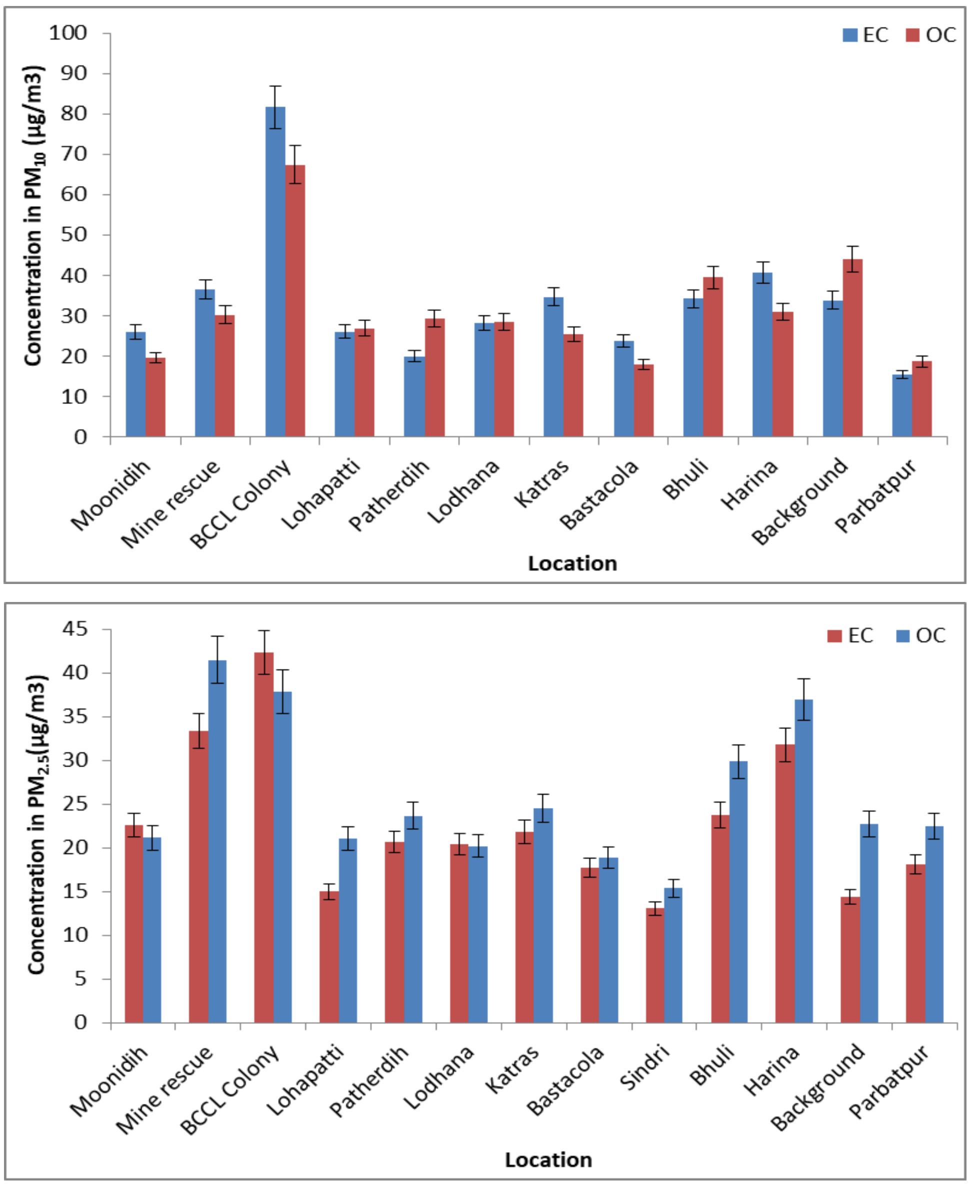


Figure 3.10: EC & OC concentration in PM_{10} and $PM_{2.5}$ in Summer season

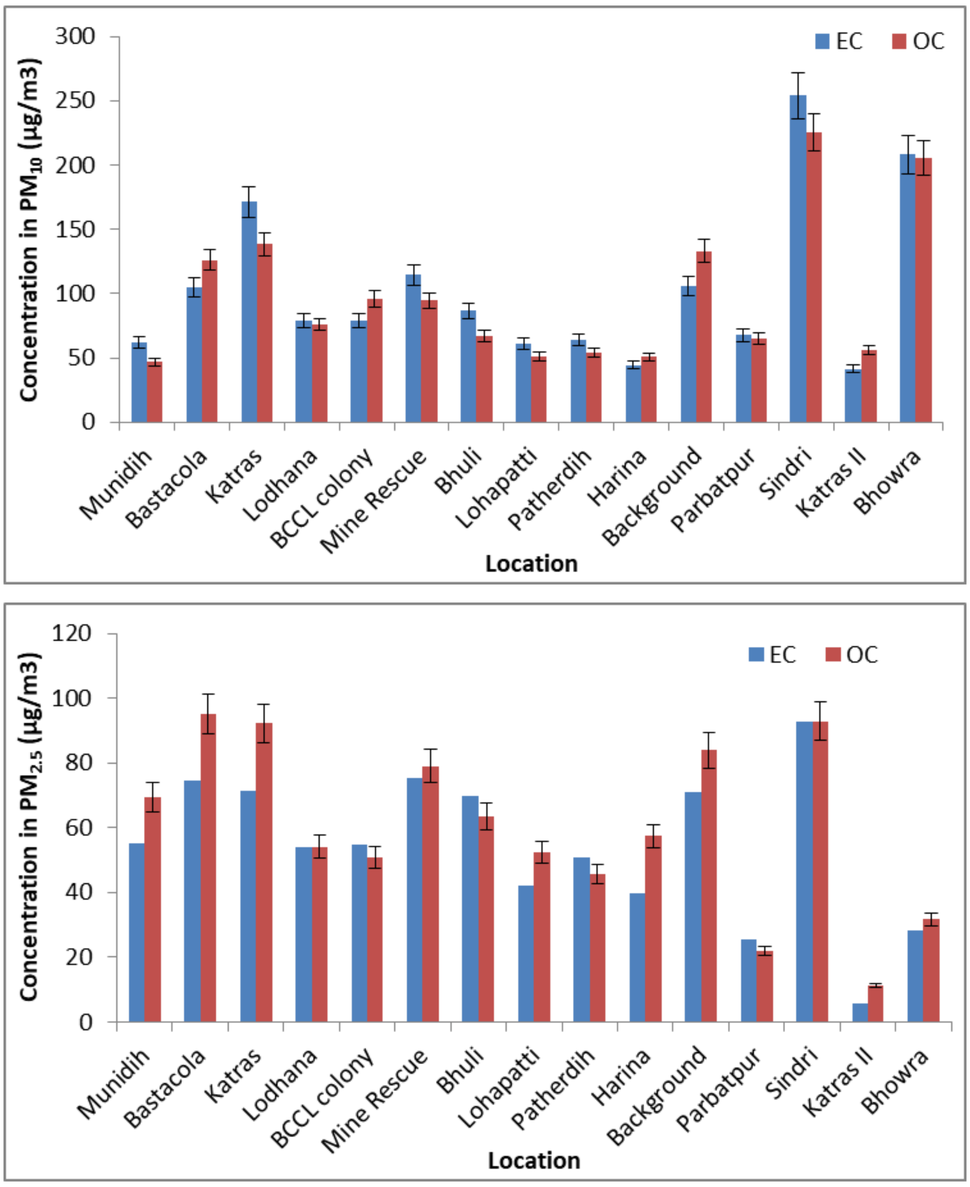


Figure 3.11: EC & OC concentration in PM_{10} and $PM_{2.5}$ in Winter Season

3.3.8. Ionic composition of PM_{10} and $PM_{2.5}$ in Summer season

The anions (SO_4^{2-}, NO_3^- and Cl^-) and cations (NH_4^+, Na^+, Ca^{2+}, K^+) are the water-soluble inorganic ions found in abundance. In summer, the mass concentration of SO_4^{2-} in PM_{10} was in the range of 1.06-20.17µg/m^3 where a higher concentration was observed in Harina, BCCL colony, and Lodhana sites. Likewise, NO_3^- was in the range of 0.32-19.2µg/m^3 with the highest in the Harina site. PO_4^{3-} and Cl^- concentration was highest in Harina and < 2µg/m^3 in other locations. NH_4^+ was in the range of 0.75-16.24µg/m^3, Harina with the highest concentration, and Bastacola with the lowest concentration. Na^+ concentration (0.18-8.6µg/m^3) was highest in Harina followed by BCCL colony and less than 2µg/m^3 in remaining sites. Ca^{2+} concentration (1.5-11.77µg/m^3) was highest in Lohapatti and BCCL colony while lowest in Katras. K^+ ion was also observed in the Harina site with a concentration of 5.85µg/m^3 (Figure 3.12).

The mass concentration of SO_4^{2-} in $PM_{2.5}$ was highest in Patherdih with a concentration of 15.13µg/m^3 and lowest in Bhuli. In Bastacola site, the concentration of NO_3^- (2.85µg/m^3), Cl^- (2.04µg/m^3), K^+ (1.84µg/m^3) were the highest among the other sites. Ca^{2+} (6.17µg/m^3) and Mg^{2+} (0.57µg/m^3) concentration was highest in Lohaptti site (Figure 3.13).

3.3.9. Ionic composition of PM_{10} and $PM_{2.5}$ in Winter season

PM_{10} ions concentration in Bastacola and Background were highest among all the monitoring sites which followed the increasing order of $Na^+ < Mg^{2+} < F^+ < K^+ < Ca^{2+} < Cl^- < NH_4^+ < SO_4^{2-} < NO_3^-$. It has been observed that SO_4^{2-}, NO_3^- and NH_4^+ ions were present in abundant in PM_{10} mass concentration, and concentration of NO_3^- in these sites contributes majorly to PM_{10}. Ions concentration in Katras, Lohapatti, and Bhuli sites were observed having lower ionic concentration Figure 3.14.

The ionic composition of $PM_{2.5}$ comprises mainly of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Ca_2^+ and K^+ ions. Locations such as Bastacola and Parbatpur have higher concentration of ions compared to remaining sites in following order: $Mg^{2+} < Na^+ < Ca^{2+} < K^+ < Cl^- < NH_4^+ < SO_4^{2-} < NO_3^-$. The same trend has been observed i.e. SO_4^{2-}, NO_3^- and NH_4^+ ions contribute mainly in $PM_{2.5}$ mass concentration. The average concentration of SO_4^{2-} and NO_3^- in winter was higher than in summer.

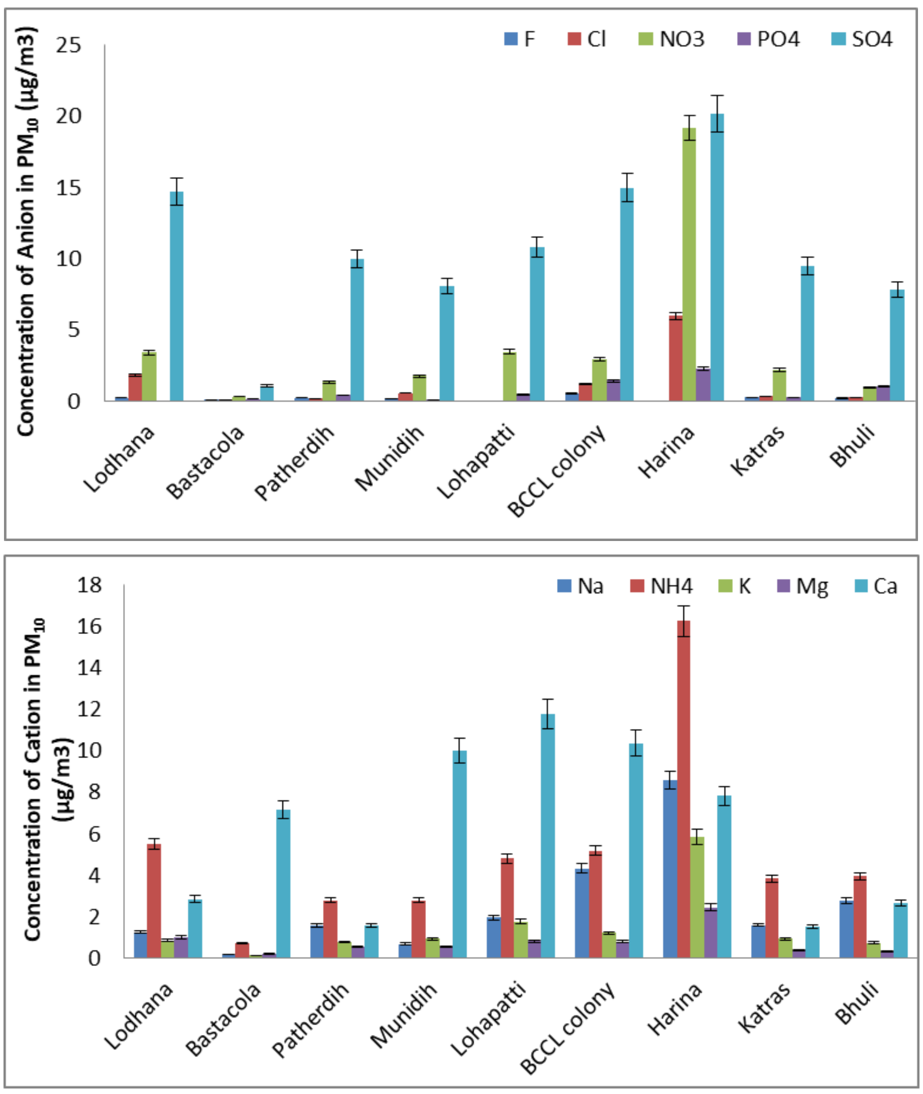


Figure 3.12: Anion and Cation concentration in PM_{10} in summer

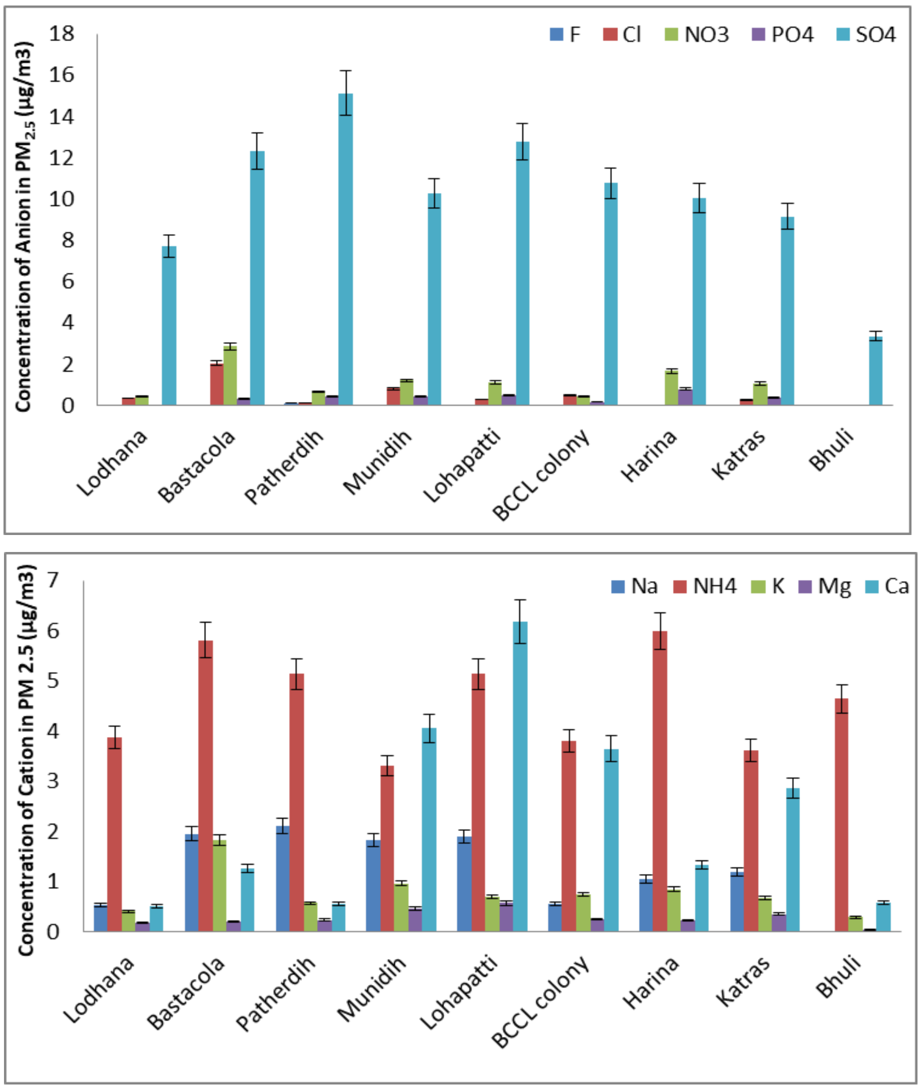


Figure 3.13: Anion and Cation concentration in $PM_{2.5}$ in summer

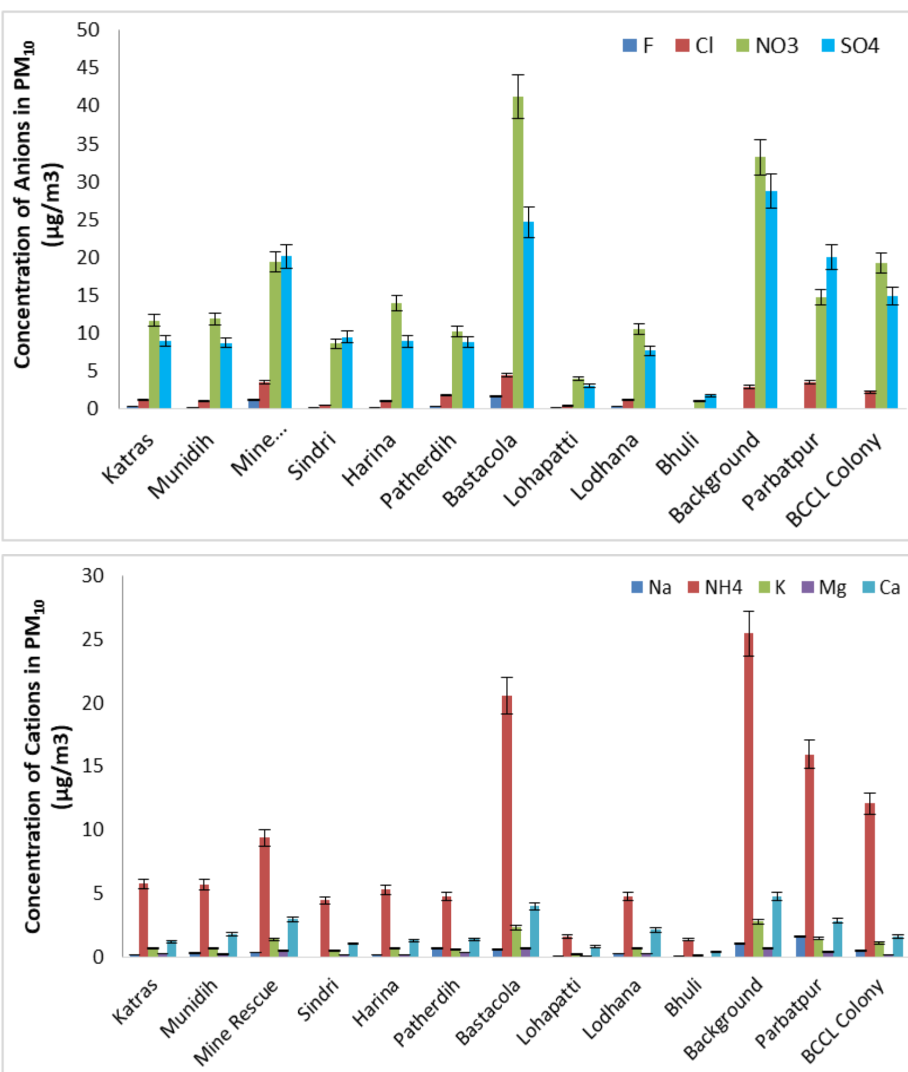
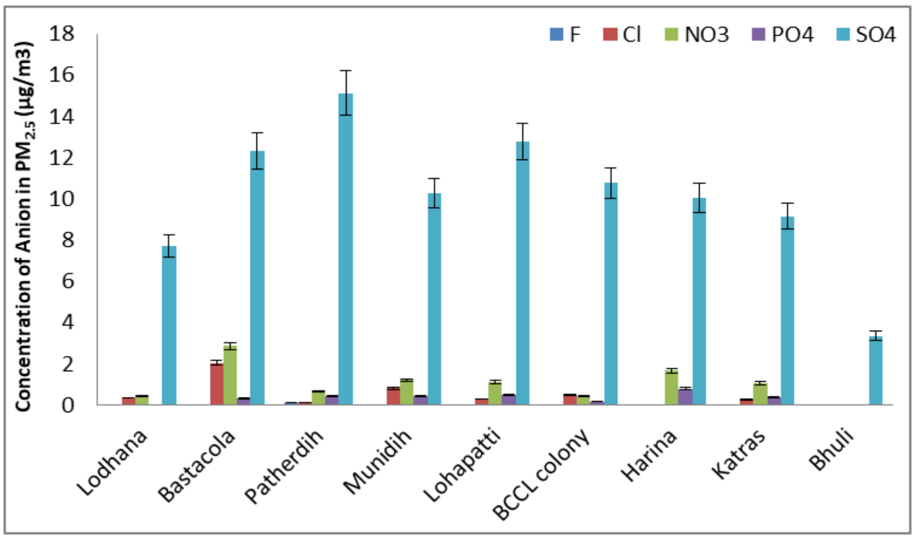


Figure 3.14: Anion and Cation concentration in PM_{10} in winter



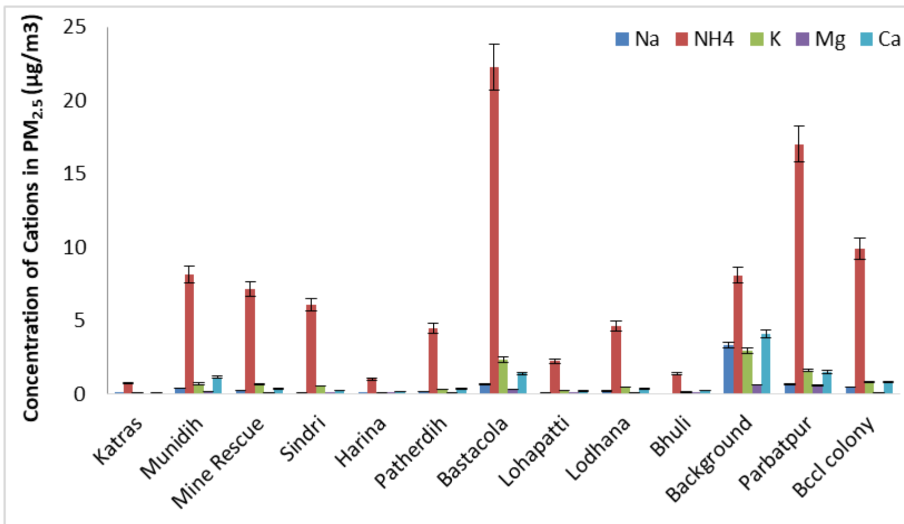


Figure 3.15: Anion and Cation concentration in $PM_{2.5}$ in winter

Chapter 4 Receptor modelling

4.1. Source Apportionment

The source apportionment study was carried out to identify the potential sources contributing to the particulate matter of aerodynamic size less than 10 µm in the Jharia coalfield (JCF) using a receptor modelling approach. In receptor modelling, the particulate matter (PM_{10}) characterization in terms of metal, ions, elementary and organic carbon profiles is statistically matched with that of various source profiles in the study area. For the source apportionment study of JCF, the area is divided into various zones (buffer, core and background zone). And the ambient PM_{10} characterization obtained from the multiple monitoring locations in the study area is conflated and compared with source profiles viz. industrial (mining and non-mining) and allied industrial activities, transportation, local vehicular movement and domestic fuel (coal wood burning, etc.). The chemical mass balance (CMB) model EPA-CMB v8.2 is one of the several receptor models and is most trusted for coarse and fine particulate matter source apportionment. The CMB model estimates source contributions by determining the best linear combination of emission source profiles and the chemical composition of ambient particulate, aerosol, and volatile organic compound samples. The study is studying the apportionment of particulate matter is considered owing to the nature of high particulate matter pollution in the study area. The source apportionment study is useful for devising an effective action plan for abatement of emission load in the region; thereby the region‟s overall air quality can be improved.

Jharia is one of the eight blocks in Dhanbad and is the main source of metallurgical coal in India, and is termed as the powerhouse of the country owing to its best quality coking coal, which is required by the steel and other industries in India. Dhanbad lies between 23°37‟3” N and 24°4‟ N latitude and between 86°6‟30” E and 86°50‟ E longitude with an average elevation of 222 m. Its geographical length, extending from North to South, is 43 miles and width 47 miles, stretching across East to West. It shares its boundaries with West–Bengal in the Eastern and Southern parts, Dumka and Giridih in the North, Bokaro in the west. It is the administrative headquarter of the district and Dhanbad Municipal Corporation (DMC).

The air quality status is determined by dividing the study area into background, core, and buffer zones. Thirteen sites were selected to represent various regions, including two references or background sites. The sampling locations are shown in Figure 3.1.

4.1.1. Chemical Mass Balance (CMB)

A mass balance equation can be written to account for all the chemical species in the samples as contributions from independent sources:

$$\mathbf{C_i = \sum_j m_j X_{ij} a_{ij}} \qquad 4.1$$

C_i is the concentration of species i measured at a receptor site (derived from the chemical analysis), X_{ij} is the i^{th} elemental concentration measured in the j^{th} sample, and m_j is the airborne mass concentration of material from the j^{th} source contributing to the j^{th} sample. The term a_{ij} is included as an adjustment for any gain or loss of species i between the source and receptor. The term is assumed to be unity for most of the chemical species.

The CMB 8.2 software (USEPA 1997) is used in this study. It is windows-based software that requires input data on ambient (at receptor locations) and source profiles of PM characterization. The model runs multiple iterations to provide optimum goodness of fit among the sources and receptors and verifies the model with various checks viz. Chi-square statistic, t-tests, mass percentage, and correlation coefficient. The following assumptions should be understood before proceeding with the CMB analysis.

The CMB model assumptions are:

- The concentration of emissions sources is constant throughout ambient and source sampling;
- Chemical species do not react with each other (i.e., they add linearly);
- All sources with potential for contributing to the receptor have been identified and have had their emissions characterized;
- The number of sources or source categories is less than or equal to the number of species;
- The source profiles are linearly independent of each other; and
- Measurement uncertainties are random, uncorrelated, and normally distributed.

The following steps are followed for running the CMB model:

- Identification of the contributing emission source types based on primary survey and emission inventory data collected around the monitoring sites.
- The selection of chemical species to be included in the CMB modelling calculation is based on the Central pollution control board (CPCB) guidelines.
- The source profiles with the fraction of each chemical species and uncertainty are withdrawn from the SPECIATE 5.1 database. SPECIATE 5.1 is US-EPA‟s repository of organic gas and particulate matter (PM) speciation profile of air pollution sources.
- Estimate ambient concentration (ambient data) is based on chemical analysis of the PM samples collected at the respective site during monitoring. The uncertainty of the chemical species is mainly based on the instrument uncertainty.
- The CMB 8.2 model run provides the solution of the chemical mass balance equation.

For source apportionment of PM_{10}, CMB 8.2 software (USEPA 1997) provides many goodness‟s of fit tests to verify the accuracy of the model. The normal checks, as specified in the manual by USEPA (1997) to accept the model are; t-statistics i.e., source contribution divided by the error of source contribution should be greater than 2, χ^2 (chi-square) is the weighted sum of squares of the differences between calculated and measured fitting species concentrations divided by the effective variance and the degrees of freedom, it should be less than 4. The weighting is inversely proportional to the squares of the precision in the source profiles and ambient data for each species. Ideally, χ^2 would be zero, there would be no difference between calculated and measured species concentrations. The χ^2 less than one indicate a very good fit for the data. Values greater than 4 indicate that one or more of the fitting species concentrations are not well-explained by the source contribution estimates (SCE). The source contribution estimate approximates the total mass concentration which is a convenient check on the %mass explained value. When the SCE is less than its standard error, the source contribution is undetectable. Two or three times the standard error may be taken as the upper limit of the SCE in this case. Assuming that the errors are normally distributed, there is about a 66% probability that the true source contribution is within one standard error and about a 95% probability that the true concentration is within two standard errors of the SCE.

R^2 is determined by the linear regression of the measured versus model-calculated values for the fitting species. R^2 ranges from 0 to 1. The closer the value is to 1.0, the better the SCEs explain the measured concentrations. When R^2 is less than 0.8, the SCEs does not explain the observations very well with the given source profiles. The percentage mass explained should be between 80% and 120%, the ratio of the computed and the measured concentration of each element (C/M ratio) should be close to 1 and R/U ratio, i.e., the ratio of residuals to uncertainty should be less than 2. As the model requires the source contribution estimates and receptor concentrations in ambient air, the significant sources in the area need to be identified first. The investigation of sources of PM_{10} to be accounted for in the CMB model is carried out using emission inventory studies.

4.1.2. Source profiling

The Chemical profile needs to be developed for the air-polluting source as input to the receptor-oriented source apportionment models like CMB8.2 (chemical mass balance). The U.S Environmental Protection Agency‟s (EPA) SPECIATE database and several studies carried out in other parts of the world provide an extensive collection of source profiles. The source profiles required in this study are extracted from SPECIATE5.1 the database.

The source of the particulate matter in JCF accompanies various coal handling activities such as opencast coal mining and its associated activities, thermal power stations, automobiles, generator sets fuel burning, construction activities, domestic coal, cooking gas burning, etc. and even the background contribution of natural dust (crustal origin) cannot be ruled out, particularly, in the zones having loose topsoil (Roy and Singh 2014). So, the sources profiles considered here are coal dust, coal combustion, road dust, heavy vehicle diesel, light vehicle gasoline, etc.

4.1.3. Ambient profiling

As discussed in Chapter 3**,** the samples collected from the sampling location undergo chemical characterization. The species obtained from the chemical analysis used in ambient profile structuring and the uncertainty is based on the instrument.

The overall methodology used in the source apportionment study is depicted by the flow diagram as follows:

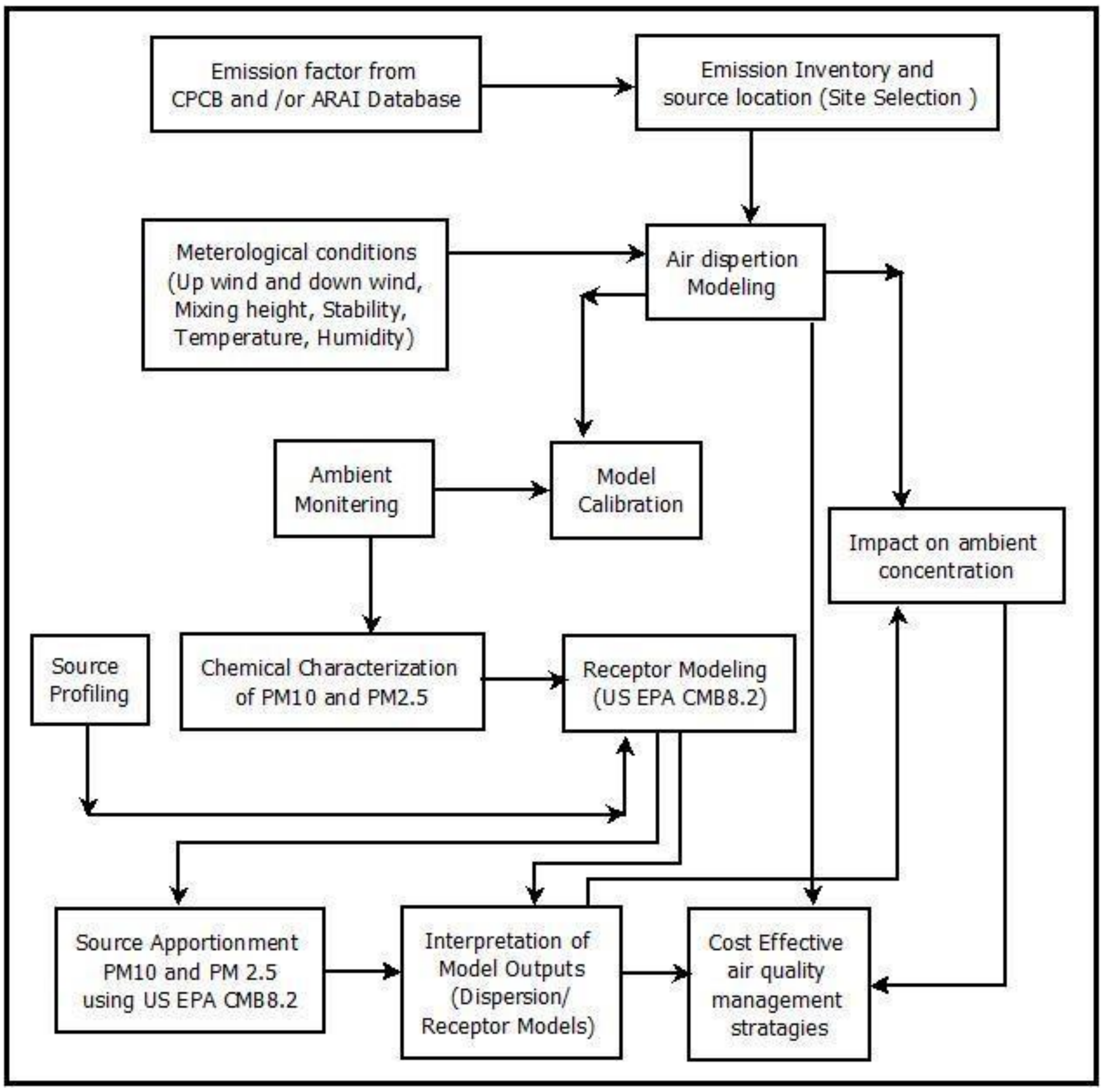


Figure 4.1: General methodology followed in the source apportionment studies

4.2. Results of the Chemical Mass Balance

CMB8.2 is performed for all the air quality monitoring locations. The significant sources in the area are identified first based on the field surveys. The general category of sources included in the model for all the sites are composites of all the vehicular sources, domestic combustion, road dust, agricultural waste burning, Industries, etc (Summary of relevant air quality studies from major Indian cities is given in Table 4.1). However, the choice of sources varies concerning the activities prevailing in the area and CMB model performance. A similar approach also applies to the selection of species. Efforts were made to include as many species in the model as possible. The choice was, however, restricted based on model performance. The source contributions are shown in the following Figures 4.3. The CMB model performance with respect to various sources is shown in Annexure 1.

4.2.1. Domestic combustion

In the summer season, the foremost emission source was domestic combustion for PM_{10} and $PM_{2.5}$. The domestic combustion percentage was observed at 22% and 25% for PM_{10} and $PM_{2.5}$ in the summer season. In the winter season, domestic combustion contribution was the second most percentage contributor for PM_{10} and $PM_{2.5}$. The PM_{10} percentage was 23% while the $PM_{2.5}$

percentage contribution was 28% in this season. The higher concentration of Cl^-, F^-, Cr, and Br. Cl^- and F^- are the markers of coal-burning and wood-burning (Jain et al., 2020). High Br along with Cl^- suggests the contributions from coal combustion.

4.2.2. Industrial Emission

The industrial combustion percentage contribution observed 16% in PM_{10} and 13% in $PM_{2.5}$ in the summer season. In the winter season, contribution to industries is determined to be 15% in PM_{10} and 24% in $PM_{2.5}$. The abundances of elements like As, Zn, Fe, Cu, Cr, Pb, and S indicate the industrial source's emissions. Kumar et al. (2001) used Cu, Mn, and Ni as tracers for industrial emissions in Mumbai; Sharma et al. (2014b) used Cu, Cr, Mn, Ni, Co, and Zn as industrial emission tracers for metal manufacturing plants in Delhi; Kulshrestha et al. (2009) used a combination of Ni, Cu, Fe, and Cr as a marker for construction activities in Agra; and Karet al. (2010) used Zn, Cu, and Ni as tracers of galvanizing, metallurgy, and electroplating industries while Cr from tannery industry in Kolkata.

4.2.3. Coal Mining

Opencast coal mining activity comprises heavy-duty diesel vehicle usage, blasting, Coal handling and overburden management. During the summer season, the coal mining activity in PM_{10} and $PM_{2.5}$ is observed to be 8% and 7% respectively while in the winter season it contributes somewhat 6% and 5% in PM_{10} and $PM_{2.5}$ respectively.

4.2.4. Transportation

The overall transportation contribution is 25% for PM_{10} and 32% for $PM_{2.5}$ in the summer season. In the winter season, the transportation emission contribution is examined at 16% for PM_{10} and 18% for $PM_{2.5}$. The OC/EC ratio is a convenient diagnostic tool for investigating the sampling site and its emission sources. In the present study, the OC/EC ratio shows significant seasonal variations for a coarser fraction of PM than for a finer fraction. It is well established that OC/EC ratio values between 1.4 and 4 indicate emissions from gasoline catalyst vehicles and 0.3 to 1 suggest diesel vehicle emissions (Amato et al., 2016; Cesari et al., 2018). Assessing the ratio of nss-K+/EC is another diagnostic check for estimating the relative loading of vehicular emissions, where nss-K+ is a non-sea-salt water-soluble potassium ion (calculated as K+- 0.129Na+) (Andreae and Merlet, 2001).

4.2.5. Secondary Inorganic Aerosol

During summer, the secondary inorganic aerosol contribution to PM_{10} and $PM_{2.5}$ is about 8% and 16%, respectively. Secondary inorganic aerosols contribution found in winter is about 14% and 17%, respectively for PM_{10} and $PM_{2.5}$. The secondary inorganic aerosol source is a high concentration of nitrate (NO_3^-), sulphate (SO_4^{2-}), and ammonium ((NH_4^-). These secondary products are formed in the atmosphere, being emitted either by natural or anthropogenic sources. The oxidation of NO_x forms the secondary nitrate. It is favoured by low temperature (Li et al.2004), while high temperature and strong solar radiations favour the formation of secondary sulfates through photochemical reactions (Seinfieldand Pandis, 2016). Secondary inorganic aerosol formation from precursors (SO_2 and NO_2) enhances the pollution burden over the vicinity. Biomass burning, the presence of metal traces (Fe, Al, Mn, Zn, Cr etc.) from vehicular or industrial emission play a key role to neutralise the oxides of nitrogen and sulphur and thus raises the amount of secondary inorganic aerosols in the atmosphere.

4.2.6. Agriculture

The agriculture contribution observed that 5% for PM_{10} and 2% for $PM_{2.5}$ in the study period during the summer season. In the winter season, the contribution is 3% and 2% for PM_{10} and $PM_{2.5}$ respectively. Agricultural activities contribute ammonium to the atmosphere (Pant and Harrison, 2012; Jain et al., 2019). The OC and EC are also significant agricultural activity sources (Ram and Sarin 2011; Sharma et al.2016a).

4.2.7. Open burning

The contribution of open burning in the summer season is 5% for both PM_{10} and $PM_{2.5.}$ In winter, the garbage burning contribution is 6% and 2% for PM_{10} and $PM_{2.5}$ respectively during study time. The abundance of tracers like K^+, Pb, Br and consider-able Cl^- marks this garbage/biomass burning source. K^+ and levoglucosan are globally employed as biomass burning markers. Biomass consists of residential and agricultural wastes, post-harvest residue, cow dung, dry leaves, fuelwood, and wildfires (Almeida et al., 2006; Khare and Baruah, 2010; Shridhar et al., 2010). The OC and EC are also traced insignificant amounts along with K+, indicating the biomass burning emanations (Cesari et al., 2018; Sharma et al., 2014; Jain et al., 2018).

4.2.8. Road Resuspension dust

The re-suspension dust is a significant contributor to PM_{10}. The contribution of resuspension dust is during the summer season 12% while in the winter season the emission contribution is 10% for PM_{10}. In the summer season, resuspension dust's contribution is higher because of the high wind velocity and dry condition. The lower percentage contribution of road dust to fine particulate matter is attributed to substantial road dust particulates in coarse mode, found in other studies (Gupta et al., 2007; Masri et al., 2015). Crustal elements are significant constituents of airborne soil and re-suspension road dust. Generally, they contribute to coarse aerosols, including Al, Si, Ca, Ti, Mg, Fe, and Na used as tracers for soil dust or crustal re-suspension (Lough et al.2005; Begum et al. 2011). The marker elements that have been used in India for the identification of soil dust include Al, Si, Ca, Ti, Fe, Pb, Cu, Cr, Ni, Co, and Mn (Sharma et al., 2017). Cu, Zn, and Ba are associated with road dust/re-suspension dust due to the release of these marker elements from cars and non-exhaust sources.

4.2.9. Other emission Contribution

Other area sources contributed in the summer season is 12% for PM_{10} and 7% for $PM_{2.5}$ during the study period. In the winter season, emission contribution is 14% for PM_{10} and 9% for $PM_{2.5}$.

4.3 Inferences

The receptor modelling (CMB) results (Figure 4.3) revealed that the transport sector and domestic combustion are the predominant emission sources contributing to the receptor levels. During the summer season, the contribution of the transport sector was found maximum in both PM_{10} (23%) and $PM_{2.5}$ (30%) followed by the contribution of domestic combustion (17% and 23% for PM_{10} & $PM_{2.5}$ respectively). While in the winter season, the contribution of domestic combustion outruns the contribution of the transport sector. During the winter season, domestic combustion has contributed 22% (PM_{10}) and 28% ($PM_{2.5}$) whereas the transport sector has contributed 16% (PM_{10}) and 21% ($PM_{2.5}$) of the total emission.

After transport sector and domestic combustion, Industrial emission (12% of PM_{10} emission) and Road Resuspension (12% of PM_{10} emission) followed by Coal mining activity and secondary inorganic aerosol formation (both 8%) are contributing majorly to PM_{10} emission at receptor during the summer season.

In $PM_{2.5}$ source contribution, secondary inorganic aerosol formation contributed majorly (16% & 15% in summer and winter seasons respectively) after domestic combustion and transport sector. Secondary inorganic aerosol formation from precursors (SO_2 and NO_2) enhances the pollution burden over the vicinity. Biomass burning, the presence of metal traces (Fe, Al, Mn, Zn, Cr etc.) from vehicular or industrial emission play a key role to neutralise the oxides of nitrogen and sulphur and thus raises the amount of secondary inorganic aerosols in the atmosphere.

Industrial activity contributed 12% and 11% of total PM_{10} load in summer and winter respectively but in the case of finer dust ($PM_{2.5}$), it contributed 17% in the winter season at the receptor level. This may be due to the calm winter conditions that allow finer dust ($PM_{2.5}$) to settle near to ground than that of summer conditions that allow more turbulence mixing in the atmosphere.

Road re-suspension of dust contributes significantly in PM_{10} load at receptor both in summer (12%) and in winter (8%). As these are larger and heavier particles, they contribute to PM_{10} fraction and are not found in $PM_{2.5}$ fraction at the receptor.

After the contribution of the industrial sector, coal-mining activity contributed around 8% and 6% of the total PM_{10} receptor dust load during summer and winter respectively. In the case of $PM_{2.5}$ dust load at the receptor, coal-mining activity contributed 7% and 5% during summer and winter respectively.

From the results and analysis of receptor modelling, it can be summarised that mitigation and abatement of the emissions from domestic combustion and transport sector alone may reduce receptor dust load by 40% (approx.).

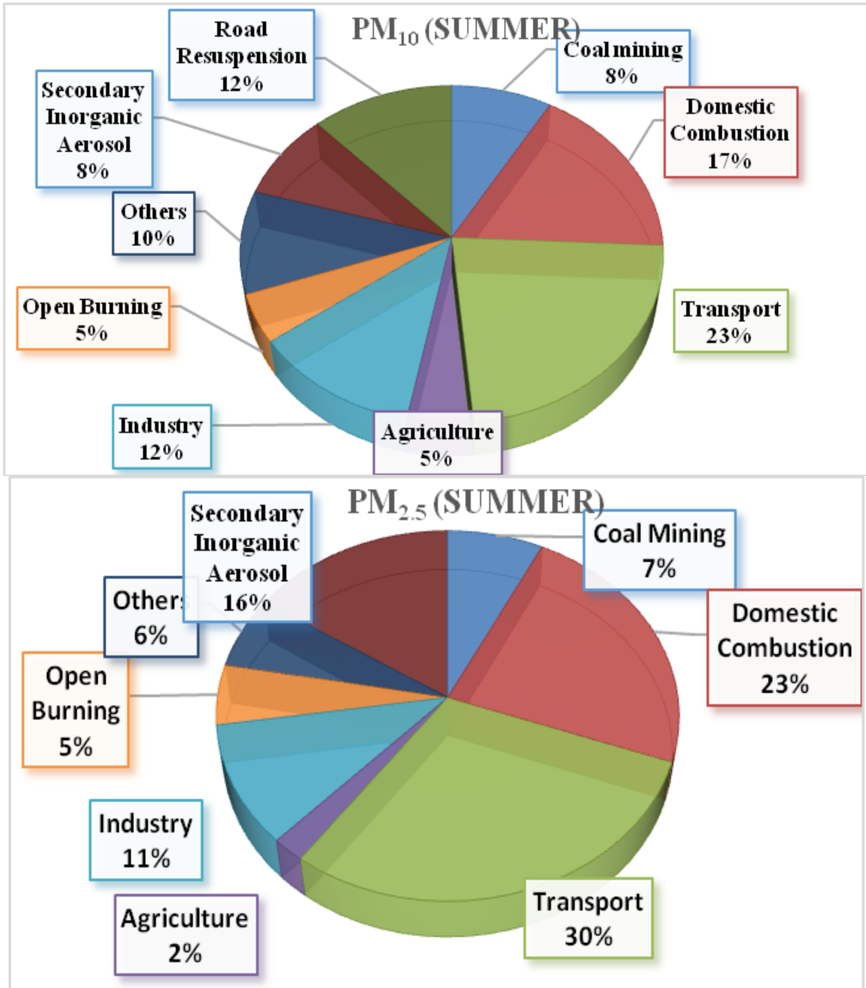


Figure 4.2: Source contribution at receptor locations of PM_{10} and $PM_{2.5}$ in summer

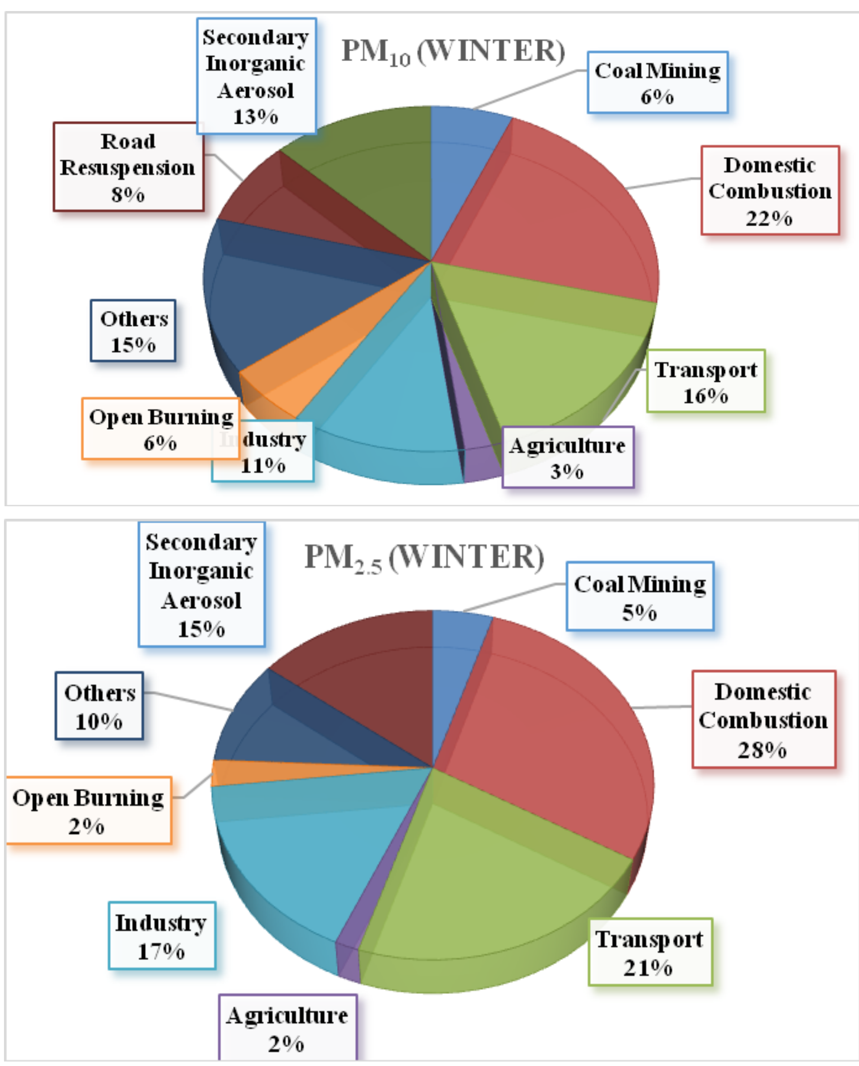


Figure 4.3: Source contribution at receptor locations of PM_{10} and $PM_{2.5}$ in winter

Table 4.1: Summary of relevant air quality studies from major Indian cities.

Area/Location	Particle size	Sources	Elements and Ions	References
Delhi	PM_{10} and $PM_{2.5}$	Secondary Nitrate, Secondary Sulfate, Vehicular emission, Biomass burning, Soil dust, Fossil fuel combustion, Sodium and magnesium salt, Industrial emission	Al, Mg, Ca, Ti, Fe, Cr, Mn, Zn, As, Pb, Br, M, F^-, Cl^-, NO_3^-, SO_4^{2-}, K^+, NH_4^+, and Na^+	Jain et. Al., 2020
Mangalore	PM_{10} and $PM_{2.5}$	Construction dust, Diesel generator, Tyre wear emission, Brake lining emission, Sand dust emission, gasoline vehicle emission, Diesel vehicle emission, Unpaved and paved road emission, Biomass burning, LPG stove emission, Solid fuel emission, Ferrous and steel industries emission, Fabrication and welding emission, Kerosene stove emission	As, Ba, Cd, Cr, Cu, Fe, Mg, Mn, Mo, Ni, Pb, Sr, Zn, $F^−$, $Cl^−$, $NO_3^−$, $PO_4^{3−}$, $SO_4^{2−}$, Na^+, K^+, Mg^{2+} and Ca^{2+}	G. Kalaiarasan et al. 2018
Delhi NCR	PM_{10} and $PM_{2.5}$	Dust construction, Vehicle emission, Biomass Burning, Industrial emission, Secondary Pollutants, DG sets emission,	Al, Si, P, S, Cl, Br, V, Mn, Fe, Co, Ni, Cu, Zn, As, Ti, Ca, $F^−$, $Cl^−$, $NO_3^−$, Br^-, NO_2^-, $SO_4^{2−}$, Na^+, K^+, Mg^{2+} and Ca^{2+}	Report No. ARAI/16-17/DHI-SA-NCR/Final Report August 2018
Delhi	$PM_{2.5}$	Secondary Aerosol, Vehicular emission, Biomass burning, Soil dust, Fossil fuel combustion, Sea salt, Industrial emission	Al, Mg, S, Si, Cl, K, Ca, Ti, Cu, Mn, Fe, Zn, Br, Cr, As, Pb, F^-, Cl^-, NO_3^-, SO_4^{2-}, K^+, NH_4^+, and Na^+	Jain et. Al., 2017
Nagpur	$PM_{2.5}$	DG sets, biomass burning, resuspended dust, secondary aerosol and mobile sources.	Al, Ba, Cd, Cr, Cu, Fe, Mg, Mn, Ni, Pb, Si, Zn. $F^−$, $Cl^−$, $NO_3^−$, $PO_4^{3−}$, $SO_4^{2−}$, Na^+, K^+, Mg^{2+} and Ca^{2+}	Pipalatkar et al., 2014
Raipur	$PM_{2.5}$	Brick kiln process, steel re-rolling mills, steel processing industries, biomass burning, metallurgical industrial emissions and coal burning	Al, As, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, S, Sb, Se, V, Zn, Na^+, K^+, Mg^{2+} NH_4^+, $F^−$, $Cl^−$, $NO_3^−$, $SO_4^{2−}$, and Ca^{2+}	Matawle et al., 2014
Hyderabad	PM_{10} and $PM_{2.5}$	Vehicles exhaust, resuspension of dust, secondary sulfates, secondary nitrates, biomass	Na, Mg, K, Al, Si, Ca, Fe, Cl, SO_4^{2-}, NO_3, NH_4^+	Guttikunda et al., 2013

		burning, coal burning.		
Pune	PM_{10} and $PM_{2.5}$	Vehicles, DG sets, construction dust, solid fuels emissions, resuspended dust	Al, Pb, Cu, Zn, As, Se, Br, Ni, Fe, Mn, Mg, Cr, Ti, Ca, Cd, S, Si, Na, Ba, Sb, Cd, Sr, Cl^-, NO_3^-, SO_4^{2-}, K^+, NH_4^+	ARAI, 2010
Kanpur	PM_{10} and $PM_{2.5}$	Vehicles, open burn, road dust, domestic wood, coal and LPG, metal smelting, DG sets.	Cl^-, NO_3^-, SO_4^{2-}, K^+, NH_4^+, Na^+, Ca^{2+}, Mg^{2+} Si, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Cd, Sn, Sb, Pb	CPCB, 2010b
Mumbai	PM_{10} and $PM_{2.5}$	Wood combustion, Fuel oil combustion, kerosene combustion, biomass burning, LPG, ammonium sulfate, ammonium nitrate, heavy duty diesel vehicles emissions, soil dust.	Na, Mg, Al, Si, P, S, Cl, Ca, Br, V, Mn, Fe, Co, Ni, Cu, Zn, As, Ti, Ga, Rb, Y, Zr, Pd, Ag, In, Sn, La, Se, Sr, Mo, Cr, Cd, Sb, Ba, Hg, and Pb. F^-, Cl^-, Br_-, NO_2^-, NO_3^-, SO_4^{2-}, K^+, NH_4^+, Na^+, Ca^{2+}, Mg^{2+}	CPCB, 2010a
Chennai	PM_{10} and $PM_{2.5}$	Vehicles, DG sets, bakeries, soil dust, construction dust, paved road dust, kerosene and LPG emissions.	As, Ag, Ca, Na, Fe, Mg, Cu, Zn and other metals. Cl^-, $NO3^-$, $SO4^{2-}$, K^+, NH_4^+, Na^+, Mg^{2+}	IIT Madras, 2010
Bangalore	PM_{10} and $PM_{2.5}$	Petrol vehicles, diesel vehicles, secondary particulates, fuel oil burning, wood domestic wood burning, DG set, kerosene generator set, paved road dust re suspension, soil dust.	Na, Mg, Al, Si, P, S, Cl, Ca, Br, V, Mn, Fe, Co, Ni, Cu, Zn, As, Ti, Ga, Rb, Y, Zr, Pd, Ag, In, Sn, La, Se, Sr, Mo, Cr, Cd, Sb, Ba, Hg, and Pb. F^-, Cl^-, Br^- NO_2^-, NO_3^-, SO_4^{2-}, Na^+, K^+, Mg^{2+} and Ca^{2+}	TERI, 2010

DG - Diesel generators; LPG - Liquefied petroleum gas; OC - Organic carbon; EC - Elemental carbon.

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Chapter 5 Dispersion Modelling

Air quality modeling includes four major processes (a) emission of pollutants, (b) transportation of the pollutants due to mean wind profile (c) chemical transformations and (d) deposition/removal. In the present study the particulate matter emissions, transportation and dispersion are carried out using the AERMOD model, which is developed by USEPA. AERMOD model estimates the spatial profile of pollutants based on the Gaussian plume equation, which is an analytical solution to the steady-state approximation of the advection-diffusion phenomenon. The boundary conditions about the atmospheric mixing height and other thermodynamic vertical profiles for the simulations are derived from the mesoscale model. The model relies on the atmospheric stability classes for deriving the dispersion coefficients across the multiple dimensions with respect to the distance away from the sources. In this study, only the ground level concentrations of the particulate matter are simulated during the study period. The study domain envelops the Jharia Coal Fields situated in the Jharkhand state of India. The methodology followed in the present study is shown in Figure 5.1. The southwest part of the Dhanbad City shares borders with the study area, but the majority of emission load used in the study is included from the JCF.

5.1. Wind data analysis

The nearest IMD (India Meteorological Department) observations are at Patna and Kolkata, which are approximate >150km from the study area. Hence, hourly meteorological observations required for the study for the AERMOD dispersion model were simulated through the Weather Research and Forecast, version-3.9 (WRF), which is a meteorological model that dynamically downscales the global NCAR/UCAR meteorological data to the regional level data (www.mmm.ucar.edu). Nested domains of grid resolution 12km and 4km, respectively were laid over the study area for simulation of hourly meteorological variables using the WRF model (Figure 5.2). Hourly meteorological data, including both the surface variables and upper atmosphere variables, were simulated for the study period viz. 23 May to 12 June 2019 and 23 January to 12 February 2020, representing the summer and winter seasons, respectively.

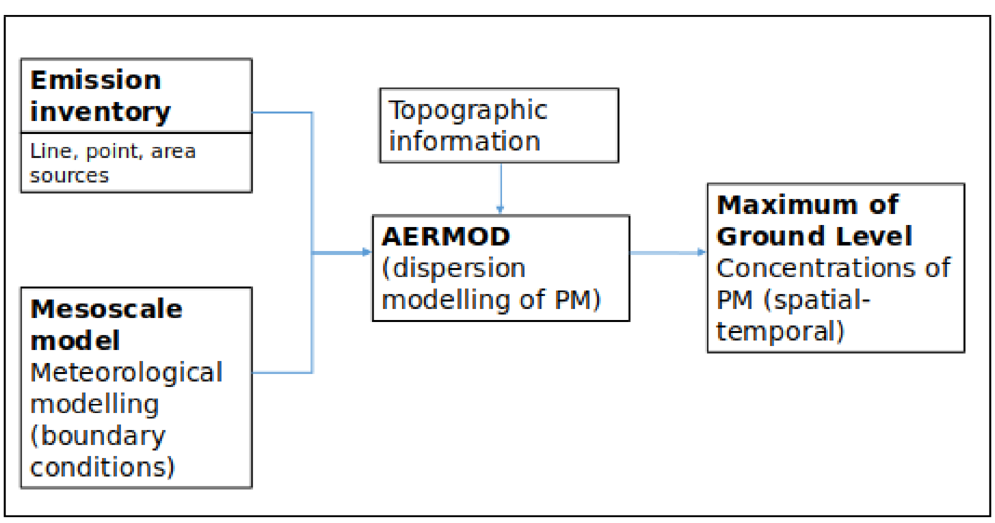


Figure 5.1: Methodology followed in the study.

The mesoscale model interface program MMIF (https://www.epa.gov/) converter tool was used to convert the inner domain‟s gridded WRF model simulated meteorological data into a format suitable for the AERMOD model. The AERMOD receptor grid covering the study area is shown in Figure 5.3. A Cartesian receptor grid having 21 rows and 21 columns with a resolution of 2000 m was laid for the simulation of particulate matter dispersion /concentration at the receptor locations. Overall there are 20 grids in each direction covering an area of 40 km by 40 km enveloping the JCF.

The spatial pattern of the predominant wind profile over the study area is plotted using the windrose diagrams for the summer (March to May 2019) and winter season (November 2019 to February 2020), shown in Figures 5.2 and 5.3, respectively. Results show that the study area is experiencing the predominant wind (having high frequency) flow from east to west direction followed by north-west to south-east direction during summer, while in winter the predominant wind direction is from north to south. The wind speeds vary in the range of 0.5 to 11.1m/s during the summer predominantly in the range of 2.1 to 3.6m/s whereas wind speeds vary in the range of 0.5 to 8.8m/s during the winter, predominantly in the range of 2.1 to 3.6m/s.

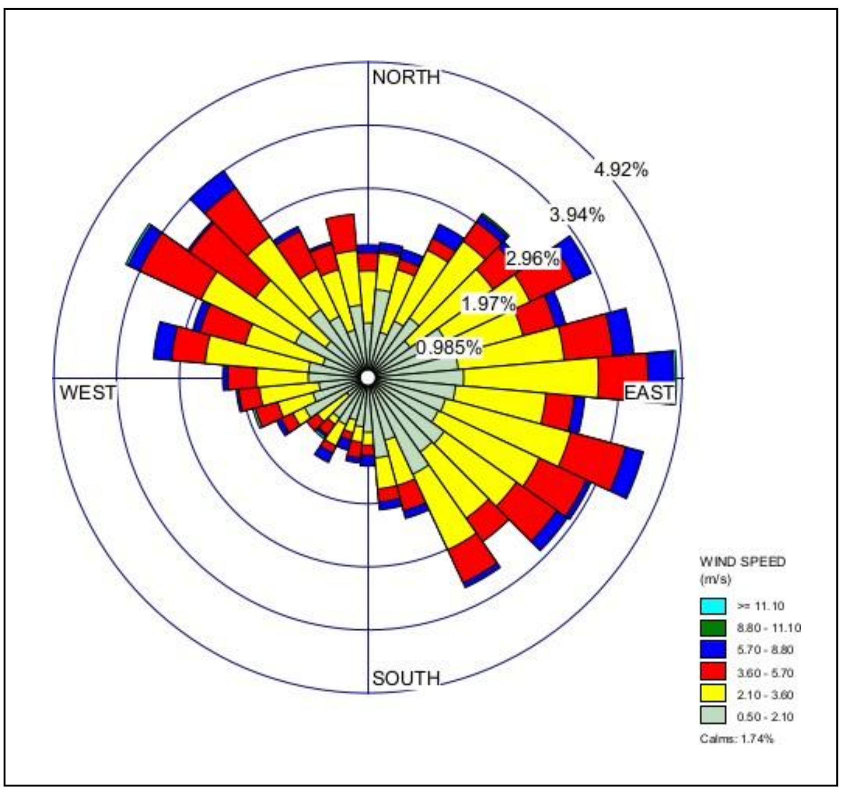


Figure 5.2: Windrose of the study area during March-June, 2019 (wind direction blowing towards the center)

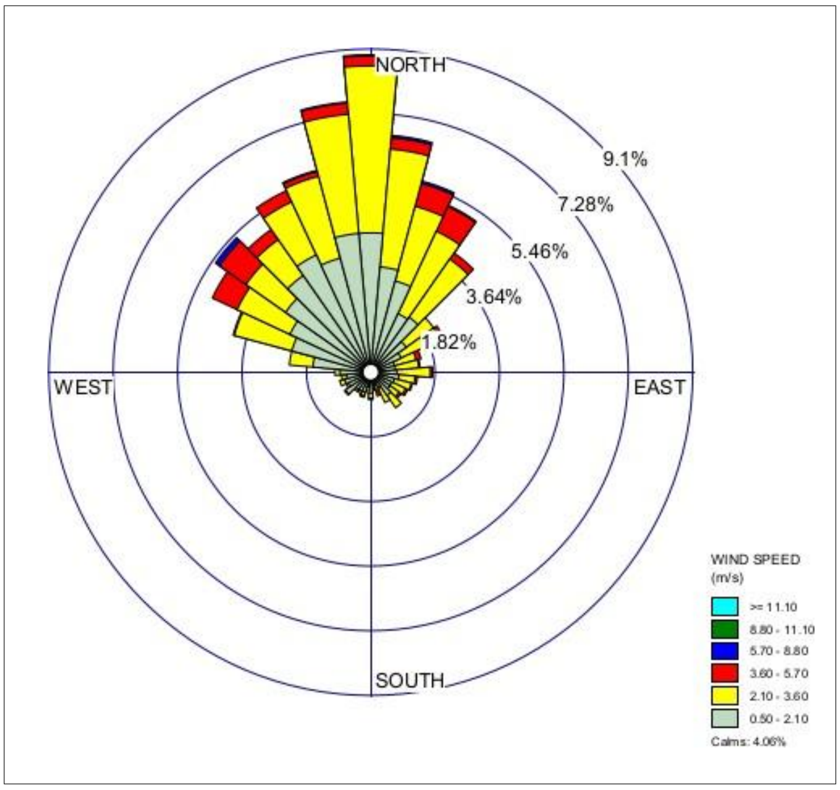


Figure 5.3: Windrose of the study area during November-December 2019 (wind direction blowing towards the centre)

5.2. Dispersion of Particulate matter

Spatial profiles of maximum ground-level concentrations of 24-hour average values of PM_{10} and $PM_{2.5}$ were simulated using the AERMOD Gaussian plume model. The emission rates of particulate matter from multiple source types including the point, line, and area were derived from the field monitoring of the emission inventory. Point sources mainly include the emissions from the industries situated in the study area that mainly use coke/coal as the fuel. The line sources include the emissions from the vehicular exhaust. Emission inventory of traffic pollution was carried out in the study area by noting down the vehicular activity. The vehicular activity of different vehicular types such as trucks, light motor vehicles, three-wheeled vehicles, motorbikes, etc. was multiplied by the corresponding emission factors for the estimation of gaseous pollution. The summation of emissions from all vehicle types adds to the overall line sources contributing to the pollution load in the study area. The area sources include emissions from the open cast mining emissions (including all the activities in the mine premises) and domestic burning (including emissions from crematoria, bakeries, open eat-outs, restaurants, chulha burning from the slum, etc.).

The emissions in grams per second were calculated from the emission inventory survey, for the line and point sources. Whereas, the emission rates in $g/s/m^2$ were calculated for the area sources including mining. These emission rates from each source type have been computed in the study area and fed into the AERMOD model domain for the simulation of spatial average concentrations of PM_{10} and $PM_{2.5}$. In the present study, the maximum GLC (ground level concentrations, in $\mu g/m^3$) was simulated at several receptor grid locations in AERMOD domains. The AERMOD model was run during the sampling period in May 2019 and November 2019, representing the pre-monsoon and post-monsoon seasons, respectively.

Analysis of WRF model simulated wind speed and direction data shows that the wind is predominantly flowing from south-east direction to north-west direction, followed by the reversal in the direction, during the monitoring in summer, representing pre-monsoon conditions (Figure 5.5). The wind speeds during the monitoring period in summer month varied between 0.5 and 8.8m/s. During the monitoring period in winter (post-monsoon), the wind predominantly flowed from the north-east to south-west direction having wind speeds in the range of 0.5 to 3.6m/s (Figure 5.5).

The wind blowing from different directions in the study area determines the direction of pollution dispersion. The Gaussian plume equation used in the AERMOD model estimates the diffusion and advection of the pollutants concerning the emission rates and meteorology (wind speed, direction and atmospheric stability categories). The model simulated maximum ground level concentration of the particulate matter (PM_{10} and $PM_{2.5}$) in the study area covering the JCF is shown through the isopleths. The isopleths (contours connecting the regions with the same ground level concentration in the context of the present study) of maximum GLC of PM_{10} and $PM_{2.5}$ were observed to form a pattern according to the predominant wind directions flowing in different monitoring seasons. It is observed that the line sources in the study area have contributed the maximum to the surface GLC of PM_{10}, following the open cast mines. The AERMOD model simulated the value of GLC of PM_{10} due to line sources, open cast mines, and all sources are 927, 286, and 978µg/m^3, respectively, for the summer season. The $PM_{2.5}$ maximum GLC contributed by the line sources, open cast mines, and all sources included are 809, 143, and 835µg/m^3, respectively. It is evident from the result that the line sources are significantly contributing to the overall particulate pollution in the study area during summer.
The analysis of the PM_{10} and its maximum GLC simulated by the AERMOD model for the winter season also follows a similar pattern as of summer. The contribution of line sources, open cast mines, and all sources included are 1565, 597, and 1679µg/m^3, respectively. The $PM_{2.5}$ maximum GLCs during the winter are 1004, 299, 1167µg/m^3 as contributed by line, open cast mines, and all sources including, respectively. Based on the emission inventory and the prevailing meteorological conditions during the winter season have in general contributed to the higher particulate matter than that of the summer season.

Pockets of maximum concentrations of PM_{10} (200-1000 µg/m^3 and above) are observed in the vicinity to roads nearer to the open cast mines south of Dhanbad City during the winter (Figure 5.5). The localities of the high concentrations of PM_{10} are Sabji Patti road and Sudamdih mine area, which is reflected in the figure. The area covering the Dhanbad city and the mines situated in the southwest have PM_{10} concentrations in the range of 200-900µg/m^3. The fringes of the JCF have recorded the PM_{10} concentrations in the range of 100-250µg/m^3. In contrast, the PM_{10} concentrations for the summer season have significantly lower and the majority of the study area have PM_{10} < 100µg/m^3, however, the area extending from south of Dhanbad City and Sudamdih mine have relatively high PM_{10} concentration in the range of 100-500µg/m^3. Baghmara and Sonardih mine area in the west of Dhanbad City have also been observed to have high GLC of PM_{10} in the range of 100-500µg/m^3.

A similar pattern of the spatial distribution of $PM_{2.5}$ is reflected as of PM_{10}. As the underlying meteorological conditions are the same for both the PM_{10} and $PM_{2.5}$ simulations the spatial pattern is nearly similar. High concentrations of $PM_{2.5}$ (100-500µg/m^3) are observed in the southwest direction of Dhanbad City (Figure 5.6). The maximum GLC of PM_{10} is found to be higher than $PM_{2.5}$ during both the monitoring seasons, and higher concentrations are observed during the winter season. The prevailing winter meteorology in the region has lower wind speeds and mixing heights, which poses an unfavorable situation for the dispersion of particulate matter, hence containing a high chance of accumulation of airborne pollutants. The significant contribution of particulate matter from the line sources is observed in the study area, followed by the area sources (from open cast mining, domestic burning, bakeries, open eat-outs, and restaurants). The locations of the highly polluted can be interpreted from the images shown in Figures 5.6 (a) and 5.6 (b) for devising realistic and grass-root level mitigation strategies.

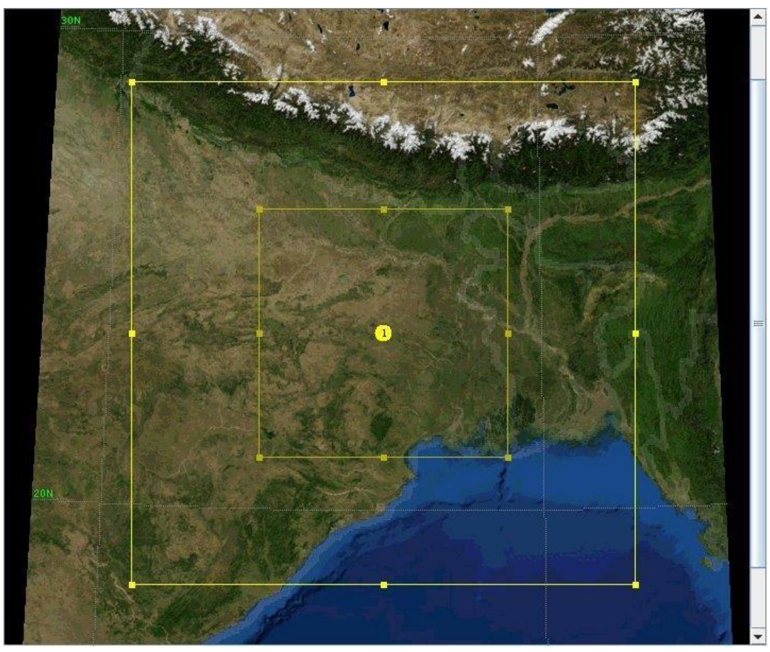


Figure 5.4: AERMOD grid covering the Jharia Coal Fields (JCF). The line, area, and point sources covered in the study are indicated in red color. The UTM coordinates of the left bottom point are x=406111 and y=2603492, and the coordinates of the right top point are x=456248 and y=2653417.

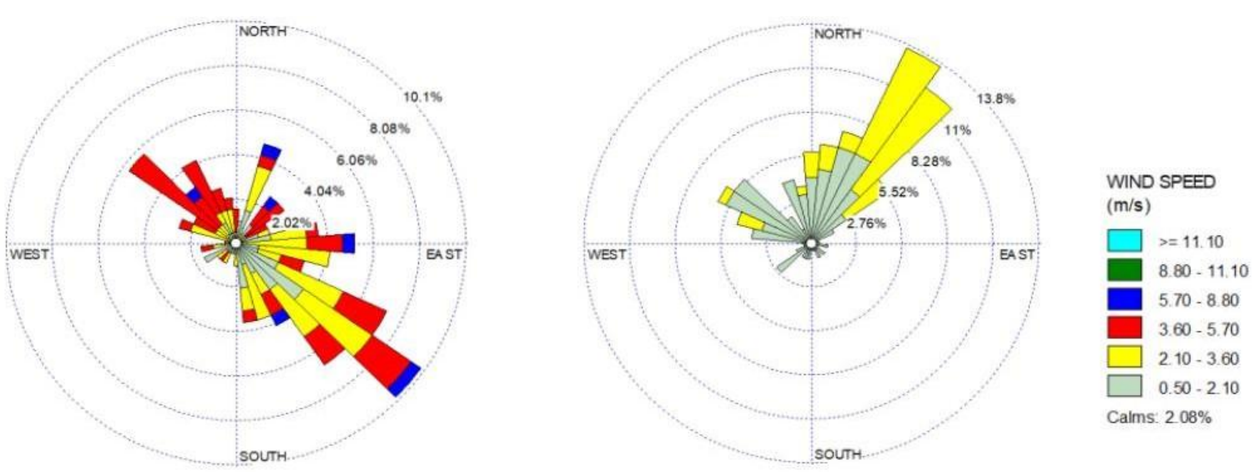
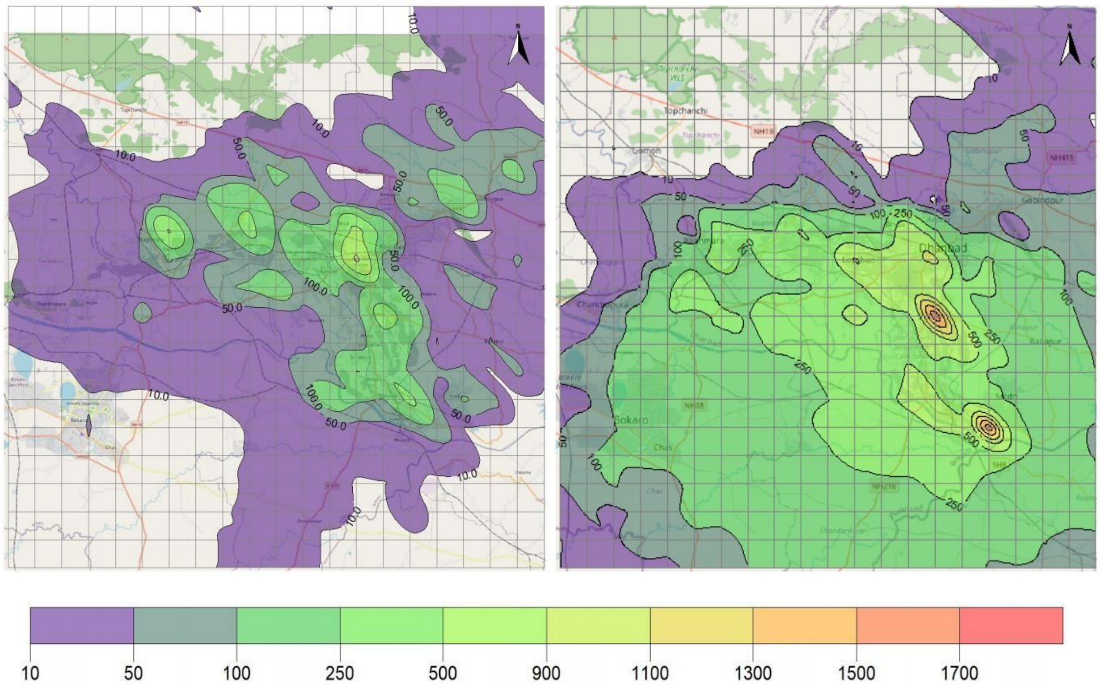
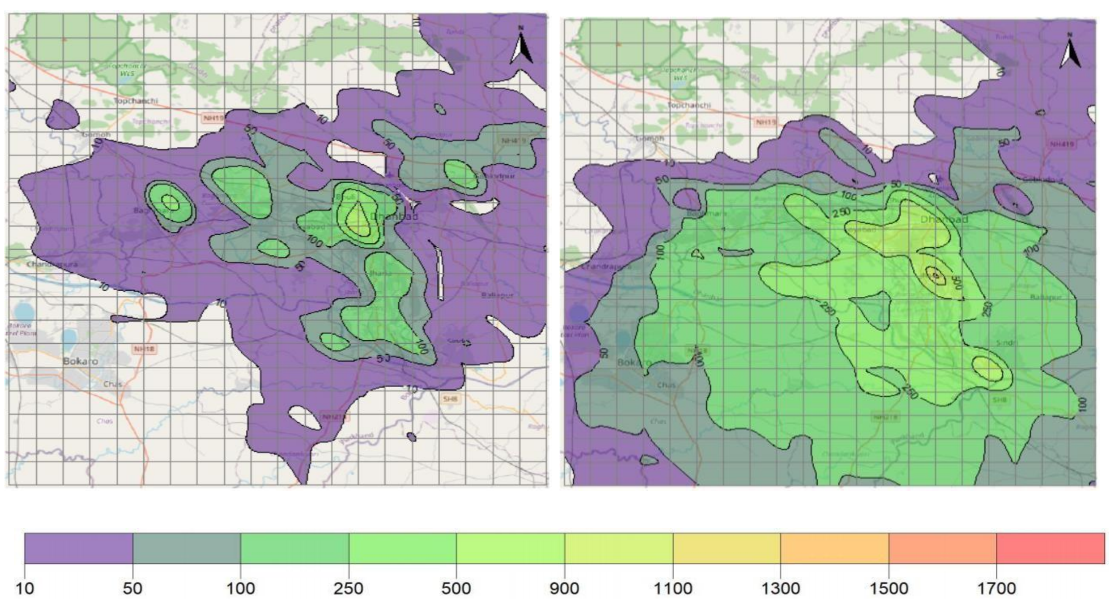


Figure 5.5: Windrose diagram for the summer (left) and winter seasons (right) at Jharia Coal Fields during the sampling period. Wind direction is flowing towards the centre.



(a)



(b)

Figure 5.6: 24-hour average maximum ground level concentration of PM contours in the study area simulated during the study periods in summer (left) and winter (right) seasons (a) PM_{10} ($\mu g/m^3$) and (b) $PM_{2.5}$ ($\mu g/m^3$)

5.3 Validation of the model

Comparison between the model simulated period average PM and the measured PM concentrations was made to determine the overall efficiency of the dispersion model. In the present study, the model validation metrics viz. mean bias (MB), normalized mean bias (NMB), mean gross error (MGE), normalized mean gross error (NMGE), and Pearson‟s correlation (r) were calculated for PM_{10} and $PM_{2.5}$ separately including data of both seasons. At some of the monitoring locations like Mines Rescue, Katras, Patherdih, Harina, Lodhna, and Lohapatti the discrepancies between the modeled and observed data were found to be high, for both summer and winter seasons. At remaining locations for both seasons, the results indicate an acceptable/fair degree of model performance in simulating the particulate dispersion. Results show that the correlation coefficient between the measured and modeled PM_{10} is 0.6, which is fair enough in environmental open systems, similarly, for $PM_{2.5}$ the correlation value is around 0.7 (Table 5.1).

Table 5.1 Performance Stimulation Metric

Model metric	PM_{10}	$PM_{2.5}$
MB	-19.46	20.67
NMB	-0.11	0.24
NMGE	0.32	0.37
Correlation Coefficient	0.6	0.7

The NMB values are observed to be lower for PM_{10} (-0.11) than $PM_{2.5}$ (0.24), which indicates the slight negative bias in PM_{10} simulations (under-prediction of the concentrations) and positive bias in $PM_{2.5}$ (over-prediction of the concentrations). Whereas, the NMGE for both PM_{10} and $PM_{2.5}$ are 0.32 and 0.37, respectively, which indicates the variation in the model simulations deviate around 30% from the mean values on average (which is a result due to some extreme values in the simulations). However, this discrepancy could be minimized if long-term simulations are carried out, which is highly computationally intensive. Nevertheless, the model performance metrics in terms of correlation and normalized mean gross error infer that the model could capture the spatial profile of the particulate matter distribution to a good extent.

Chapter 6 Recommendation

6.1. Mine industries

1. The project proponent might consider installing conveyor systems for transporting the coal from the coal handling plant to the railway siding or to the nearest thermal power plant (if feasible).
2. A sufficient number of plants should be planted around the mine pit to arrest the movement of particulate matter or dust into the surrounding areas.
3. Scientific studies might be necessary to design a green belt with an optimized dimension of plot size and direction as per the prevailing meteorology. Similar studies are required to design a wind barrier for optimized benefits.
4. Adequate dust control measures should be in place, like mechanized sweeping, water sprinkling or mist spraying systems on the haul roads and at loading sites. Long-range misting or fogging canons are also should be in place.
5. Dust suppression measures at all operations of mining should be ensured.
6. Ensuring the complete coverage of the trucks and railway wagons that carry coal with a tarpaulin sheet is necessary.
7. In the long-run mobilization of closed trucks to carry the coal is preferable.
8. The coal transport roads should not be left with open curb sides. End to end covering up of curb side is essential to avoid the re-suspension of coal due to the truck movement.

6.2. Area Sources

Area sources are mainly domestic sources of fuel (coal, wood, kerosene, LPG) burning, trash/MSW combustion, bakeries, hotels/restaurants etc. and re-suspension of dust. Based on the survey and assessment, the following recommendations emerge:

1. Construction and demolition of buildings in the urban area give high local dust contribution resulting health problems. These practices need to follow compliance guidelines to reduce emissions.
2. Road and pavement should be well constructed to suppress road dust. The standard specifications and code of practice for road construction should be followed and implemented as per the Indian Road Congress (IRC) guidelines or international standard guidelines.
3. Strategically placed green cover in urban and semi-urban areas can help to improve localair quality.
4. Manage agricultural residues, including strict enforcement of bans on open burning
5. Strictly enforce bans on the open burning of household waste.
6. Use clean fuels – electricity, natural gas, liquefied petroleum gas (LPG) in cities, and LPG and advanced biomass cooking and heating stoves in rural areas; substitution of coal by briquettes
7. Use incentives to improve the energy efficiency of household appliances, buildings, lighting, heating and cooling; encourage roof-top solar installations
8. Promote the use of electric vehicles

9. Encourage centralized waste collection with source separation and treatment, including gas utilization.
10. There is a substantial population that also uses available coal. These houses could be given a combination of improved chulla or free/subsidised power for cooking purposes.
11. Hotels and dhabas need to be educated and compulsorily asked to use LPG for its cooking purposes.
12. The trash and MSW burning is very common. Some of the places contain a mix of plastics and thermocol. The combustion of these materials is very harmful to human health.
13. Coal depot pollution is due to open storage and unregulated buying, selling and transportation. These coal depots are responsible for nearby air pollution peaks. However, the contribution of the same need to be assessed.

6.3. Line Source

The vehicular sector in cities has been seen to be a major source of gaseous and fine particulate matter. The action plan for this sector would need a combination of efforts:

1. Vehicle inspection and maintenance: Enforce mandatory checks and repairs for vehicles.
2. Improved public transport: Encourage a shift from private passenger vehicles to public transport.
3. Set up a mechanism of Inspection and Maintenance programme for all vehicles in the district through RTO with automated system assessment.
4. The Inspection & Maintenance (I & M) centre shall also test all vehicles for their inbuilt emission tests.
5. All commercial vehicles should be phased out after 8 years of age or subjected to two years extension after rigorous I&M tests
6. All private vehicles should be subjected to proper assessment and fitness tests through I&M centres.
7. All autos and buses shall also be subjected to I&M tests
8. Dhanbad city does not have a designated place for truck parking and maintenance related activities. A separate designated place should be allocated to prevent illegal parking and repair shops on the roads and kerbside.
9. Dhanbad city does not have a designated place for Auto-rikshaw. A separate designated place should provide to prevent traffic congestion and control vehicle emission.
10. Major haul trucks with heavy loads should not pass through the main city. The plan being made should be implemented in the next 1-1.5 years.
11. Overloading is a common phenomenon in the region resulting in poor road quality. This can be avoided through online checking when vehicles leave industries with a guarantee that the vehicle is not carrying more material than its designated loads.

6.4. Others

- There is a need to explore various options for controlling air pollutants to tackle increased emissions in future.
- The local authority should stress sustainable and affordable public transport keeping clean air goals in mind.
- Frequent (time to time) arrangement of campaign/awareness programmes for lawmakers, stakeholders, health professionals, academicians to brainstorm about the future scenario and importance of clean air.
- Strategic installation of continuous air quality monitoring systems at various locations of urban, semi-urban and rural areas to check the existing air quality and information dissemination to the general public.

Annexure -1

[A] Cumulative receptor sample of PM_{10} for source profiling with fitting parameters

Source contribution estimate	**Source profiles**	**Std Error**	**R-square**	**Chi-square**
82.7% mass	Unpaved road	0.056	0.96	2.41
	Coal combustion	0.643		
	Light Duty vehicle	1.60		
	Heavy Diesel vehicle	2.19		
	Residential combustion	5.59		
	Iron and steel industry	7.16		
	Agriculture soil dust	0.212		
	Solid waste	1.37		

[B] Cumulative receptor sample of $PM_{2.5}$ for source profiling with fitting parameters

Source contribution estimate	**Source profiles**	**Std Error**	**R-square**	**Chi-square**
88.1% mass	Residential combustion	3.34	0.98	2.44
	Coal combustion	0.094		
	Light Duty vehicle	0.30		
	Heavy Diesel vehicle	1.91		
	Agriculture soil dust	0.10		
	Flyash	0.51		

Annexure -2

Emission Inventory Data

Name of Mine:

S.no	Operation	Quantity Kg/day	Type of fuel & quantity (litre/day)	Moisture content %	Silt content %	Details
Point source						
1	Drilling					Hole dia ---mm & Frequency ---/day
2	Blasting					----/day
3.	Overburden loading					Drop height ----m; Frequency ------/day
4	Coal loading					Drop height ----m; Frequency -----/day
5	Overburden unloading					Drop height -----m; Frequency ----/day
6	Coal unloading					Drop height ----m; Frequency ------/day
7	Top soil removal					
8	Crushing					
9	DG sets					
Line source						
10	Transfer of coal through haul road					Average speed ------- km/hr & frequency -------/day Distance ---- km Width ------m
11	Transfer of OB through haul road					Average speed -----km/hr & frequency -------/day Distance -----km
12	Transport road					Average speed -----km/hr Distance ------ km
13	Haul Road length (km)					-----Km
Area Source						
14	Stockyard					Unloading freq. -------/day & Coal Loading ------T/day Area -------- m^2
15	Workshop (m^2)					Area
16	Exposed pit (km^2)					
17	Colony					Fuel for cooking :-----

Annexure-X

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GROUNDWATER LEVEL & QUALITY REPORT

FOR CLUSTER OF MINES, BCCL

(Assessment year – 2022-23)

[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

Exploration Division

CMPDI (HQ), Ranchi

MARCH – 2023

Job no - 200422005

Annexure-XI

Details of CSR amount spent against ongoing projects for FY 2022-23

Sl. No.	Name of the Project	Item from the list of activities in Schedule VII to the Act	Local area (Yes/No)	Location of the project		Project duration	Amount allocated for the project (in ₹ Lakhs)	Amount spent in the current financial Year (in ₹ Lakhs)	Amount transferred to Unspent CSR Account for the project as per Section 135(6) (in ₹ Lakhs)	Mode of Implementation - Direct (Yes/No)	Mode of Implementation - Through Implementing Agency	
				State	District						Name	CSR Registration number
1	Skill development training in plastic engineering for 40 candidates at Central Institute of Petrochemicals Engineering and Technology (CIPET)	Item No. (ii) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	28.00	14.00	14.00	Yes	NA	NA
2	Distribution of assistive devices to Divyangjans in Dhanbad	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	58.71	0.00	58.71	Yes	NA	NA
3	Skill development training in General Duty Assistant (GDA)-advanced for beneficiaries of Dhanbad	Item No. (ii) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	27.60	5.52	22.08	No	Pramith Foundation	CSR00002914
4	Developmental activities for special needs children at PehlaKadam School, Jagjeevan Nagar, Dhanbad	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	16.50	0.00	16.50	Yes	NA	NA

5	Construction of water tank at the campus of Leprosy Centre at G'pur Dhanbad	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	28.90	8.31	20.59	Yes	NA	NA
6	Infrastructural works at LalmaniVriddh SevaAshraam, Dhanbad	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	27.53	9.09	18.44	Yes	NA	NA
7	Infrastructural development works of VinodBihariMahto Inter MahilaMahavidyalayTopchanchi, Dhanbad	Item No. (ii) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	12.47	4.62	7.85	Yes	NA	NA
8	CSR funding for the educational performance of tribal children of Jharkhand state through 'Healthy Aging India'	Item No. (ii) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	20.00	4.00	16.00	No	Healthy Aging India	CSR00005412
9	Drinking water supply arrangement in 03 colleges of Tundi & East Tundi blocks of Dhanbad district. (1) Sibu Soren Inter College, Tundi (2) Sibu Soren Degree College, Tundi (3) BinodBihariMahato Inter College, East Tundi	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	7.68	6.19	1.49	Yes	NA	NA

10	Arranging water supply to Palashiya village for domestic use	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	13.40	11.96	1.44	Yes	NA	NA
11	Arranging water supply to JogradBasti	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	7.58	7.21	0.37	Yes	NA	NA
12	Arranging water supply to Niche Deoghara village for mine water utilisation for domestic use	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	42.26	0.00	42.26	Yes	NA	NA
13	Construction of community hall under HarinaPanchayat	Item No. (x) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	17.49	0.00	17.49	Yes	NA	NA
14	Water supply arrangement at HarsudihBasti	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	4.84	0.00	4.84	Yes	NA	NA
15	Infrastructural development works in Gandhi SmarakUccha Vidyalaya	Item No. (ii) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	7.23	0.00	7.23	Yes	NA	NA
16	Constrution of toilets in NagarikalaUtkramitUcchaVidyalaya	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	5.86	0.00	5.86	Yes	NA	NA
17	Distribution of TB nutritional Baskets	Item No. (i) of Schedule VII	Yes	Jharkhand	Dhanbad	02 years	24.89	0.00	24.89	No	CINI	CSR00000494

Annexure-XI

18	Expenditure towards GST for ongoing projects						11.86	0.00	11.86			
Total							362.80	70.90	291.90			

Details of CSR amount spent against other than ongoing projects for the financial year 2022-23

(1)	(2)	(3)	(4)	(5)		(6)	(7)
Sl No	**Name of the Project**	**Item from the list of the activities in schedule VII to the act**	**Local area (Yes/No).**	**Location of the project.**		**Amount spent for the project (₹ lakhs)**	**Mode of implementation-Direct (Yes/No).**
				State	**District**		
1	Construction of low cost houses for 111 Nos. of flood affected families of Chirkunda Nagar Parishad under "Pradhanmantri Awash Yojna (Urban)" for EWS/LIG/MIG categories including slum dwellers near CV Area (through Dhanbad district administration)	Promoting healthcare including preventive healthcare	Yes	Jharkhand	Dhanbad	249.75	Yes
2	Development of 500 Aanganwadis to model Aanganwadis in Dhanbad district	Promoting healthcare including preventive healthcare	Yes	Jharkhand	Dhanbad	486.22	Yes
3	CSR Conclave	Promoting education, including special education and employment enhancing vocation skills especially among children, women, elderly, and differently abled and livelihood enhancement projects	Yes	Jharkhand	Dhanbad	5.00	Yes
4	Expenditure towards Har Ghar Tiranga Campaign	Promoting education, including special education and employment enhancing vocation skills especially among children, women, elderly, and differently abled and livelihood enhancement projects	Yes	Jharkhand	Dhanbad	27.60	Yes
5	Blankets distribution to poor during winter season	Promoting healthcare including preventive healthcare	Yes	Jharkhand	Dhanbad	8.80	Yes
6	Expenditure towards Medical Camps	Promoting healthcare including preventive healthcare	Yes	Jharkhand	Dhanbad	0.18	Yes
7	Installation of Masala Grinder for SHGs/women through Bastacolla Area	Promoting education, including special education and employment enhancing vocation skills especially among children, women, elderly, and differently abled and livelihood enhancement projects	Yes	Jharkhand	Dhanbad	1.65	Yes
Total						**779.20**	

Annexure-XII

Water Supply to nearby villagers

Treated mine water is being supplied through water pipelines and water tankers to the nearby villagers, from the different collieries of Govindpur Area under Cluster III.

There is a central water treatment plant at Sinidih with a capacity 1.3MLD. Apart from this collieries have their own water treatment plants as well to supply the water to nearby 29 villages. Details of villages, where water is being supplied and corresponding nos. of beneficiaries (Family) are given below:

<table>
<tr><th>Sl. No.</th><th>Colliery name</th><th>Name of beneficiary villages</th><th>No. of Beneficiaries (Family)</th><th>Quantity of water supplied</th></tr>
<tr><td>1.</td><td>New Akashkinaree Colliery</td><td rowspan="5">Behrakudar, Bahiyardih, Jogidih Basti, Bhatmorna, Maheshpur Basti, Kharkharee Basti, Deoghara, Premnagar, Sinidih village, Mathadih basti, Dharmabandh basti, chanchani colony, majhlitand, khash Tundoo, Narayan Dhowrah, Madhuban thana, Tundoo village, Jogidih village, chitahi basti, barmasiya etc.</td><td rowspan="5">Approx. 1,03,000</td><td rowspan="5">Approx 7500 cum/day</td></tr>
<tr><td>2.</td><td>Block-IV/Kooridih Colliery</td></tr>
<tr><td>3.</td><td>Maheshpur Colliery</td></tr>
<tr><td>4.</td><td>Jogidih Colliery</td></tr>
<tr><td>5.</td><td>Teturiya Colliery</td></tr>
</table>

In addition to this Cluster-III (Govindpur Area), BCCL is paying to **MADA** as well for the supply of water to localities in Govindpur Area. The details of payment made are given as below:

Financial Year	Amount paid (Rs.)
2013-14	84,00,275
2014-15	76,77,525
2015-16	39,35,600
2016-17	36,14,075
2017-18	29,03,400
2018-19	38,71,200
2019-20	70,88,190
2020-21	51,87,080

WATER QUALITY REPORT

OF

BHARAT COKING COAL LIMITED, CLUSTER – III

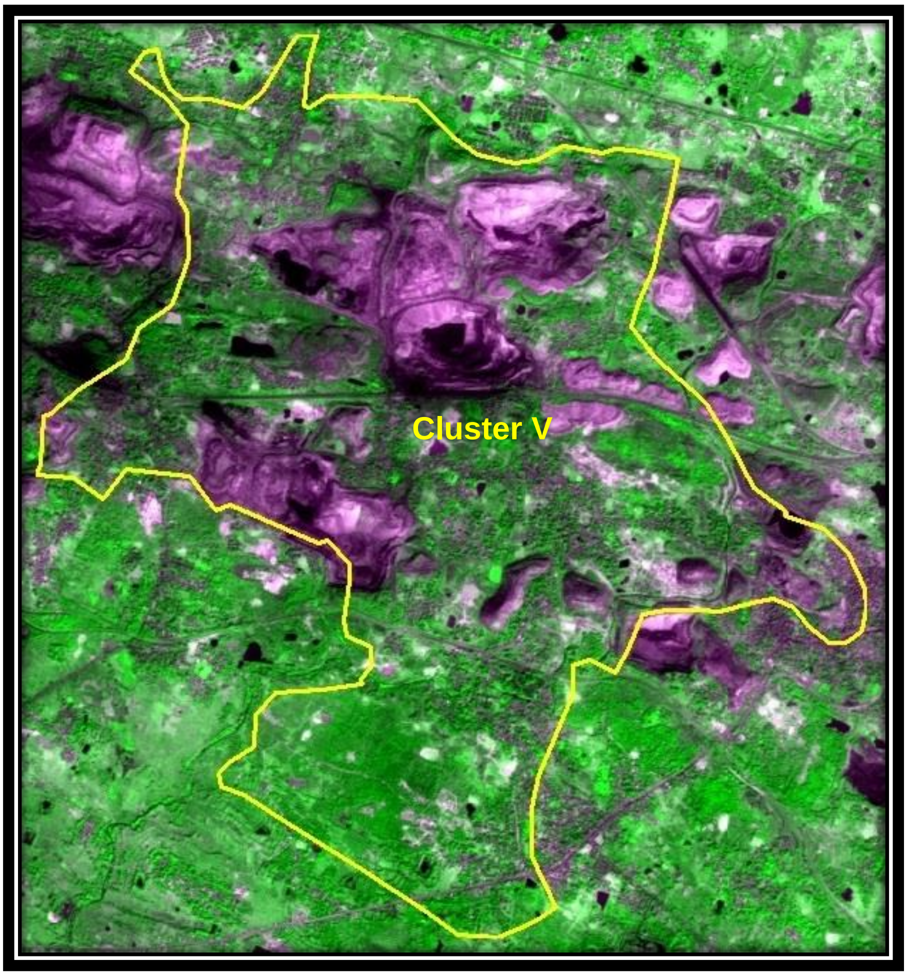
(FOR THE Q.E. JUNE, 2023)

E. C. no. J-11015/213/2010-IA.II (M) dated 06.02.2013

CMPDI
ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

Annexure-XIV

Land Reclamation/ Restoration Monitoring of five Clusters of (Opencast + Underground) Coal Mines of Bharat Coking Coal Limited based on Satellite Data of the Year 2020



Submitted to

Bharat Coking Coal Limited

कोल इण्डिया Coal India

cmpdi

A Mini-Ratna Company

Land Reclamation/ Restoration Monitoring of five Clusters of (Opencast + Underground) Coal Mines of Bharat Coking Coal Limited based on Satellite Data of the Year 2020

March-2021

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

CONTENTS

Executive Summary

1. Project — Land reclamation/ restoration monitoring of five clusters of (Opencast + Underground) coal mines of Bharat Coking Coal Ltd. (BCCL), based on satellite data, on every three-year basis.

2. Objective — Objective of land reclamation/ restoration monitoring is to assess the area of backfilled, plantation, social forestry, active mining area, water bodies, and distribution of wasteland, agricultural land and forest in the leasehold area of the project. This will help in assessing the progressive status of mined land reclamation and to take up remedial measures, if any, required for environmental protection.

3. Salient Findings

- Out of 5 Clusters of mines viz. III, V, VIII, IX and XVII considered for land reclamation monitoring during the year 2020-21; XVII cluster of mines is added during the year 2020-21. These clusters consist of mainly opencast mines.

- Out of the total mine leasehold area of 7988.22 Ha. of the 05 clusters producing less than 5mcm (Coal+OB) annually considered for monitoring during the year 2020-21; total excavated area is 1300.74 Ha. out of which 27.81 Ha. area (2.14%) has been planted on backfill (Biological Reclamation) and 657.49 Ha. area (50.55%) is under backfilling (Technical Reclamation) and 615.44 Ha. area (47.31%) under active mining. Cluster wise details of land reclamation of the above Clusters is given in Table-1.

- Total area under plantation (green cover) covers an area of 645.75 Ha. which is 8.08% of total leasehold area.

- This report and the findings will be considered as basis for further monitoring and reclamation related activities.

Table 1

Land Reclamation Status in five Clusters (Underground + Opencast Mines) of BCCL based on Satellite Data of the Year 2020

Table - 1 Status of Land Reclamation in 5 clusters of BCCL based on Satellite Data of the Year 2020

(Area in Hectare)

Sl. No.	Cluster No.	Total Leasehold Area		Technical Reclamation: Area under Backfilling		Plantation: Biological: Plantation on Excavated / Backfilled Area		Plantation: Other Plantations: Plantation on External OB Dumps		Plantation: Other Plantations: Social Forestry, Avanue Plantation Etc.		Area under Active Mining		Total Excavated Area		Total Area under Plantation (% Green Cover Generated in Leasehold)		Total Area under Reclamation	
1	*2*	*3*		*4*		*5*		*6*		*7*		*8*		*9 (=4+5+8)*		*10 (=5+6+7)*		*11(=4+5)*	
		2017	2020	2017	2020	2017	2020	2017	2020	2017	2020	2017	2020	2017	2020	2017	2020	2017	2020
1	Cluster III	1552.53	1552.53	55.87	60.37	3.89	3.89	21.11	21.11	128.07	162.33	101.50	104.79	161.26	169.05	153.07	187.33	59.76	64.26
				34.65%	35.71%	2.41%	2.30%					62.94%	61.99%			9.86%	12.07%	37.06%	38.01%
2	Cluster V	1724.52	1724.52	162.09	187.59	7.19	7.19	23.85	23.85	105.29	105.29	112.24	103.52	281.52	298.30	136.33	136.33	169.28	194.78
				57.58%	62.89%	2.55%	2.41%					39.87%	34.70%			7.91%	7.91%	60.13%	65.30%
3	Cluster VIII	1331.95	1331.95	161.86	206.91	13.72	9.93	21.97	21.97	24.70	24.70	111.06	124.49	286.64	341.33	60.39	56.60	175.58	216.84
				56.47%	60.62%	4.79%	2.91%					38.75%	36.47%			4.53%	4.25%	61.25%	63.53%
4	Cluster IX	1967.22	1967.22	77.53	77.53	6.80	6.80	41.79	41.79	168.58	168.58	181.85	217.24	266.18	301.57	217.17	217.17	84.33	84.33
				29.13%	25.71%	2.55%	2.25%					68.32%	72.04%			11.04%	11.04%	31.68%	27.96%
5	Cluster XVII	-	1412.00	-	125.09	-	0.00	-	5.00	-	43.33	-	65.40	-	190.49	-	48.32	-	125.09
					65.67%		0.00%						34.33%				3.42%		65.67%
	TOTAL	**6576.22**	**7988.22**	**457.35**	**657.49**	**31.60**	**27.81**	**108.72**	**113.72**	**426.64**	**504.23**	**506.65**	**615.44**	**995.60**	**1300.74**	**566.96**	**645.75**	**488.95**	**685.30**
				45.94%	**50.55%**	**3.17%**	**2.14%**					**50.89%**	**47.31%**			**8.62%**	**8.08%**	**49.11%**	**52.69%**

(% is calculated with respect to Excavated Area as applicable)

Note: In reference of the above Table, different parameters are classified as follows: (Cluster XVII started from current year)

1. Area under Biological Reclamation includes Areas under Plantation done on Backfilled Area Only.
2. Area under Technical Reclamation includes Area under Barren Backfilling only.
3. Area under Active Mining Includes Coal Quarry, Advance Quarry Site and Quarry filled with water etc., if any.
4. Social Forestry and Plantation on External OB Dumps are not included in Biological Reclamation and are put under separate categories as shown in the above Table.
5. (%) calculated in the above Table is in respect to Total Excavated Area except for "Total Area under Plantation" where % is in terms of "Leasehold Area"'.

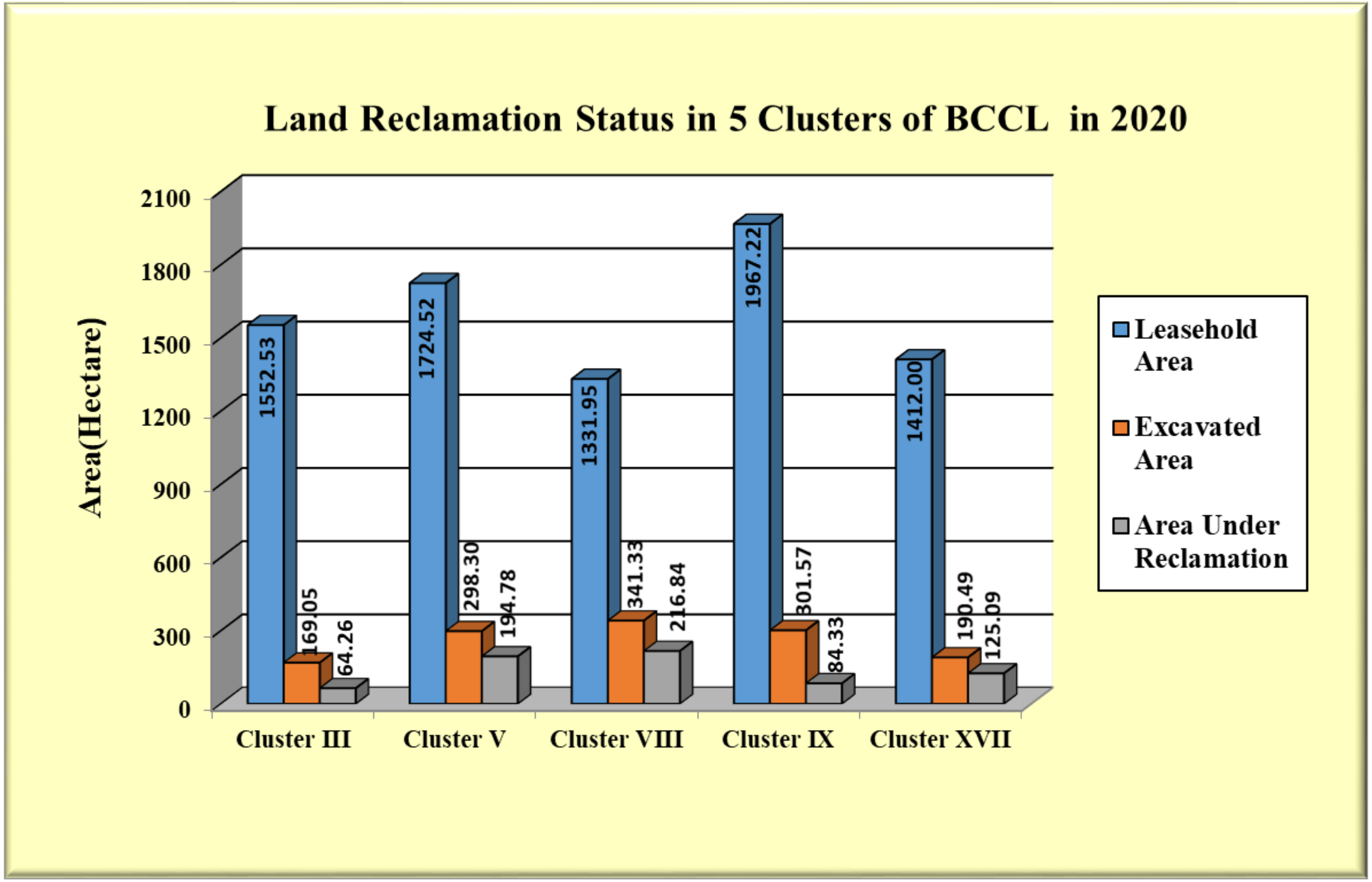


Fig. 1: Cluster wise Land Reclamation Status in five Clusters - 2020 (BCCL)

1. Background

1.1 Land is the most important natural resource which embodies soil, water, flora, fauna and total ecosystem. All human activities are based on the land which is the scarcest natural resource in our country. Mining is a site specific industry and it could not be shifted anywhere else from the location where mineral occurs. It is a fact that surface mining activities do affect the land environment due to ground breaking. Therefore, there is an urgent need to reclaim and restore the mined out land for its productive use for sustainable development of mining. This will not only mitigate environmental degradation, but would also help in creating a more congenial environment for land acquisition by coal companies in future.

1.2 Keeping above in view, Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/ENV/2017/DP/8391 dated 22.06.2017 to Central Mine Planning & Design Institute (CMPDI), Ranchi, for monitoring of clusters with coal mines (both underground and open cast projects) having less than 5 million m^3 per annum capacity (Coal +OB) at an interval of three years based on remote sensing satellite data for sustainable development of mining. Earlier, CMPDI used to carry out land reclamation monitoring for individual projects of less than 5 million capacity, but from 2017 the same was carried out cluster wise for mines of BCCL. For operational reasons and convenience, underground and opencast mines (often with multiple overlapping seams), have now been clustered together. The result of land reclamation status of all such mines are hosted on the website of CIL, (www.coalindia.in), CMPDI (www.cmpdi.co.in) and the concerned coal companies in public domain. Detailed report is submitted to Coal India and respective subsidiaries.

1.3 Land reclamation monitoring of all cluster coal mining projects would also comply the statutory requirements of Ministry of Environment, Forest & Climate Change (**MoEF&CC**). Such monitoring would not only facilitate in taking timely mitigation measures against environmental degradation, but would also enable coal companies to utilize the reclaimed land for larger socio-economic benefits in a planned way.

1.4 Present report is embodying the finding of the study based on satellite data of the year 2020 carried out for five clusters of mines comprising both underground and OC projects for Bharat Coking Coal Ltd.

2. Objective

Objective of the land reclamation/restoration monitoring is to assess the area of backfilled, plantation, OB dumps, social forestry, active mining area, settlements and water bodies, distribution of wasteland, agricultural land and forest land in the leasehold area of the project. This is an important step taken up for assessing the progressive status of mined land reclamation and for taking up remedial measures, if any, required for environmental protection.

3. Methodology

There are number of steps involved between raw satellite data procurement and preparation of final map. National Remote Sensing Centre (NRSC) Hyderabad, being the nodal agency for satellite data supply in India, provides only raw digital satellite data, which needs further digital image processing for extracting the information and map preparation before uploading the same in the website. Methodology for land reclamation monitoring is given in fig 2. Following steps are involved in land reclamation/ restoration monitoring:

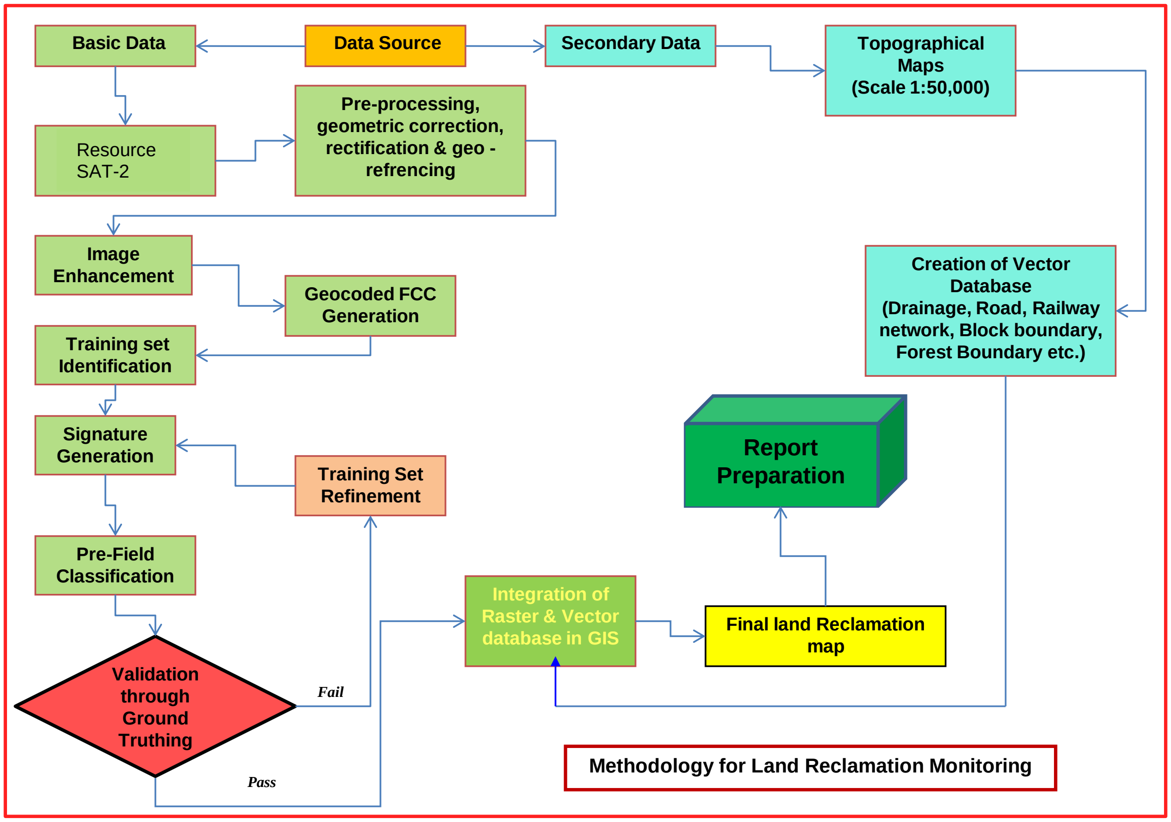


Fig. 2: Methodology of Land Reclamation Monitoring

3.1 Data Procurement: After browsing the data quality and date of pass on internet, supply order for data is placed to NRSC. Secondary data like leasehold boundary, toposheet are procured for creation of vector database.

3.2 Satellite Data Processing: Satellite data are processed using ERDAS IMAGINE digital image processing s/w. Methodology involves the following major steps:

- **Rectification & Geo-referencing:** Inaccuracies in digital imagery may occur due to 'systematic errors' attributed to earth curvature and rotation as well as 'non-systematic errors' attributed to satellite receiving station itself. Raw digital images may contain geometric distortions, which make them unusable as maps. Therefore, geo-referencing is required for correction of image data using ground control points (GCP) to make it compatible with the new series WGS-84 compatible SoI toposheet.

- **Image enhancement:**

  To improve the interpretability of the raw data, image enhancement is necessary. Local operations modify the value of each pixel based on brightness value of neighbouring pixels using ERDAS IMAGINE 14.0 s/w. and enhance the image quality for interpretation.

- **Training set selection**

  Training set requires to be selected, so that software can classify the image data accurately. The image data are analysed based on the interpretation keys. These keys are evolved from certain fundamental image-elements such as tone/colour, size, shape, texture, pattern, location, association and shadow. Based on the image-elements and other geo-technical elements like land form, drainage pattern and physiography; training sets were selected/identified for each land use/cover class. Field survey was carried out by taking selective traverses in order to collect the ground information (or reference data) so that training sets are selected accurately in the image. This was intended to serve as an aid for classification.

- **Classification and Accuracy assessment**

  Image classification is carried out using the maximum likelihood algorithm. The classification proceeds through the following steps: (a) calculation of statistics [i.e. signature generation] for the identified training areas, and (b) the decision boundary of maximum probability based on the mean vector, variance, covariance and correlation matrix of the pixels. After evaluating the statistical parameters of the training sets, reliability test of training sets is conducted by measuring the statistical separation between the classes that resulted from computing divergence matrix. The overall accuracy of the classification was finally assessed with reference to ground truth data.

- **Area calculation**

  The area of each land use class in the leasehold is determined using ERDAS IMAGINE v. 14.0 s/w.

- **Overlay of Vector data base**

  Vector data base is created based on secondary data. Vector layer like drainage, railway line, leasehold boundary, forest boundary etc. are superimposed on the image as vector layer in the Arc GIS database.

- **Pre-field map preparation**

  Pre-field map is prepared for validation of the classification result.

3.3 Ground Truthing:

Selective ground verification of the land use classes are carried out in the field and necessary corrections if required, are incorporated before map finalization.

3.4 Land reclamation database on GIS:

Land reclamation database is created on GIS platform to identify the temporal changes identified from satellite data of different cut - of dates. The database boundary shape files (.shp), kml files and the maps thus prepared confirm to the WGS-84 datum and UTM projected co-ordinate system.

4. Land Reclamation Status in Bharat Coking Coal Ltd.

4.1 Following 5 clusters of mines comprising both underground and opencast projects of Bharat Coking Coal Ltd. have been taken up for land reclamation monitoring during the year 2020-21:

- Cluster III
- Cluster V
- Cluster VIII
- Cluster IX
- Cluster XVII

4.2 Cluster wise Land Reclamation status of above mentioned clusters in BCCL is given in Table 1 and also shown graphically in Fig 1. Area statistics of different land use classes present in the mine leasehold of the above projects for the year 2020 are shown in Table 2. Land use maps derived from the satellite data are shown in Plate 1 - 5. Different land use classes based on satellite data are depicted in bar charts in Fig. 3 - 7.

4.3 Study reveals that out of total mine leasehold area of 7988.22 ha. of the 5 clusters of mines (Underground + Opencast) of BCCL mentioned above taken for this study in 2020-21, total excavated area is 1300.74 ha. out of which 27.81 ha. (2.14%) has been planted (*Biologically Reclaimed*), 657.49 ha. (50.55%) is under backfilling (*Technically Reclaimed*) and balance 615.44 ha. (47.31%) is under active mining.

4.4 Land reclamation monitoring for cluster XVII of BCCL is taken up for the first time in the year 2020-21. Hence comparison of this cluster in year 2020 has not been made with respect to year 2017. The data thus generated in the year 2020 will be considered as base data for comparison of land reclamation of this cluster of mines at the interval of every three year.

4.5 Study reveals that out of five clusters of mines of BCCL considered for reclamation monitoring in 2020, the area under total plantation (Green Cover) is maximum in Cluster IX i.e 217.17 ha., followed by Cluster III with 187.33 ha., Cluster V with 136.33 ha., Cluster VIII with 56.60 ha. and Cluster XVII with 48.32 ha.

4.6 Out of the 5 Clusters in BCCL considered for satellite data based land reclamation monitoring in 2020, Cluster XVII tops with 65.67% reclamation followed by Cluster V with 65.30%, Cluster VIII with 63.53%, Cluster III with 38.01% and Cluster IX with 27.96%.

4.7 In Cluster VIII, it is revealed that area under plantation on backfill (Biological Reclamation) has decreased from 13.72 ha. in the year 2017 to 9.93 ha. in the year 2020. This decrease of 3.79 ha. area in Biological reclamation is due to rehandling of backfill. Hence total area under plantation on backfill has decreased from 31.60 ha. (Yr 2017) to 27.81 ha. (Yr 2020).

4.8 On comparing the status of land reclamation for the year 2020 with respect to the year 2017 it is evident from the analysis that area under land reclamation has increased from 488.95 ha. (Yr 2017) to 685.30 ha. (Yr 2020). This increase of 196.35 ha. area under land reclamation is due to increase in reclamation activities in Cluster III, V & VIII as well as addition of Cluster XVII.

4.9 This study will again be carried out after an interval of three years to assess the progress and changes in land reclamation in the above clusters.

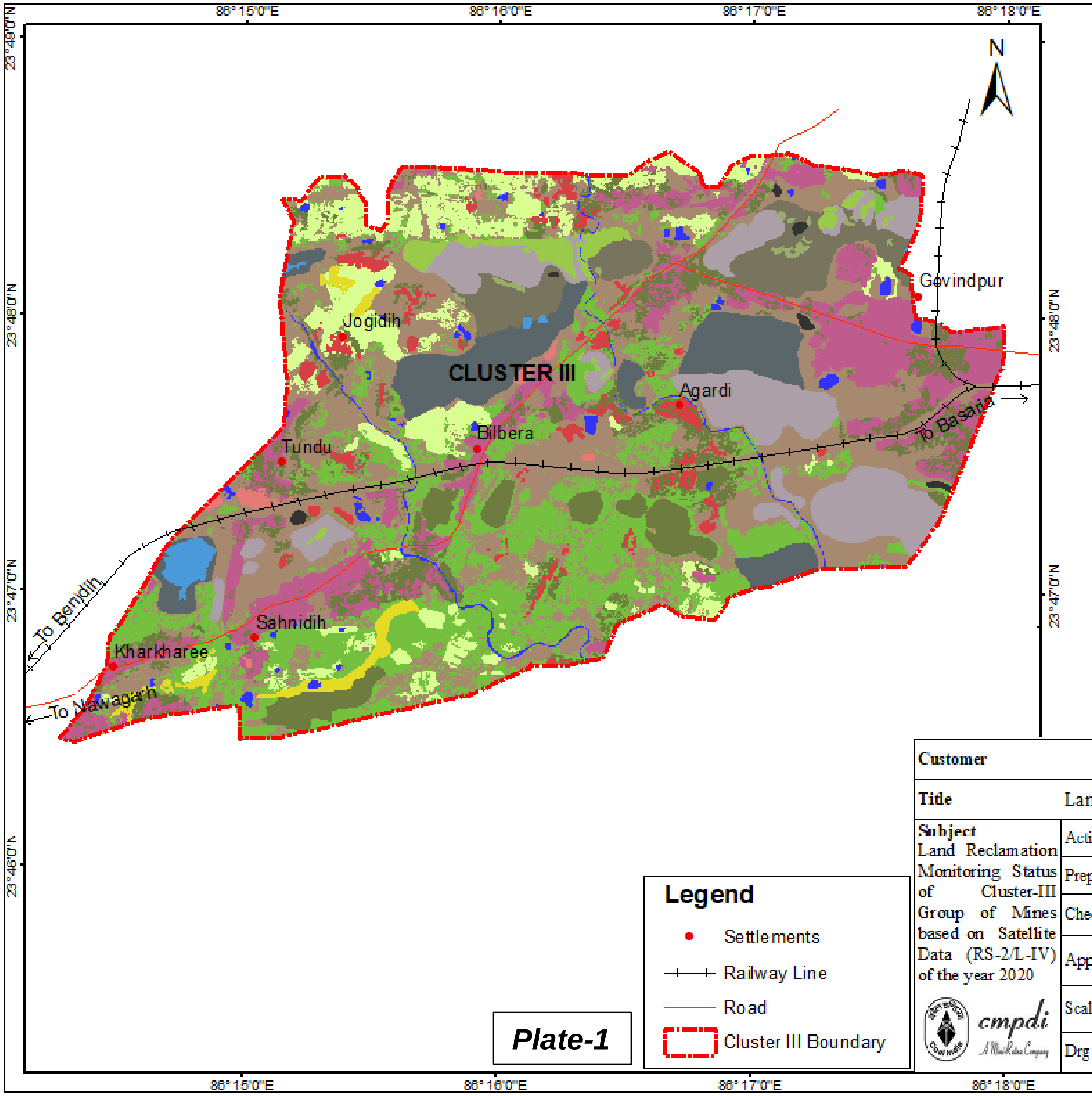
Table 2

Cluster wise Area Statistics of Land Use/ Cover classes in five Clusters of (OC+UG) mines of BCCL based on Satellite Data of the year 2020

Status of Land Reclamation in 5 Clusters of (UG+OC) mines of Bharat Coking Coal Ltd. based on Satellite data of the Year 2020

(Area in Hectare)

		CLUSTER III		CLUSTER V		CLUSTER VIII		CLUSTER IX		CLUSTER XVII		TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Open Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Forest (A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SCRUBS	**Scrubs (B)**	271.78	17.51	320.90	18.61	157.58	11.83	346.67	17.62	178.99	12.68	1275.92	15.97
PLANTATION	Social Forestry/Avenue Plantation	162.33	10.46	105.29	6.11	24.70	1.85	168.58	8.57	43.33	3.07	504.23	6.31
	Plantation on OB Dump	21.11	1.36	23.85	1.38	21.97	1.65	41.79	2.12	5.00	0.35	113.72	1.42
	Plantation on Backfill (Biological Reclamation)	3.89	0.25	7.19	0.42	9.93	0.75	6.80	0.35	0.00	0.00	27.81	0.35
	Total Plantation (C)	187.33	12.07	136.33	7.91	56.60	4.25	217.17	11.04	48.32	3.42	645.75	8.08
	Total Vegetation (A+B+C)	**459.11**	**29.57**	**457.23**	**26.51**	**214.18**	**16.08**	**563.84**	**28.66**	**227.31**	**16.10**	**1921.67**	**24.06**
	Coal Dump	3.58	0.23	1.70	0.10	3.72	0.28	4.89	0.25	0.00	0.00	13.89	0.17
ACTIVE MINING	Coal Quarry	94.89	6.11	87.72	5.09	101.43	7.62	191.65	9.74	56.82	4.02	532.51	6.67
	Advance Quarry Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Quarry Filled With Water	9.90	0.64	15.80	0.92	23.06	1.73	25.59	1.30	8.58	0.61	82.93	1.04
	Total Area under *Active Mining*	**104.79**	**6.75**	**103.52**	**6.00**	**124.49**	**9.35**	**217.24**	**11.04**	**65.40**	**4.63**	**615.44**	**7.70**
	Barren OB Dump	126.59	8.15	174.62	10.13	152.06	11.42	166.03	8.44	44.48	3.15	663.78	8.31
RECLAIMED	Area Under Backfilling (Technical Reclamation)	60.37	3.89	187.59	10.88	206.91	15.53	77.53	3.94	125.09	8.86	657.49	8.23
	Total Area under Mine Operation	**295.33**	**19.02**	**467.43**	**27.10**	**487.18**	**36.58**	**465.69**	**23.67**	**234.97**	**16.64**	**1950.60**	**24.42**
WASTELAND	Waste Lands	426.21	27.45	472.92	27.42	373.70	28.06	581.57	29.56	112.68	7.98	1967.08	24.62
	Fly Ash Pond / Sand Body	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.76	0.48	6.76	0.08
	Total Wasteland	**426.21**	**27.45**	**472.92**	**27.42**	**373.70**	**28.06**	**581.57**	**29.56**	**119.44**	**8.46**	**1973.84**	**24.71**
WATERBODIES	Reservoir, Nallah, Ponds	18.74	1.21	13.66	0.79	13.95	1.05	23.33	1.19	31.81	2.25	101.49	1.27
	Total Waterbodies	**18.74**	**1.21**	**13.66**	**0.79**	**13.95**	**1.05**	**23.33**	**1.19**	**31.81**	**2.25**	**101.49**	**1.27**
AGRICULTURE	Crop Lands	16.60	1.07	8.41	0.49	16.63	1.25	0.00	0.00	69.45	4.92	111.09	1.39
	Fallow Lands	122.68	7.90	58.64	3.40	58.63	4.40	43.56	2.21	472.71	33.48	756.22	9.47
	Total Agriculture	**139.28**	**8.97**	**67.05**	**3.89**	**75.26**	**5.65**	**43.56**	**2.21**	**542.16**	**38.40**	**867.31**	**10.86**
SETTLEMENTS	Urban Settlement	173.86	11.20	220.71	12.80	99.22	7.45	232.31	11.81	214.25	15.17	940.35	11.77
	Rural Settlement	33.95	2.19	13.97	0.81	60.71	4.56	47.79	2.43	31.36	2.22	187.78	2.35
	Industrial Settlement	6.05	0.39	11.55	0.67	7.75	0.58	9.13	0.46	10.69	0.76	45.17	0.57
	Total Settlements	**213.86**	**13.77**	**246.23**	**14.28**	**167.68**	**12.59**	**289.23**	**14.70**	**256.31**	**18.15**	**1173.31**	**14.69**
	Grand Total	**1552.53**	**100.00**	**1724.52**	**100.00**	**1331.95**	**100.00**	**1967.22**	**100.00**	**1412.00**	**100.00**	**7988.22**	**100.00**



Area Statistics - Cluster III (2020)				
Classes		Colour	Core Zone	
Level-I	Level-II		Area (Ha)	% of Total
Forest	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		**0.00**	**0.00**
	Scrubs (B)		**271.78**	**17.51**
Plantation Area	Social Forestry		162.33	10.46
	Plantation on OB		21.11	1.36
	Plantation on Backfill		3.89	0.25
	Total Plantation Area (C)		**187.33**	**12.07**
	Total Vegetation (A+B+C)		**459.11**	**29.57**
Agriculture Land	Crop land		16.60	1.07
	Fallow Land		122.68	7.90
	Total Agriculture Land		**139.28**	**8.97**
Waste Land	Waste Land		426.21	27.45
	Sand Body		0.00	0.00
	Total Waste Land		**426.21**	**27.45**
Mining Area	Advance Quarry area		0.00	0.00
	Coal Quarry		94.89	6.11
	Barren OB Dump		126.59	8.15
	Back Fill		60.37	3.89
	Coal Dump		3.58	0.23
	Water Filled Qry		9.90	0.64
	Total Mining Area		**295.33**	**19.02**
Settlements	Urban Settlements		173.86	11.20
	Rural Settlements		33.95	2.19
	Industrial Settlements		6.05	0.39
	Total Settlement Area		**213.86**	**13.77**
Water Body	**River/ Ponds**		**18.74**	**1.21**
	Total Area		**1552.53**	**100.00**

Customer	Bharat Coking Coal Limited				
Title	Land Reclamation Monitoring of BCCL Clusters				Job No. 561410027
Subject Land Reclamation Monitoring Status of Cluster-III Group of Mines based on Satellite Data (RS-2/L-IV) of the year 2020	Activity	Name	Designation	Signature	
	Prepared	A. Parida	Dy. Mgr(Geology)	[signature]	
	Checked	B.K. Choudhary	Ch. Mgr(RSC)	[signature]	
	Approved	R. Kumar	GM(Geomatics)	[signature]	
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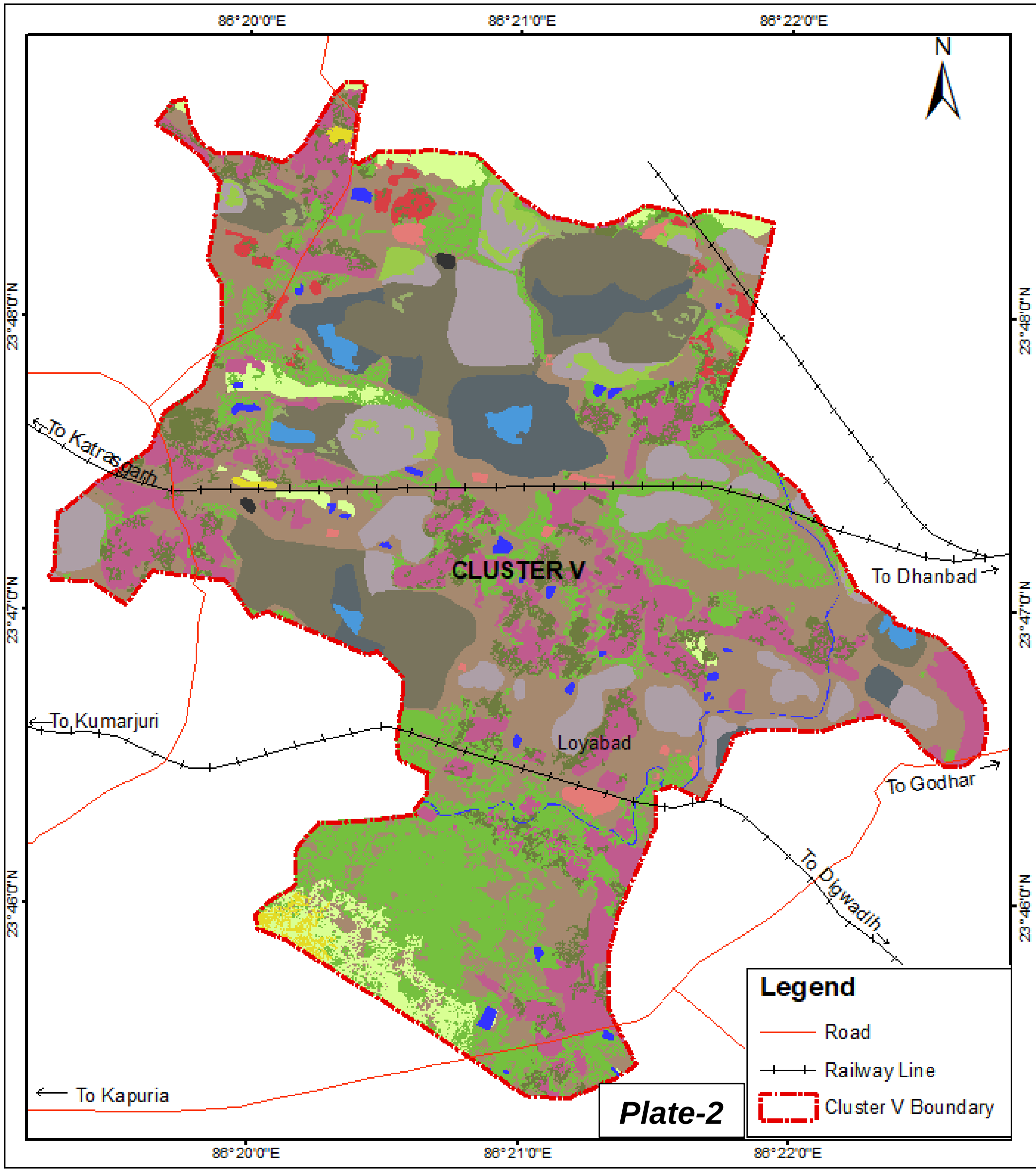
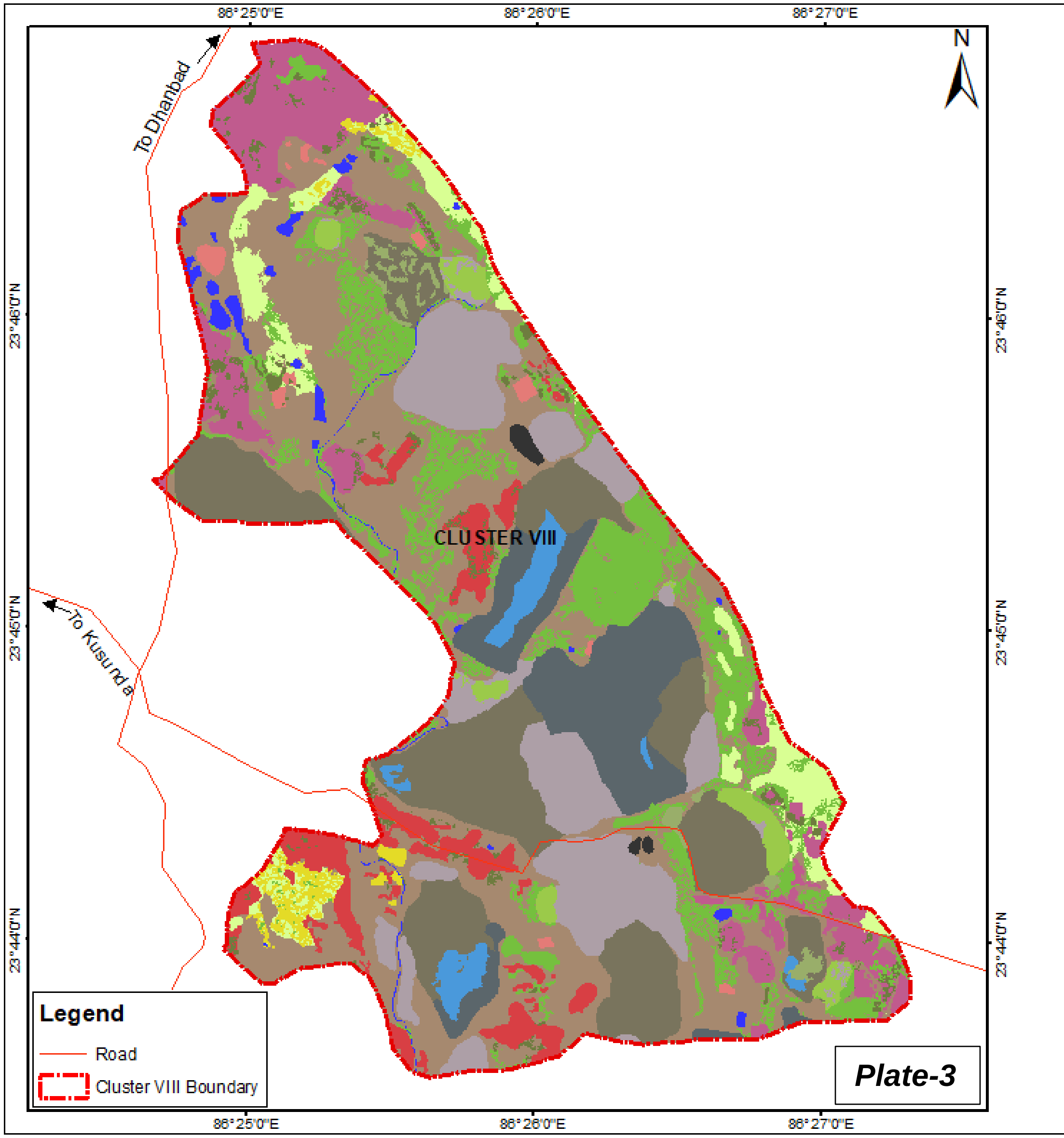
	Drg No.	HQREM20 R2 A4 CL-III			RevNo.0



Area Statistics - Cluster V (2020)

Classes Level-I	Classes Level-II	Colour	Core Zone Area (Ha)	Core Zone % of Total
Forest	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		**0.00**	**0.00**
	Scrubs (B)		**320.90**	**18.61**
Plantation Area	Social Forestry		105.29	6.11
	Plantation on OB		23.85	1.38
	Plantation on Backfill		7.19	0.42
	Total Plantation Area (C)		**136.33**	**7.91**
	Total Vegetation (A+B+C)		**457.23**	**26.51**
Agriculture Land	Crop land		8.41	0.49
	Fallow Land		58.64	3.40
	Total Agriculture Land		**67.05**	**3.89**
Waste Land	Waste Land		472.92	27.42
	Sand Body		0.00	0.00
	Total Waste Land		**472.92**	**27.42**
Mining Area	Advance Quarry area		0.00	0.00
	Coal Quarry		87.72	5.09
	Barren OB Dump		174.62	10.13
	Back Fill		187.59	10.88
	Coal Dump		1.70	0.10
	Water Filled Qry		15.80	0.92
	Total Mining Area		**467.43**	**27.10**
Settlements	Urban Settlements		220.71	12.80
	Rural Settlements		13.97	0.81
	Industrial Settlements		11.55	0.67
	Total Settlement Area		**246.23**	**14.28**
Water Body	**River/ Ponds**		**13.66**	**0.79**
	Total Area		**1724.52**	**100.00**

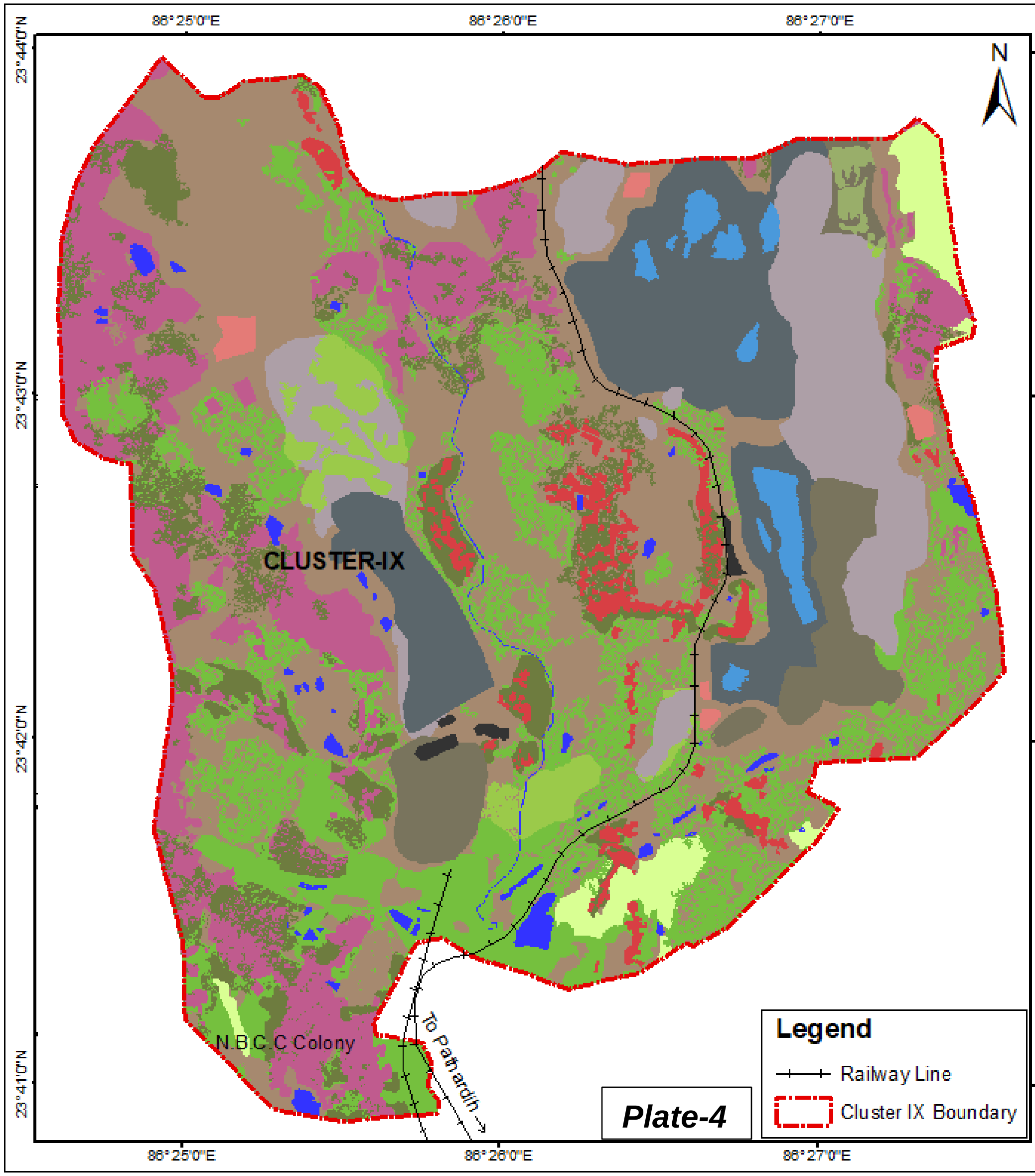
Customer	Bharat Coking Coal Limited			
Title	Land Reclamation Monitoring of BCCL Clusters			Job No. 561410027
Subject Land Reclamation Monitoring Status of Cluster-V Group of Mines based on Satellite Data (RS-2/L-IV) of the year 2020	Activity	Name	Designation	Signature
	Prepared	A. Parida	Dy. Mgr(Geology)	
	Checked	B K Choudhary	Ch. Mgr(RSC)	
	Approved	R. Kumar	GM(Geomatics)	
cmpdi A Mini Ratna Company	Scale: 0 0.25 0.5 1 Km			Sheet 1
	Drg No.	HQ REM 20 R2 A4 CL-V		Rev No.0



Area Statistics - Cluster VIII (2020)

Classes		Colour	Core Zone	
Level-I	Level-II		Area (Ha)	% of Total
Forest	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		**0.00**	**0.00**
	Scrubs (B)		**157.58**	**11.83**
Plantation Area	Social Forestry		24.70	1.85
	Plantation on OB		21.97	1.65
	Plantation on Backfill		9.93	0.75
	Total Plantation Area (C)		**56.60**	**4.25**
	Total Vegetation (A+B+C)		**214.18**	**16.08**
Agriculture Land	Crop land		16.63	1.25
	Fallow Land		58.63	4.40
	Total Agriculture Land		**75.26**	**5.65**
Waste Land	Waste Land		373.70	28.06
	Sand Body		0.00	0.00
	Total Waste Land		**373.70**	**28.06**
Mining Area	Advance Quarry area		0.00	0.00
	Coal Quarry		101.43	7.62
	Barren OB Dump		152.06	11.42
	Back Fill		206.91	15.53
	Coal Dump		3.72	0.28
	Water Filled Qry		23.06	1.73
	Total Mining Area		**487.18**	**36.58**
Settlements	Urban Settlements		99.22	7.45
	Rural Settlements		60.71	4.56
	Industrial Settlements		7.75	0.58
	Total Settlement Area		**167.68**	**12.59**
Water Body	**River/ Ponds**		**13.95**	**1.05**
	Total Area		**1331.95**	**100.00**

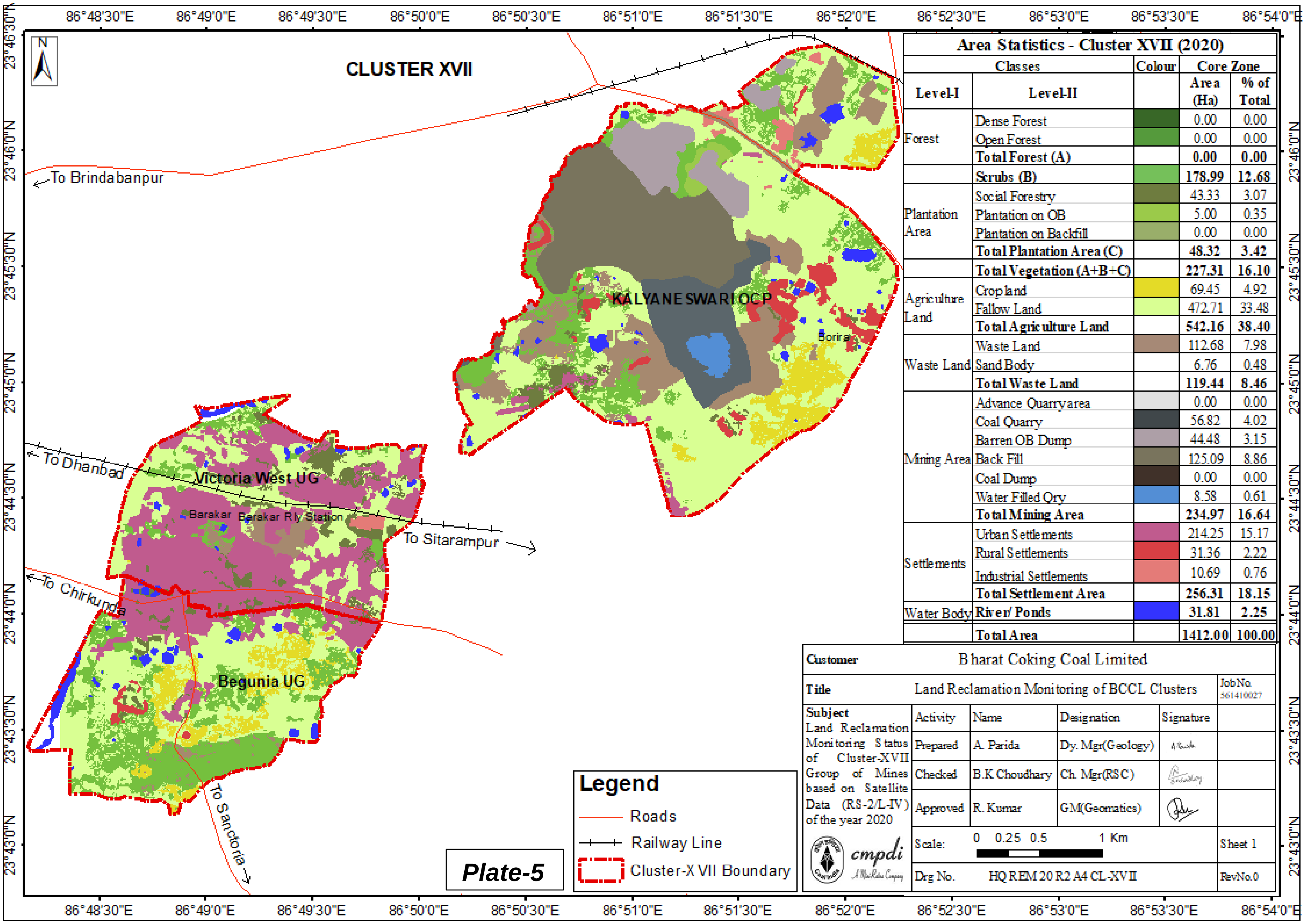
Customer	Bharat Coking Coal Limited			
Title	Land Reclamation Monitoring of BCCL Clusters			Job No. 561410027
Subject: Land Reclamation Monitoring Status of Cluster-VIII Group of Mines based on Satellite Data (RS-2/L-IV) of the year 2020	Activity	Name	Designation	Signature
	Prepared	A Parida	Dy. Mgr(Geology)	
	Checked	B.K Choudhary	Ch. Mgr(RSC)	
	Approved	R. Kumar	GM(Geomatics)	
cmpdi	Scale: 0 0.25 0.5 1 Km			Sheet 1
	Drg No. HQ REM 20 R2 A4 CL-VIII			Rev No 0



Area Statistics - Cluster IX (2020)

Level-I	Level-II	Colour	Core Zone Area (Ha)	Core Zone % of Total
Forest	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		**0.00**	**0.00**
	Scrubs (B)		**346.67**	**17.62**
Plantation Area	Social Forestry		168.58	8.57
	Plantation on OB		41.79	2.12
	Plantation on Backfill		6.80	0.35
	Total Plantation Area (C)		**217.17**	**11.04**
	Total Vegetation (A+B+C)		**563.84**	**28.66**
Agriculture Land	Crop land		0.00	0.00
	Fallow Land		43.56	2.21
	Total Agriculture Land		**43.56**	**2.21**
Waste Land	Waste Land		581.57	29.56
	Sand Body		0.00	0.00
	Total Waste Land		**581.57**	**29.56**
Mining Area	Advance Quarry area		0.00	0.00
	Coal Quarry		191.65	9.74
	Barren OB Dump		166.03	8.44
	Back Fill		77.53	3.94
	Coal Dump		4.89	0.25
	Water Filled Qry		25.59	1.30
	Total Mining Area		**465.69**	**23.67**
Settlements	Urban Settlements		232.31	11.81
	Rural Settlements		47.79	2.43
	Industrial Settlements		9.13	0.46
	Total Settlement Area		**289.23**	**14.70**
Water Body	**River/ Ponds**		**23.33**	**1.19**
	Total Area		**1967.22**	**100.00**

Customer	Bharat Coking Coal Limited				
Title	Land Reclamation Monitoring of BCCL Clusters				Job No. 561410027
Subject: Land Reclamation Monitoring Status of Cluster-IX Group of Mines based on Satellite Data (RS-2/L-IV) of the year 2020	Activity	Name	Designation	Signature	
	Prepared	A. Parida	Dy. Mgr(Geology)		
	Checked	B.K. Choudhary	Ch. Mgr(RSC)		
	Approved	R. Kumar	GM(Geomatics)		
cmpdi A Mini Ratna Company	Scale: 0 0.25 0.5 1 Km				Sheet 1
	Drg No. HQ REM 20 R2 A4 CL-IX				Rev No.0



Area Statistics - Cluster XVII (2020)

Classes		Colour	Core Zone	
Level-I	**Level-II**		**Area (Ha)**	**% of Total**
Forest	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		**0.00**	**0.00**
	Scrubs (B)		**178.99**	**12.68**
Plantation Area	Social Forestry		43.33	3.07
	Plantation on OB		5.00	0.35
	Plantation on Backfill		0.00	0.00
	Total Plantation Area (C)		**48.32**	**3.42**
	Total Vegetation (A+B+C)		**227.31**	**16.10**
Agriculture Land	Cropland		69.45	4.92
	Fallow Land		472.71	33.48
	Total Agriculture Land		**542.16**	**38.40**
Waste Land	Waste Land		112.68	7.98
	Sand Body		6.76	0.48
	Total Waste Land		**119.44**	**8.46**
Mining Area	Advance Quarry area		0.00	0.00
	Coal Quarry		56.82	4.02
	Barren OB Dump		44.48	3.15
	Back Fill		125.09	8.86
	Coal Dump		0.00	0.00
	Water Filled Qry		8.58	0.61
	Total Mining Area		**234.97**	**16.64**
Settlements	Urban Settlements		214.25	15.17
	Rural Settlements		31.36	2.22
	Industrial Settlements		10.69	0.76
	Total Settlement Area		**256.31**	**18.15**
Water Body	**River/ Ponds**		**31.81**	**2.25**
	Total Area		**1412.00**	**100.00**

Customer	Bharat Coking Coal Limited			
Title	Land Reclamation Monitoring of BCCL Clusters			Job No. 561410027
Subject Land Reclamation Monitoring Status of Cluster-XVII Group of Mines based on Satellite Data (RS-2/L-IV) of the year 2020	Activity	Name	Designation	Signature
	Prepared	A. Parida	Dy. Mgr(Geology)	
	Checked	B.K Choudhary	Ch. Mgr(RSC)	
	Approved	R. Kumar	GM(Geomatics)	
cmpdi A Mini Ratna Company	Scale: 0 0.25 0.5 1 Km			Sheet 1
	Drg No.	HQ REM 20 R2 A4 CL-XVII		Rev No.0

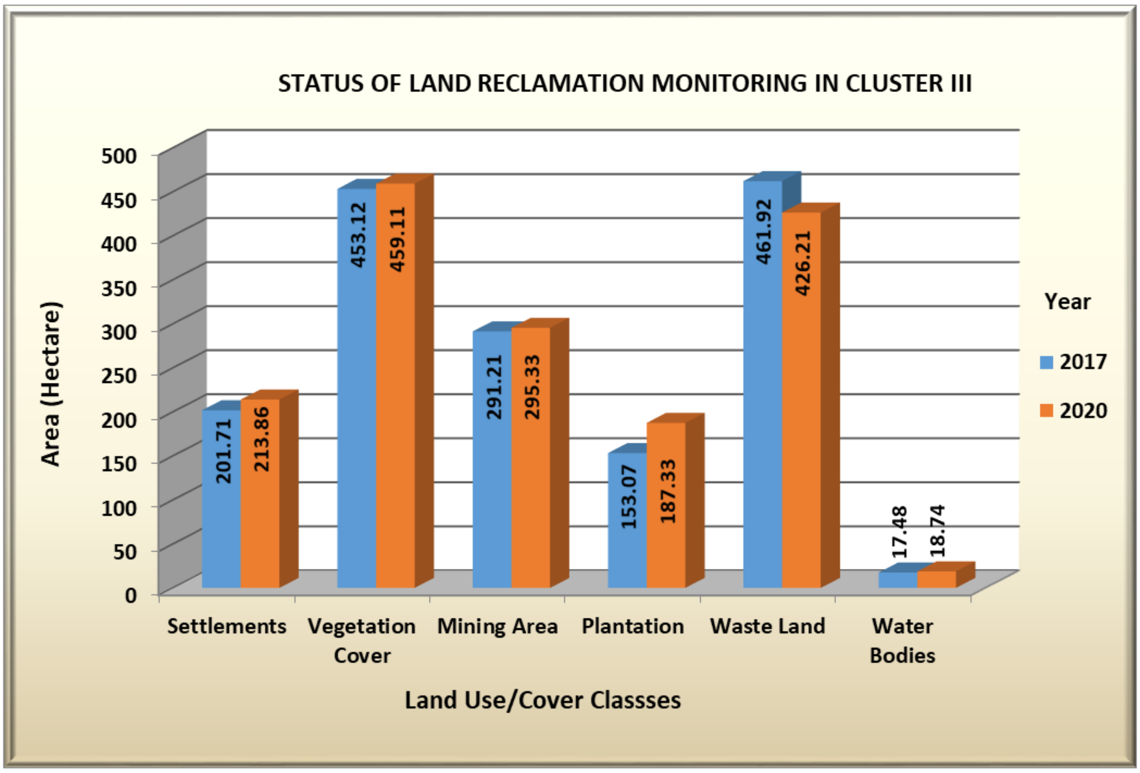


Fig. 3: Land Reclamation Status of Cluster III

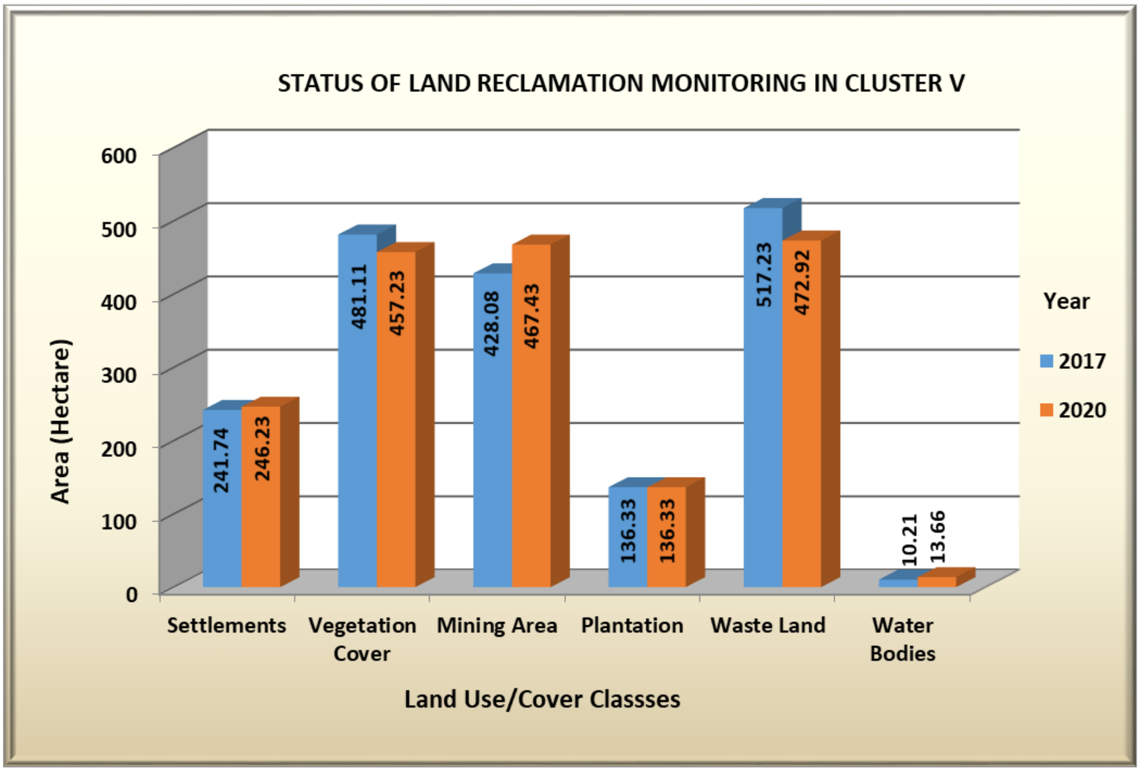


Fig. 4: Land Reclamation Status of Cluster V

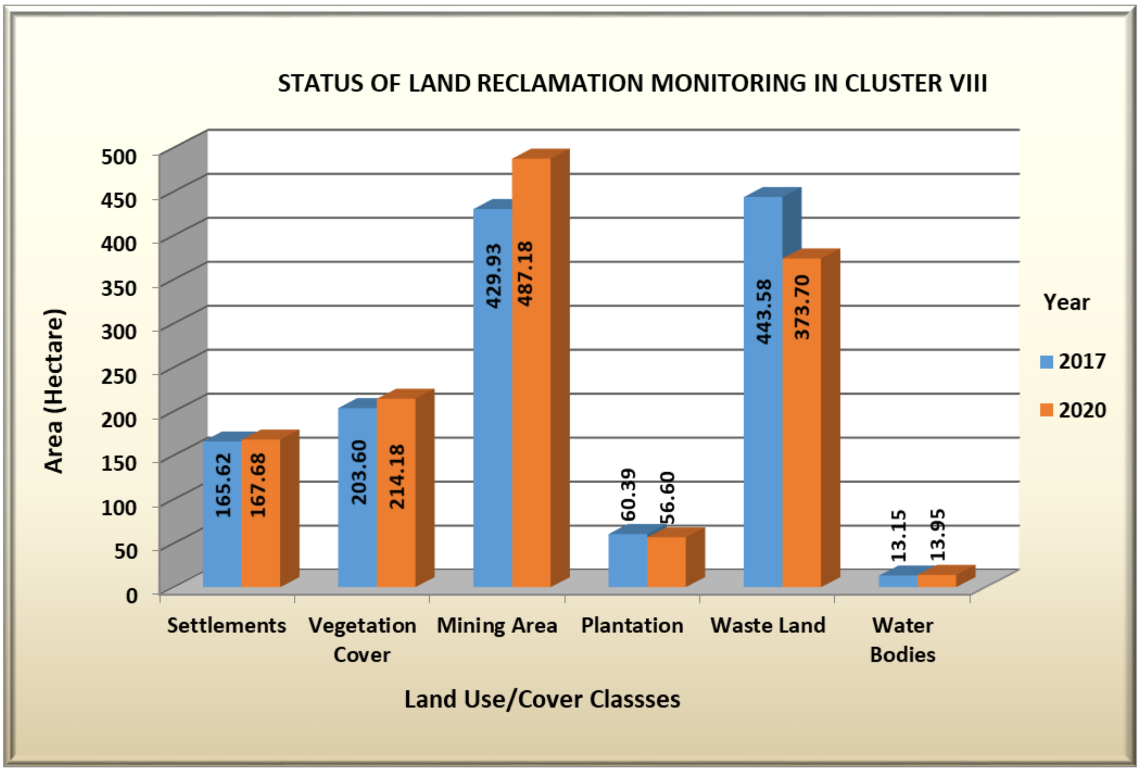


Fig. 5: Land Reclamation Status of Cluster VIII

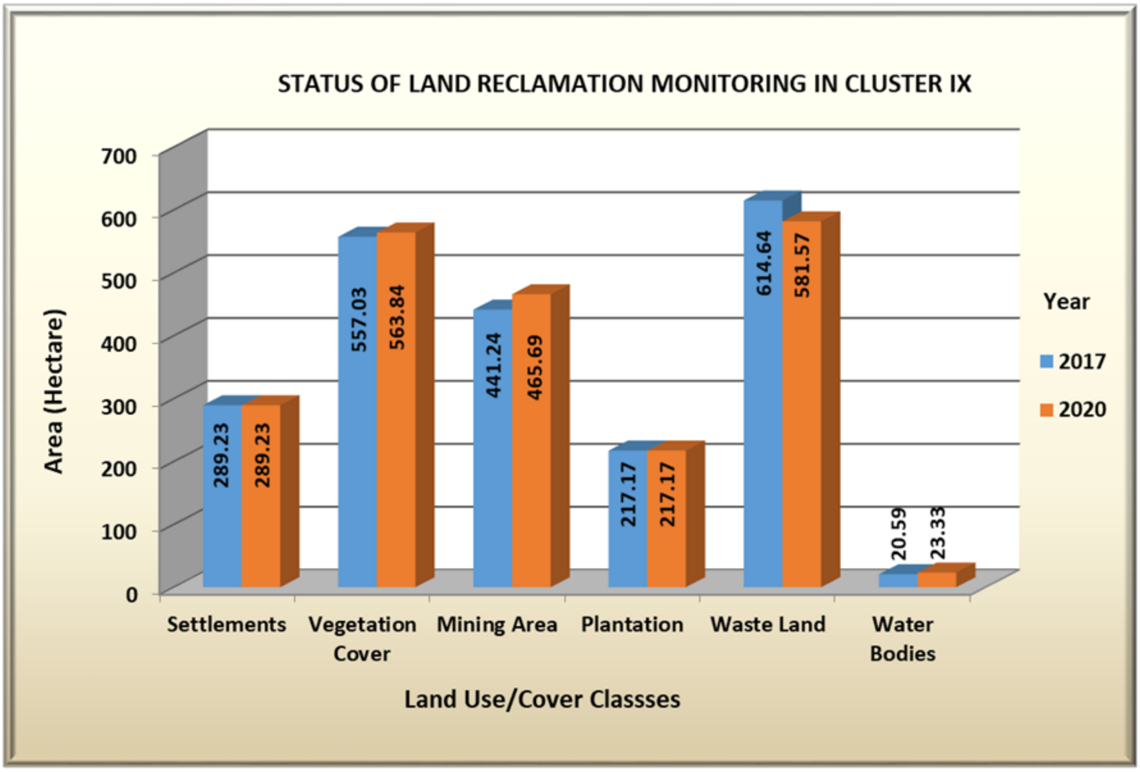


Fig. 6: Land Reclamation Status of Cluster IX

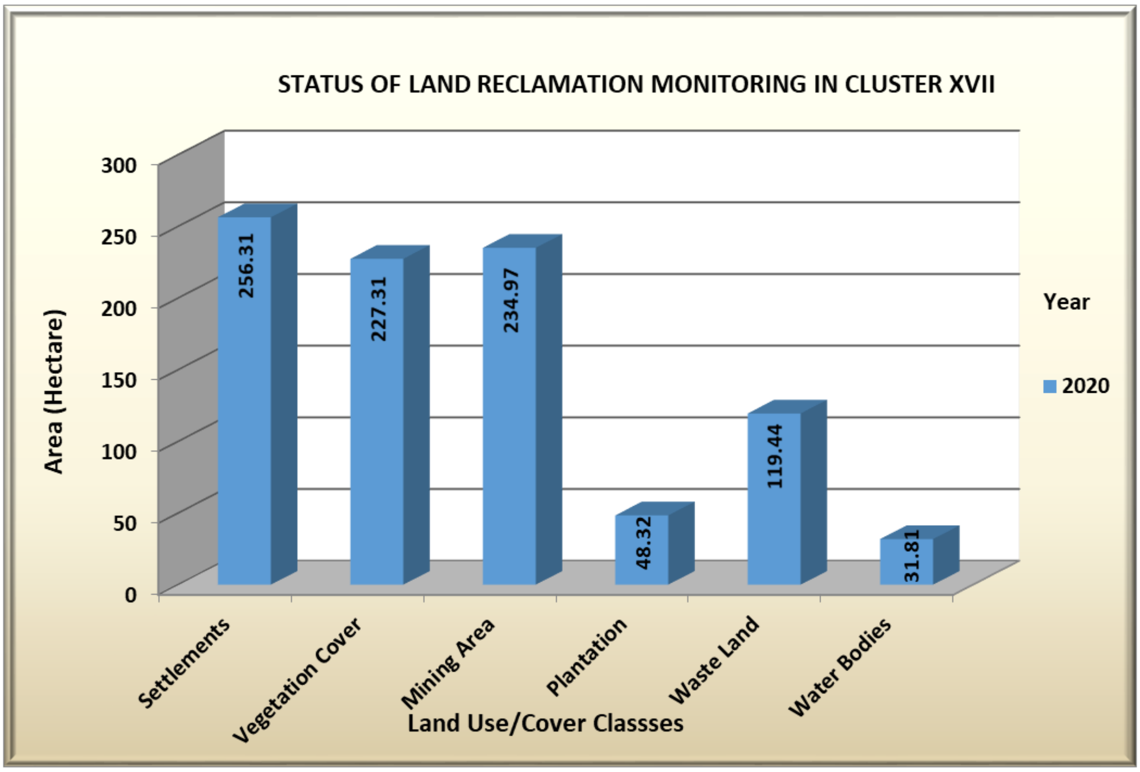


Fig. 7: Land Reclamation Status of Cluster XVII

Photo 1: Plantation on OB dump, Cluster III

Photo 2: Eco Restoration Site, Cluster V

Photo 3: Plantation on OB Dump, Cluster V

Photo 4: Plantation on OB Dump, Cluster VIII

Photo 5: Gokul Eco Cultural Park, Cluster IX

Photo 6: Plantation in Cluster XVII

Central Mine Planning & Design Institute Ltd.
(A Subsidiary of Coal India Ltd.)
Gondwana Place, Kanke Road, Ranchi 834031, Jharkhand
Phone : (+91) 651 2230001, 2230002, 2230483, FAX (+91) 651 2231447, 2231851
Wesite : www.cmpdi.co.in, Email : cmpdihq@cmpdi.co.in

Annexure-XV

Revenue Expenditure on Environment Management (Cluster-III)

Sl. No.	Element	Annually Recurring Cost (Rs. in Lakhs) as per EIA/EMP	Actual cost incurred (Lakhs) FY 2022-23	Remarks
1.	Pollution control	20.00	24.13	Water Sprinkling on haul roads, railway siding and public roads.
2.	Pollution monitoring	5.00	32.15	As per information provided by Env department, HQ; Being done by CMPDIL RI-II, Dhanbad
3.	Occupational health	5.00	10.03	Expenditure incurred on purchase of florescent jackets, rubber and leather gloves ear plugs, Safety helmets, goggles, medical kits etc. for persons engaged in mining activities.
4.	Green belt & biological reclamation	10.00	45.13 (05 nos. of Manpower with EMS@ Rs. 2735.19)	Manpower Cost incurred on biological reclamation of OB dumps
			16.47	Expenditure on maintenance work of OB plantation on 32.5 Ha by DFO, Dhanbad.
5.	Corporate Social Responsibility	138.45	CSR: 493*	Being dealt at HQ level. Cluster-III is contributor for the same.
6.	Corpus fund for mine-closure	130.00	318.43	Deposited in Escrow account.
7.	Water cess and consent to operate	6.00	NIL	
8.	Others (Lump sum)	5.00	1.58	Landscaping at Maheshpur Eco-Park
9.	Mine Reclamation	25.00	215**	** 50% of cost deposited in escrow amount with interest for FY 2022-23. Reimbursement is subjected to Third party audit of the claim as per approved Mine Closure Plan.
Total *		**344.45**	**415.77**	

*** Cost of CSR expenditure done at corporate level, mine reclamation is not included.**

Capital cost of Environment Management for Cluster-III

Sl. No.	Activity head as per EMP	Item	Unit Name	Year	Cost (Lakhs)	Remarks
1.	Pollution abatement cost including providing 02 additional water sprinklers.	Procurement of two Mobile water Sprinkler (28 KL Capacity)	New Akashkinaree Colliery	2013-14	126.67	As per information provided by Colliery.
			Block-IV Colliery	2020-21	162.84	
2.	Development of green belt (100 Ha and the left out area will be taken up during mine closure period) (Rs. 1 lakh per Ha)	Advance work for bamboo gabion plantation	Advance work for bamboo gabion plantation in Maheshpur, Jogidih, Govindpur Colliery	2021-22	17.29	By DFO, Dhanbad
		Completion work for bamboo gabion plantation	Completion work for bamboo gabion plantation in Maheshpur, Jogidih, Govindpur Colliery (1978 Nos.)	2022-23	11.50789	
3.	Dust suppression & extraction in coal handling plant & feeder breaker	Procurement of 3 nos. trolley mounted fog cannon	SLG Railway Siding	2021-22	20.85	
4.	EMP Report	Preparation of EIA and EMP report	Cluster-III	2012-13	89.34851	As per information provided Env Dept, BCCL HQ
5.	Industrial sewage treatment in workshop	Construction of Oil & Grease trap	New Akashkinaree Colliery and Block-IV Colliery	2020-21	22.40	As per details provided by Area Civil Deptt.
6.	Cost of Anti-pollution measures in mine & Industrial area	Construction of Coal transportation Road	Block-IV Colliery	2020-21	5.78	WBM Road for coal transportation. As per details provided by Area Civil Deptt.
			SLG Siding	2020-21	17.72	
			Maheshpur Colliery	2019-20	21.08	
			New Akashkinaree Colliery	2019-20	19.74	
7.	Other provisions	Construction of Toe wall around OB dump	Maheshpur Colliery	2020-21	9.61268	As per details provided by Area Survey Deptt.
		Construction of Rain Water Harvesting Arrangement	New Akashkinaree Colliery	2021-22	8.40	
		Construction of Toe wall around OB dump	Maheshpur Colliery	2022-23	7.77941	
		Construction of Toe wall around OB dump	New Akashkinaree Colliery	2022-23	7.90340	
		Development of Eco-park	New Akashkinaree Colliery	2022-23	13.30	
		Purchase of 05 nos. PM10 Online analyzer	Cluster-III	2021-22	62.00	PO by HQ MM deptt.

Annexure- XVI

BHARAT COKING COAL LIMITED
A Mini Ratna Company
(A Subsidiary of Coal India Ltd.)
Office of the General Manager
Govindpur Area No.III
PO- Sonardih, DHANBAD – 828125
Contact No: 0326-2392162 email- cgmgovindpur@bccl.gov.in

Ref: BCCL: AR.III:GM:20: 18

Dated: 13.04.2020

To
Panchayat Sachiwalay,
Tundoo Panchayat,
KalludihPanchayat,
AkashkinareePanchayat,
BahiyardihPanchayat,
Jamua Panchayat

Sub: Copy of Environmental Clearance granted to Cluster-III group of Mines, BCCL by Ministry of Environment & Forest

Dear Sir

Kindly find herewith the attached copy of Environmental Clearance granted to Cluster-III group of Mines, BCCL by Ministry of Environment & Forest.

This is for your kind information.

Encl: As above

Yours faithfully
13/04/2020.

Addl. General Manager/ Nodal Officer (Env)
Govindpur Area

Copy to:
1. General Manager, Govindpur Area- for kind information
2. HoD (Env), Koyla Bhawan, BCCL- for kind information

झरिया के लोगों ने कहा

आम बजट से जनता को राहत नहीं मिली है। बेरोजगार युवकों को रोजगार का अवसर नहीं मिला है। बजट ने सभी को निराश किया है। इसका खमियाजा चुनाव में कांग्रेस को भुगतना पड़ेगा।

संजीव सिंह, संयुक्त महामंत्री जमसं।

बजट कहीं से संतोषप्रद नहीं है। निराशाजनक बजट है। आम जनता पर बोझ बढ़ेगा। उद्योग खोलने पर कोई ध्यान नहीं दिया गया है।

एसके बख्शी, केंद्रीय उपाध्यक्ष सीटू

आम बजट में बेरोजगारों के लिए कुछ नहीं किया गया। आम लोगों पर बोझा लादा गया

शिवबालक पासवान, माकपा

कांग्रेस ने जनता को निराश किया है। जनता इस बार आम बजट का जवाब बैलेट से देगी।

मुनिलाल रांम, झाविमो

आम बजट जनविरोधी और महंगाई बढ़ाने वाला है। आंकड़ों के जाल में यूपीए ने फंसा कर जनता को दिग्भ्रमित किया है।

राजकुमार अग्रवाल, भाजपा नेता

आम बजट से जनता को उतनी राहत नहीं मिलेगी जितना होने वाले चुनाव को रखकर जनता ने उम्मीद लगा रखी थी।

डॉ. जेके सिन्हा, निदेशक आइएसएल

बजट संतुलित है। लेकिन आम जनता को ध्यान में नहीं रखा गया है। जनता को निराशा हाथ लगी है।

अनूप साव, पार्षद

आम बजट का बोझ जनता के सिर पर पड़ा है। जनता को कोई राहत नहीं मिली है।

हरीश जोशी, अधिवक्ता

बजट से महंगाई बढ़ेगी। यह बजट वोट को प्रभावित करनेवाला वित्त मंत्री चिदंबरम का आखिरी बजट कहलाएगा।

कादिर अंसारी, व्यवसायी

बजट में व्यवसायियों पर कोई ध्यान नहीं दिया गया है। लोगों को भी इससे कोई फायदा नहीं है।

मणिशंकरकेसरी, पूर्व जिलाध्यक्ष चैंबर

लोक सुनवाई की सूचना

सड़क परिवहन एवं राजमार्ग मंत्रालय, भारत सरकार द्वारा बिहार राज्य के अन्तर्गत राष्ट्रीय उच्चपथ संख्या–30A फतुहा–बाढ़ खण्ड को दो लेन पक्की पटरी सहित चौडीकरण परियोजना का प्रस्ताव है। इसकी कुल लम्बाई लगभग 72.390 कि0मी0 है। यह उच्चपथ पटना जिला के फतुहा से प्रारम्भ होकर नालंदा जिला के चण्डी, हरनौत होते हुए बाढ़ (पटना) तक जायगी। इस राजमार्ग में तीन बाईपास क्रमशः दनियाँवा, हरनौत एवं बाढ़ मे प्रस्तावित है, इसके अतिरिक्त इसमें उपमार्ग, पुल, पुलिया, भूमिगत मार्ग, रूकाव स्थल एवं टॉल प्लाजा आदि की व्यवस्था होगी। परियोजना का कुल लागत 420.70 करोड है। इस परियोजना मार्ग में कोई राष्ट्रीय उद्यान, वन्य–जीव अभ्यारण्य नहीं है।

पर्यावरण एवं वन मंत्रालय, भारत सरकार के पर्यावरणीय प्रभाव मूल्यांकन (ई.आई.ए.) अधिसूचना, 2006 एवं उसमें संशोधित अधिसूचना के आलोक में प्रस्तावित योजना की पर्यावरणीय स्वीकृति हेतु ई.आई.ए. रिपोर्ट तैयार किया गया है, जिसमें संभावित कुप्रभावों के नियंत्रण हेतु उपाय दर्शायें गये हैं। ई.आई.ए. प्रतिवेदन एवं ई.आई.ए. सार–प्रतिवेदन को संबंधित जिलाधिकारी, जिला परिषद् एवं महाप्रबंधक जिला उद्योग केन्द्र के कार्यालयों के साथ–साथ पर्षद मुख्यालय, पटना में कार्यालय कार्य दिवस के दौरान देखी जा सकती हैं। वैसे व्यक्ति जो इस परियोजना से प्रभावित होने वाले हों, अपना सुझाव/प्रतिक्रिया इस सूचना के प्रकाशित होने के 30 दिनों के अन्दर पर्षद को उपलब्ध करा सकते हैं।

स्थानीय जनता की प्रतिक्रिया/सुझाव आमंत्रित करने हेतु लोक सुनवाई कार्यक्रम निम्नवत् है :–

दिनांक	समय	लोक–सुनवाई का स्थल
05.04.2013 (शुक्रवार)	3.00 बजे अपराह्न	प्रखंड कार्यालय, हरनौत, नालंदा
06.04.2013 (शनिवार)	3.00 बजे अपराह्न	प्रखंड कार्यालय, बाढ़, पटना

सभी संबंधित से अनुरोध है कि उपरोक्त कार्यक्रम में उपस्थित होने का कष्ट करेंगे।

सदस्य–सचिव

BIHAR

बिहार राज्य प्रदूषण नियंत्रण पर्षद्

बेल्ट्रॉन भवन, शास्त्रीनगर, पटना – 800 023
दूरभाष नं0–0612–2281250 / 2282265, फैक्स–0612–2281050
वेबसाईट–http://bspcb.bih.nic

क्षेत्रीय कार्यालय फोन नं. 01482-241159

राजस्थान राज्य प्रदूषण नियन्त्रण मण्डल

18, आजाद नगर, पन्नाधाय सर्किल, भीलवाड़ा

राप्रनिम/क्षेका भील/राज/ दिनांक

पर्यावरणीय स्वीकृति हेतु लोक सुनवाई के लिए आम सूचना

1. सर्वसाधारण को सूचित किया जाता है कि **मैसर्स भारतीय राष्ट्रीय राजमार्ग प्राधिकरण, परियोजना क्रियान्वयन इकाई, ए 11, चन्द्रकिरण, रीको हाउसिंग कॉलोनी, ब्यावर** ने **प्रस्तावित राष्ट्रीय राजमार्ग संख्या 148–डी 109.750 कि.मी. राष्ट्रीय राजमार्ग–8 (जिला–राजसमन्द) से 64.200 कि.मी., राष्ट्रीय राजमार्ग–79 गुलाबपुरा (जिला भीलवाड़ा)** तक की चौड़ाई एवं सुदृढ़करण से संबन्धित प्रार्थना पत्र मय दस्तावेज पर्यावरणीय स्वीकृति से पूर्व आवश्यक लोक सुनवाई हेतु प्रस्ताव राजस्थान राज्य प्रदूषण नियंत्रण मण्डल (यहाँ तथा बाद में मण्डल के नाम से अभिलिखित) को प्रस्तुत किया गया है।
2. और चूंकि **मैसर्स भारतीय राष्ट्रीय राजमार्ग प्राधिकरण, परियोजना क्रियान्वयन इकाई, ए 11, चन्द्रकिरण, रीको हाउसिंग कॉलोनी, ब्यावर** ने राजस्थान राज्य प्रदूषण नियंत्रण मण्डल को उक्त परियोजना की पर्यावरणी स्वीकृति से पूर्व आवश्यक लोक सुनवाई हेतु मण्डल को आवेदन प्रस्तुत किया है। उक्त परियोजना हेतु वन एवं पर्यावरण मंत्रालय, भारत सरकार, नई दिल्ली द्वारा जारी अधिसूचना संख्या एस. ओ. 1533 दिनांक 14.09.2006 के अनुसार लोक सुनवाई हेतु इस आशय की सूचना जारी कर 30 दिवस का नोटिस दिया जाना आवश्यक है।
3. उक्त परियोजना से सम्बन्धित EIA/EMP Report एवं संक्षिप्त कार्यपालक सार अभिलेख निम्न कार्यालयों में अवलोकनार्थ उपलब्ध है :–

(1) जिला कलेक्टर, राजसमन्द।
(2) जिला उद्योग केन्द्र, राजसमन्द।
(3) जिला परिषद, राजसमन्द।
(4) तहसील कार्यालय, भीम, जिला–राजसमन्द।
(5) कार्यालय पंचायत समिति, भीम, तहसील–भीम, जिला–राजसमन्द।
(6) कार्यालय उपखण्ड मजिस्ट्रेड, भीम, तहसील–भीम, जिला–राजसमन्द।
(7) क्षैत्रीय कार्यालय, राजस्थान राज्य प्रदूषण नियंत्रण मण्डल, भीलवाड़ा।
(8) पर्यावरण विभाग, राजस्थान सरकार, शासन सचिवालय, जयपुर।
(9) राजस्थान राज्य प्रदूषण नियन्त्रण मण्डल, 4 पर्यावरण मार्ग, संस्थानिक क्षेत्र, झालाना डूंगरी, जयपुर।
(10) क्षैत्रीय कार्यालय, पर्यावरण एवं वन मंत्रालय, पंचम तल केन्द्रीय भवन, सेक्टर एच, अलीगंज, लखनऊ।

अतः सर्व साधारण को नोटिस के माध्यम से एतद् द्वारा सूचित किया जाता है कि वे उक्त परियोजना के पर्यावरणीय स्वीकृति से संबधित लोक सुनवाई हेतु **दिनांक 02.04.2013 को 3.00 पी.एम. पर कार्यालय उपखण्ड मजिस्ट्रेट, भीम, तहसील–भीम, जिला –राजसमन्द** में उपस्थित होकर अपने लिखित / मौखिक आक्षेप / सुझाव प्रस्तुत कर सकते है।

इस संबंध में लिखित आपेक्ष / सुझाव इस सूचना के प्रकाशन की तिथि से 30 दिवस के अन्दर क्षेत्रीय कार्यालय, राजस्थान राज्य प्रदूषण नियंत्रण मण्डल, भीलवाड़ा को भी दिये जा सकते है।

(वी. एस. सांखला) क्षेत्रीय अधिकारी

NORTH EASTERN RAILWAY

Notification No.:-23/2013

IMPORTANT NOTICE FOR THE RAIL PASSENGERS

It is notified for the information of general public that provision of one additional AC-2 Tier coach in train no. 18191/18192 Chhapra-Kanpur Anwarganj Utsarg Express, notified earlier vide this office Notification No. 108/2012 dated 21.12.2012, is being further extended on experimental basis as under:-

Train No. & Name	Station From	Originating Date	Last Date
18191 Chhapra-Kanpur Anwarganj Utsarg Exp.	Chhapra	01-03-13	30-06-13
18192 Kanpur Anwarganj-Chhapra Utsarg Exp.	Kanpur Anwarganj	02-03-13	01-07-13

CPRO/T-104 **Chief Pass Trans., Manager, Gorakhpur**

Railway Vigilance Mobile Helpline No.:0551-155210 (for Complaints regarding Corruptions)

"SERVING CUSTOMERS WITH A SMILE"

Bharat Coking Coal Limited

(A Subsidiary of Coal India Limited)

This is to bring into notice of all concerned that the following 09 (Nine) Clusters of BCCL consisting of 63 Mines and 02 washeries are granted Environmental Clearances by Ministry of Environmental and forests.

Sl. No.	Name of the Cluster	Sanction order number and date
1.	**Cluster-I** (Damoda Group of 3 Mines - Damoda (Albion Section) OCP, Damoda UGP and Damuda BJ Section OCP) Group of Mines (of 0.9 MTPA normative and 1.17 MTPA (peak) in a combined ML area of 575 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Block Chandrapur, Dist. Dhanbad, Jharkhand.	J-11015/93/2009-1A.II (M) dated 6th Feb. 2013
2.	**Cluster-II** (5 mines of a combined prod. capacity 15.55 MTPA with a peak production of 20.215 MTPA) in a combined ML area of 2025.71 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand.	J-11015/35/2011-1A.II (M) dated 6th Feb. 2013
3.	**Cluster-III** (7 mines of a peak production of 3.6 MTPA in a combined ML area of 1420.61 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand (EC based on TOR granted on 04.11.2010).	J-11015/213/2010-1A.II (M) dated 6th Feb. 2013
4.	**Cluster-IV** (6 mines with production capacity 2.851 MTPA (Normative) 3.706 MTPA (Peak) in a combined ML area of 1123.79 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand excluding Gaslitand Colliery UG.	J-11015/212/2010-1A.II (M) dated 6th Feb. 2013
5.	**Cluster-V** (7 mines of a 4.854 (Normative) and 6.311 (Peak) production of MTPA in a combined ML area of 1957.08 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand (EC based on TOR granted on 16.03.2011).	J-11015/01/2011-1A.II (M) dated 11th Feb. 2013
6.	**Cluster-VII** (combined capacity 6.227 MTPA with a peak prodn. of 8.16 MTPA in a combined ML area of 2127.7 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand (EC based on TOR granted on 09.12.2010) (excluding Kustore UG and East Bhuggatdih).	J-11015/238/2010-1A.II,(M) dated 6th Feb. 2013
7.	**Cluster-X** (6 mines of 1.762 MTPA of normative and peak production of 2.289 MTPA in a combined ML area of 2057.95 ha) and Sudamdih Coal Washery (Within the lease hold of Sudamdih Shaft Mine) of 1,6 MTPA of normative and 2,08 MTPA peak production for a area of 18 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand (EC based on TOR granted on 09.02.2011).	J-11015/380/2010-1A.II (M) dated 6th Feb. 2013
8.	**Cluster-XVI** - Coalmines (Dahibari-Basantimata OCP, Basantimata under Ground Mine, New Laikdih OCP (including Dahibari Coal Washery), Laikdih Deep UG, Chanch UG) (normative 1.51 MTPA and 1.963 MTPA peak in a combined ML area of 1964.21 ha) and Dahibari washery of 1.6 MTPA in the area of 12 ha of M/s Bharat Coking Coal Ltd., in Dist. Dhanbad, Jharkhand (EC based on TOR granted on 28.05.2010).	J-11015/185/2010-1A.II (M) dated 6th Feb. 2013
9.	**Cluster-VIII** Group of 10 Mines (combined capacity 4.31 MTPA with a peak prodn. of 5.603 MTPA in a combined ML area of 1183.92 ha (1200.41 ha-1649 ha=1183.92 ha) of M/s Bharat Coking Coal Ltd., located in Jharia Coalfields, Dist. Dhanbad, Jharkhand.	J-11015/298/2010-1A.II (M) dated 15th Feb. 2013

The copy of the clearance letter is available with the Jharkhand State Pollution Control Board and may also be seen at the website of the Ministry of Environmental and forests at **http://envfor.nic.in** and on the official website of BCCL at **http://www.bccl.gov.in**

Annexure-XVII

भारत कोकिंग कोल लिमिटेड (कोल इण्डिया लिमिटेड का एक अंग) ऐक मिनीरतन कम्पनी **क्षेत्र संख्या**– 3	कोल इण्डिया Coal India	**Bharat Coking Coal Limited** (A Subsidiary of Coal India Limited) **A Miniratna Company** Govindpur Area No. III OFFICE OF THE GENERAL MANAGER PO- Sonardih, DHANBAD – 828125 **Contact No:** 0326-2392162 **Email**-gmgovindpur.bccl@coalindia.in **CIN : U10101JH1972GOI000918**

Ref. No.: BCCL/Ar.III/Envt/2023-24/ 102 **Date:** 27/09/23

To
The Regional Engineer/Officer,
Jharkhand State Pollution Control Board,
Sardar Patel Nagar, Dhanbad.

Subject: Submission of Environment Statement along with Ambient Air & Water Analysis Report (in photocopies) in Form –V of Cluster-III group of mines under Govindpur Area for the financial year 2022-23.

Dear Sir,

Enclosed please find herewith the environment statement for the financial year 2022-23 of Cluster-III group of mines under Govindpur Area of M/s BCCL.

Enclosure: -

1. Copy of Water Analysis Report& Ambient Air Report.
2. Form-V.

Yours faithfully

27/09/2023

Area Manager (Env.)
Govindpur Area

Area Manager (Environment)
Govindpur Area, BCCL
क्षेत्रीय प्रबंधक (पर्यावरण)
गोविन्दपुर क्षेत्र, बी.सी.सी.एल

Copy to:

1) Member Secretary, JSPCB, Ranchi
2) GM (Min/Env.), Koyla Bhawan, BCCL

FORM – V

(See rule-14)

Environmental statement for the financial year ending the 31st March 2023

PART – A

1. Name of the address of the owner of the industry operation or process : BCCL, Nominated owner Shri Uday Kant Kaole, DT (P&P/OP), Koyla Bhawan, Koyla Nagar, Dhanbad (Jharkhand).
2. Industry category : Large Scale
   Primary (STC code)
   Secondary (SIC code)
3. Production capacity (units) : 3.6 MTPA
4. Year of establishment : 1972
5. Date of the last environmental statement submitted : 11/08/2022

PART – B

1. Water & river material consumption
   Water consumption m^3 /d : 6600 KL/day
   Process : 600 KL/day
   Domestic : 6000 KL/day

Name of the products	Process water consumption per unit of product output	
	During the previous financial year	During the current financial year
1	0.016 KL/Te	0.015 KL/Te

2. Raw material consumption

Name of the raw material	Name of the product	Consumption of raw material per unit of out put	
		During the financial year	During the current financial year
		X	X
		X	X

Industry may use cades if disclosing details of raw material would violate contractual obligations, otherwise all industries have to name the raw materials uses.

PART-C

Pollution discharged to environment/unit of output (parameter as specified in the consent issued)

Pollutants	Quantity of pollutions discharged (mass/day)	Concentration of pollutions discharged (mass/day)	Percentage of variation from prescribed standards with reasons
a) Water (As on 02.01.2023)	Total suspended solids -39 PH – 8.1 Oil &grease < 2.0 COD - 24	Monitoring Reports Attached	
b) Air (As on 13.01.2023)	SPM PM 10 – 91 PM 2.5 - 48		
	SO_2 11		
	NOx 15		

PART-D

Hazardous Wastes
(as specified under hazardous management and Handling Rules 1989)

Hazardous Wastes	Total quantity (Kg/KL)	
	During the previous financial year	During the current financial year
a) From process	7.5	8.7
b) From pollution control facilities	NA	NA

PART-E

Solid Wastes

	Total quantity (Kg)	
	During the previous financial year	During the current financial year
a) From process	14.66 L cum	17.74 L Cum
b) From pollution control facilities	Nil	Nil
c) 1. Quantity recycled or reutilized within the unit. 2.Sold 3.Disposed	1. 14.66 L cum	1. 17.74 L Cum

PART-F

Please specify the characterizations (in terms of composition of quantum) of hazards as well as solid wastes and indicate disposal practice adopted for both these categories of wastes.

For underground mines : NA

For OCP : Burnt Oil and Over Burden Material.

PART-G

Impact of the pollution abatement measures taken on conservation of natural resources and on the cost of production.

The abatement measures are undertaken and practiced by which the impact on the atmosphere has been become positive. Due care is taken to conserve the natural resources and protect the environment and all its components.

PART-H

Additional measures/investment proposal for environmental protection including abatement of pollution, prevention of pollution.

1. Water sprinkling: - Regular Water sprinkling is carried out through mist type sprinkler in all haul roads, siding, and coal transportation route. Also, 03 nos. fog cannons have been installed in SLG railway siding for abating the pollution. Road maintenance: - Regular maintenance of roads is carried out.
2. Exhaust of vehicle control: - Coal transport vehicle with valid PUC.

PART-I

Any other particulars for improving the quality of the environment.

1. Tree plantation- 1978 nos. bamboo gabion plantation have been carried out along coal transportation route and public roads.
2. 150 nos. bamboo gabion plantation have been done in SLG railway siding.
3. Ambient air & water monitoring is carried out through CMPDIL.
4. Online PM10 analyzer has been installed for regular monitoring of air quality.
5. 02 nos. of Digital Water Level Recorder have been installed for monitoring the ground water level.
6. 01 no. truck mounted fog cannon has been procured for water sprinkling within mine premises

Area Manager (Env.)
Govindpur Area

Area Manager (Environment)
Govindpur Area, BCCL
क्षेत्रीय प्रबंधक (पर्यावरण)
गोविन्दपुर क्षेत्र, बी.सी.सी.एल

ENVIRONMENTAL MONITORING REPORT OF BHARAT COKING COAL LIMITED, CLUSTER – III

(FOR THE MONTH JANUARY, 2023)

E. C. no. J-11015/213/2010-IA.II (M) dated 06.02.2013.

CMPDI
ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

AMBIENT AIR QUALITY DATA

CENTRAL MINE PLANNING AND DESIGN INSTITUTE LIMITED
Environment Laboratory, Regional Institute-II

Ambient Air Quality Test Report

CMPDIL, RI-II
KOYLA BHAWAN COMPLEX
DHANBAD. -826005
Phone:0326-223-850
email: rdri2cmpdi@coalindia.in

cmpdi — A Mini Ratna Company

TC-10122

Test Report for Ambient Air Samples

Month & Year	01/2023	Cluster	Cluster III			Report No.	RI-II/AIR/2022-23/10
Customer	Environment Department, Bharat Coking Coal Limited (BCCL), Koyla Bhawan, Dhanbad (E-mail: gmenv.bccl@coalindia.in)					Date of Issue	23.03.2023
Project		Sample Ref. No.	REM/BCCL/2023/10	Sampling Method		CMPDI/RI-II/LPM 13 , (IS 5182)	
Sampling Stations	i	Block IV Kooridih OCP	Date of Sampling	13.01.2023	21.01.2023	Zone of Station:	Core Zone

Sl. No.	Parameter	Method of Analysis	Observed Values (in µg/m³)		Range Of Testing	LDL	MoEF Standards Notification dated 25th September,2000 (GSR 742 E)	NAAQS, 2009
			1st FN	2nd FN				
1	PM_{10}	IS -5182(Part 23):2006, R-2017	91	94	10 µg/m³ - 1000 µg/m³	10 µg/m³	300	100
2	$PM_{2.5}$	IS -5182(Part 24):2019	48	52	10 µg/m³ - 400 µg/m³	10 µg/m³	Not Specified	60
3	SO_2	IS-5182(Part-2): 2001 , R-2017	11	<10	10 µg/m³ - 1050 µg/m³	10 µg/m³	120	80
4	NO_2	IS-5182 (Part-6): 2006 , R-2017	15	30	06 µg/m³ - 420 µg/m³	06 µg/m³	120	80

** LDL indicates Lower Detection Limit,*
***All units are in µg/m3, 24 hourly Average,*

ANALYSED BY

(Gaurav Kant)
CHECKED BY

(Amit Raj Mishra)
HOD's Signature

Note: *The results above relate to the samples tested as received. This report can not be reproduced in part or full without the written permission of the HOD(Env) , CMPDI, RI-II.*

---- End of Report ----

WATER QUALITY MONITORING

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) Mine Discharge of Govindpur (MW3)

A sampling point is fixed to assess the effluent quality of Mine discharge. This location is selected to monitor effluent discharge in to Khudia Nala and Bagdighi Nala.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analysed 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.

CENTRAL MINE PLANNING AND DESIGN INSTITUTE LIMITED
Environment Laboratory, Regional Institute-II

CMPDIL, RI-II
KOYLA BHAWAN COMPLEX
DHANBAD. -826005
Phone:0326-223-850
email: rdri2cmpdi@coalindia.in

MINE EFFLUENT TEST REPORT

Test Report for Mine Effluent samples

Month & Year	01/2023	Cluster	Cluster III	Report No.	RI-II/WATER/2022-23/10
Customer	Environment Department, Bharat Coking Coal Limited (BCCL), Koyla Bhawan, Dhanbad (E-mail: gmenv.bccl@coalindia.in)			Date of Issue	23.03.2023
Project		Sampling Ref. No.	REM/BCCL/2023/10	Sampling Method	IS 3025 (Part-1) CMPDI/RI-II/LPM 13
Sampling Stations	(i)	Govindpur	Sample Collected in 2.5 Ltr Jerricane , Color as observed is transparent	Period of Analysis	JAN'2023

Sl. No.	Parameter	Method of Analysis	Date of Sampling: 02.01.2023 — Observed Values: First Fortnight	Date of Sampling: 16.01.2023 — Observed Values: Second Fortnight	STANDARDS FOR COAL MINES (Stipulated by Ministry of Environment and Forests (MoEF), Vide Notification No. GSR 742(E), Dt: 25.09.2000)	LDL
1	Total Suspended Solids	IS 3025/17:1984, R :2017, Gravimetric	39	52	*100 (Max)*	10
2	pH	IS-3025/11:1983, R-2017, Electrometric	8.1	7.78	*5.5 - 9.0*	0.2
3	Oil & Grease	IS 3025/39:1991, R : 2019, Partition Gravimetric	<2.0	<2.0	*10 (Max)*	2
4	COD	APHA 23rd Edition 5220 C Titrimetric Method	24	20	*250 (Max)*	4

***All units in mg/L unless specified otherwise. *LDL indicates Lower Detection Limit & BDL indicates Below Detection Limit,*
***Grab sampling carried out for water samples.*

ANALYSED BY

(Kumar Vaibhav)
CHECKED BY

(Amit Raj Mishra)
HOD's Signature

Note: The results above relate to the samples tested as received. This report can not be reproduced in part or full without the written permission of the HOD(Env) , CMPDI, RI-II.

---- End of Report ----