STUDY OF CHANGE IN ECOSYSTEM OF IB COALFIELD OF MAHANADI COALFIELDS LIMITED AND ITS IMPACTS ON CLIMATE CHANGE DUE TO OPEN PIT MINING

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ABSTRACT

The present study investigated three major opencast coal mine projects, i.e. Samaleswari Opencast Project, Lakhanpur OCP and Kulda Opencast Project of Ib Coalfield of Mahanadi Coalfields Limited (A subsidiary Company of Coal India Limited) and collected data of rainfall, temperature including pre-mining, post mining data and land reclamation data thereof. In the course of study, primary as well as secondary data on geology, method of mining, coal processing, and other ancillary activities were collected to interpret and evaluate the change in ecosystem in Ib Coalfield spreading in Jharsuguda and Sundargarh districts of Odisha, India. We documented the data and relevant documents and compared considering mine closure plan, evaluated and interpreted and found that there is significant improvement/restoration of damaged ecosystem in the post-mining phase of surface coal mining after technical and biological reclamation with massive plantation. Subsequently, a comparison of both pre-mining and post-mining meteorological data of the area of mining was made to depict the changes/impacts leading to climate change.

Key Words: Coal Mining, Land reclamation, Ecosystem, Climate change, Coal processing

INTRODUCTION

Energy plays an important role for improving the quality of life, increasing opportunities for development and above all for economic growth of a country. Most of energy requirement is fulfilled by coal, accounting for nearly 60% of the commercial energy demand of India. Nearly 86% of these coals are obtained from surface or opencast coal mines, which occupy very large areas. Opencast coal mining and its subsequent activities have been found to degrade the land to a significant extent. Overburden removal from the mine area results in a very significant loss of rain forest and the rich top soil. Overburden removal is normally done by the process of blasting or using excavators, which results in generation of large volume of waste (soil, debris and other material). This is useless for the industry and is normally just stored in big piles within the mine lease area, and sometimes, on public land. The bigger the scale of the mine, greater is the quantum of waste generated. Opencast mines are therefore more pollution intensive.1,4

Coal mining has severe impacts on eco-system like flora and fauna, water, land, abiotic resources and also climate conditions which is caused by Greenhouse Gas (GHG) emission. Though, we have other problems related to coal such as acidification, photochemical oxidation, etc., but the former impacts are considered to be major impacts for coal mining process. In this paper, an attempt has been made to evaluate changes in ecosystem of Ib Coalfield of Mahanadi Coalfields considering Samaleswari Opencast Project, Lakhanpur Opencast Project and Kulda Opencast Project the representative mines and its impact on the environment resulting climate change due to coal mining. Data were collected from mines in person, from environmental impact statements, coal mining permit applications, government reports, published literatures and

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relevant websites. In this work, an attempt has been made to evaluate changes in ecosystem of Ib Coalfield of M/s Mahanadi Coalfields and its impact on the environment resulting climate change due to coal mining. The study was carried out by means of field surveys and the analysis of data collected from this area.\(^5\)\(^6\)

STUDY AREA

Ib Coalfield (also named as Ib River coalfield) has derived its name from the river Ib. The coalfield is located in the district of Jharsuguda and Sundargarh in the north-western part of Odisha, India. It covers an area of about 1460 sq. Km. Ib Coalfield is a part of large synclinal Gondwana basin of Raigarh-Himgir and Chhattisgarh coalfields, and constitutes the south-eastern extension of the Sone-Mahanadi master basin. There are eight opencast coal mines in this basin viz. Lajkura Opencast Project, Samaleswari Opencast Project, Belpahar Opencast Project, Lilari Opencast Project, Lakhapur Opencast Project, Basundhara (West) Opencast Project, Kulda Opencast Project and Garjanbahal Opencast Project, which come under Jharsuguda and Sundargarh districts of Odisha, India. The location map of Ib Coalfield is shown in Fig. 1. The location and aerial extent of opencast coal mines in Ib Coalfield are shown in satellite picture in Fig. 2.

**GEOLOGY**

The Ib Coalfield forms a half elliptical basin. It is closed towards southeast and open towards north-west. The basin has normal contact with the metamorphic in the north-western, northern, north-eastern, eastern and southeastern part. It has a faulted contact with the metamorphic in the south-western boundary where younger formations viz. Raniganj and Barren Measure occur in juxtaposition with the metamorphic\(^1\). The coalfield is contiguous to Mand-Raigarh
coalfield of Chhattisgarh. The major coal-bearing formations in Ib valley Coalfields are Karhabari and Barakar, through occurrence of coal seam in Raniganj formation has been reported by Geological Survey of India (GSI). The geological map and succession coal seam of Ib coalfield has been presented in Fig. 3 and Table 1 respectively. Based on the exploration carried out in the coalfield, five coal horizons, i.e. Ib, Rampur, Lajkura, Parkhani and Belpahar have been identified in ascending order. Ib Seam occurs in Karharbari formation, whereas the rest occur in Barakar formation of lower Gondwana period.

![Geological Map of Ib Coalfield](image_url)

**Fig. 3**: Geological Map of Ib Coalfield

**Table 1**: Geological succession of coal seams of Ib Coalfield

<table>
<thead>
<tr>
<th>Seam or Coal Horizon</th>
<th>Thickness range (m)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barakar</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Belpahar Coal Horizon</strong></td>
<td>24-30</td>
<td>Highly inter-banded coal section. In two sections in northern part. Generally considered as uneconomic.</td>
</tr>
<tr>
<td>Parting</td>
<td>105-195</td>
<td></td>
</tr>
<tr>
<td>Parkhani coal horizon</td>
<td>0.5-1.0</td>
<td>Mostly shaley coal and carbonaceous shale</td>
</tr>
<tr>
<td>Parting</td>
<td>92-120</td>
<td></td>
</tr>
<tr>
<td>Lajkura seam</td>
<td>15-89</td>
<td>A persistent and highly banded horizon splits in 4 sections.</td>
</tr>
<tr>
<td>Parting</td>
<td>16-112</td>
<td></td>
</tr>
<tr>
<td>Rampur coal horizon</td>
<td>27-80</td>
<td>Highly inter-banded, contains 5 to 6 sections.</td>
</tr>
<tr>
<td>Parting</td>
<td>3-55</td>
<td></td>
</tr>
<tr>
<td><strong>Karhabari</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ib seam</td>
<td>2-10</td>
<td>Impersistent in northern part, splits up in 3 sections</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Opencast Mining Practice In Ib Coalfield

As shown in Fig. 4 and Fig. 5 the process of Surface or Open Pit Mining (OPM) of coal involves the following steps:

I. Development Phase
   1. Tree felling and removal of vegetation
   2. Leveling by Dozing

II. Production Phase
   3. Drilling & Blasting
   4. Excavation & Loading (Coal & OB)
   5. Transporting of coal to Coal Stock, CHP, SILO, Rapid Loading System, Railway Sidings, etc.
   6. Storage and Re-handling

III. Post-production phase
   7. Backfilling
   8. Dump treatment
   9. Spreading of Top soil
   10. Revegetation

The mining method adopted in all five major opencast coal mines comprises of two steps-
removal of overburden and extraction of coal. Overburden removal is done by conventional shovel-dumper combination (drilling, blasting, loading through shovel and transportation through dumper) and also through use of dragline. Coal extraction is commonly done by surface miner, front end loader, and dumper. The coal is found at a depth of 12-22 m from the overburden. The height of coal benches is around 8m and width is around 15 m. The length of road is 3-4 km for coal transportation and about 1-2 KM for OB transportation. The coal is transported from CHP to railway siding by tippers. The coal winning is done through surface miner and transported by payloader and trucks combination. About 63% coal winning is done by surface miner and 37% is done by shovel-dumper combination. Overburden removal is being done by deploying shovel-
dumper and dragline with combination both by departmental and contractual. The photographic view of the Samaleswari opencast mine is shown in Fig. 6.

Initially, OB is stored in external OB dumps and once sufficient space is created for constructions of haul roads and coal transportation roads with pliable gradient for movement of OB and coal from face to surface. Once the bottom most coal seam is extracted, the OB generated thereafter is utilized for backfilling of the opencast mines.7,8

**ECOLOGICAL IMPACTS DUE TO OPENCAST MINING IN IB VALLEY COALFIELD**9-12

The environmental impacts due to surface coal mining in Ib coalfield is broadly classified as follows:

<table>
<thead>
<tr>
<th>S/N</th>
<th>Activities</th>
<th>Impacts</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The activities like tree felling and clearing of land, creation of external dump, construction of Ancillary Facilities extensive modification of topography over the entire Area</td>
<td>Land degradation</td>
<td>Removal of vegetation Loss of fertile top soil Soil erosion Creation of huge dumps and voids Change in land use and topography</td>
</tr>
<tr>
<td>2</td>
<td>Drilling, Blasting, Loading, Unloading, Transportation, Beneficiation etc (Mine Face, Haul Roads, Transportation Roads, OB dump yards, CHP, Railway Siding)</td>
<td>Air pollution (SPM, RPM, SO2, NOx, CO, PAH etc)</td>
<td>Diseases caused by dust and noise (with or without toxic elements) Occupational hazards Accidents Effects on vegetation and reduction of yield Soiling of material Aesthetic degradation Noise and ground vibration</td>
</tr>
<tr>
<td>3</td>
<td>Mine water discharge, domestic effluent, service effluent (workshop etc), Runoff from</td>
<td>Water pollution</td>
<td>Deterioration of Human Health Sedimentation of receiving water bodies</td>
</tr>
</tbody>
</table>

Fig. 6: View of Samaleswari opencast mine
|   | OB dumps and other open areas | Scarcity of water  
Deterioration of surface water sources |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Strata removal</td>
<td>Lowering and pollution of ground water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disruption of ground water, contamination and lowering of water table</td>
</tr>
</tbody>
</table>
| 5 | Displacement of population, starting of mine | Socio-economic impact  
Displacement of people/disintegration of families  
Loss of livelihood  
Economic disparity, cost of living, increase in aspiration, increase in unsocial activities  
Increase in population, growth of shanty towns which are unplanned with inadequate social and health provisions  
Cultural and religious impact, addiction  
Migration |
| 6 | Overall mining and other allied activities | Impact on wildlife and biodiversity  
Loss of habitat  
Disturbance from noise and vibration  
Loss of river and inshore fisheries |

Fig.7 (a),(b),(c) & (d): View of virgin land of Kulda OCP before mining
Pre-mining scenario
The virgin coal bearing area is always found with flora and fauna and even with some areas with human habitation. The Ib Coalfield was of no exception. The surface or open pit or opencast mining in Ib Coalfield not only brings a considerable changes in topography of land, but also a remarkable changes in flora and fauna including air and water regimes as the important raw material of opencast coal mining is land. (Fig. 7 and Fig. 8)
In the process of surface or open pit mining (OPM) of coal man, machines, materials, land, water and energy are used as input to produce coal with environmental impacts on air, water and land. Use of energy emits GHGs which in turns helps in global warming. Extraction of coal brings in resource depletion.
Scenario during mining
When mining starts in open pit method, overburden is extracted after removing top soil. The land topography changes day by day as the mining progresses. The virgin land area takes its shape as shown in Fig. 9(a) and Fig. 9(b). Similarly eco-restoration in OCP is shown in Fig. 10.

Fig. 8(a) & (b) : View of tree felling at Kulda OCP

Fig. 9 : View of virgin land during Mining at Kulda OCP
Post-mining scenario

Backfilling of Mine void is done as per the mining plan and mine closure plan approved by Ministry of Coal/ and MCL Board. During mining, the de-coaled voids are backfilled with the excavated OB materials and unfilled or partially filled de-coaled area is also used as water harvesting resources. (Fig. 11) As such, broadly there are two types of reclamation, one is technical reclamation and other is biological reclamation (Fig. 12). In Ib Coalfield, on an average backfilling upto ground level is possible for about 50-60% area and balance 40% area will remain as partially filled area which is used as huge rainwater harvesting ponds, which ultimately recharges the underground aquifers (Fig. 13).

Status of backfilling in opencast mines of ib coalfields till 31ST Dec, 2018

<table>
<thead>
<tr>
<th>Ib Valley Coalfield</th>
<th>Total Land required (Ha)</th>
<th>Area Excavated (Ha)</th>
<th>Area under backfilling (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7,653</td>
<td>2,247</td>
<td>1,457</td>
</tr>
</tbody>
</table>

Fig. 10: Eco-restoration in Samaleswari Opencast Project

Fig. 11: Quarry De-coaled Area converted as Eco Tank at Lakhanpur Opencast Mine & Belpahar Opencast Mine

**Plantations**

<table>
<thead>
<tr>
<th>Place</th>
<th>Area planted(Ha)</th>
<th>Nos. planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ib Valley Coalfield</td>
<td>1151.16</td>
<td>3101640</td>
</tr>
</tbody>
</table>

Plantation data of Ib Coalfield since inception is given below.
Evaluation of change in ecosystem and its impacts on climate change due to coal mining in Jharia coalfield Via. Methods used for evaluating impact of coal mining

There are two wide groups of methods that are used for evaluating impact of coal mining, i.e. (1) the analytical and laboratory based and (2) the remote sensing based. Majority of the earlier studies used analytical and laboratory based methods while the later researches are more focused on remote sensing based assessments.

**Analytical method**

**Meteorological characteristics, land reclamation and plantation data**

To evaluate the change in ecosystem, rainfall, temperature including pre-mining, post mining data as the major meteorological factors and land reclamation and plantation data thereof.

**Rainfall**

Analysis of the rainfall data for any specific study area is of essential requirement in order
to have a realistic assessment of change in ecosystem in terms of climatology. With this objective, the rainfall data for a period of 19 consecutive years from 2000 to 2018 was collected and it has been presented through graph (Fig. 14) collected from www.imdorissa.gov.in. It was observed that the total annual average rainfall was 1316 mm, and average rainfall during the monsoon period was 1180 mm in Ib valley Coalfield. The monthly rainfall data from 2000 - 2018 were taken from Indian Meteorological Department and yearly total rainfall was calculated by adding.

From the above rainfall graph, it is revealed that the rainfall is continuously moderate after 2015. It indicates that it is only possible due to massive plantation after reclamation of OB dump.

**Temperature**

Similar to the rainfall data, temperature data of the study area is essentially required to have a realistic assessment of change in ecosystem in terms of climatology. With this objective, the temperature data for a period of 11 consecutive years from 2008 to 2018 was collected and it has been presented through graph (Fig. 15 and Table 2) collected from www.imdorissa.gov.in. It is observed that the graph of average temperature (Minimum) is flat after 2016, whereas the graph of average temperature (Maximum) is flat after 2015. This reveals that the temperature becomes lower than previous year due to massive vegetation on the reclaimed mine void.

**Table 2: Temperature data for eleven consecutive year**

<table>
<thead>
<tr>
<th>Year</th>
<th>Maximum Temperature (°C)</th>
<th>Minimum Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>33.8</td>
<td>9.2</td>
</tr>
<tr>
<td>2009</td>
<td>38.0</td>
<td>12.2</td>
</tr>
<tr>
<td>2010</td>
<td>36.4</td>
<td>10.7</td>
</tr>
<tr>
<td>2011</td>
<td>35.2</td>
<td>12.3</td>
</tr>
<tr>
<td>2012</td>
<td>37.6</td>
<td>9.4</td>
</tr>
<tr>
<td>2013</td>
<td>36.0</td>
<td>12.1</td>
</tr>
<tr>
<td>2014</td>
<td>33.0</td>
<td>9.2</td>
</tr>
<tr>
<td>2015</td>
<td>36.8</td>
<td>8.5</td>
</tr>
<tr>
<td>2016</td>
<td>37.5</td>
<td>11.0</td>
</tr>
<tr>
<td>2017</td>
<td>36.8</td>
<td>10.9</td>
</tr>
<tr>
<td>2018</td>
<td>36.6</td>
<td>10.7</td>
</tr>
</tbody>
</table>
Remote sensing method
In remote sensing method, pictures are taken from satellite imagery of different date and is compared to evaluate the state of the pre-mining and post mining land profile and land use pattern. It is now widely used for this purpose. Fig. 16 shows the satellite imagery of Kulda OCP before and during mining. The pictures clearly indicates differences of the land profile.

Climate change
Impact on climate is assessed from the amount of Greenhouse gas emissions mainly CO$_2$ and CH$_4$. In the process of coal mining, Coal Bed Methane emissions occupy a heavier portion in GHG emissions. CO$_2$ is also emitted from the equipment utilizing HSD, electricity and explosives.

CONCLUSION
The trends illustrated by showing the top cited comparison based on relevant photographs, data and graphs, it is quite satisfactory that MCL is doing the best for restoration of ecosystem during and after mining in Ib Coalfield. However, there is need of adoption of advanced technology and methods of vegetation not only to stabilize the OB dump slope but also to well vegetate the reclaimed areas with nutrients of plants of native species including ethnobotanical plants. The vulnerability of the forests and various land use sectors to the global climate change due to mining contributions also need to be addressed so as to build resilience to a changing climate and develop strategies for mitigation and adaptation.
REFERENCES


