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Effects of Opencast Coal Mines on People and Climate at Sathupally and Surrounding Catchment Areas: An Overview

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Abstract

This research examines the environmental, social, and climatic impacts of opencast coal mining operations in Sathupally and surrounding catchment areas within the Godavari River Basin in Telangana, India. The study focuses on the operations of Singareni Collieries Company Limited (SCCL), particularly the Jalagam Vengal Rao Opencast Mines, and their effects on local communities, water quality, air pollution, land use changes, and climate. The findings reveal significant adverse impacts including water contamination with potentially toxic elements, air quality degradation, ecosystem disruption, and greenhouse gas emissions, alongside socioeconomic transformations in affected communities.

Key Words: Opencast mines, Singareni Collieries Company Limited, Adverse impacts, Quality of air, water, land, Socio economic transformations.

1. Introduction

1.1 Background

Sathupally, located in Khammam district of Telangana State, India, sits within the Godavari River Basin, one of India's major river systems. The region has been subjected to intensive opencast coal mining operations by the Singareni Collieries Company Limited (SCCL), a Government-Owned coal mining corporation. SCCL currently operates 40 mines across Telangana, including 18 opencast and 22 underground mines, contributing approximately 9.2% to India's domestic coal production.

The Jalagam Vengal Rao Opencast Mine-I (JVR OC-I) and Jalagam Vengal Rao Opencast Mine-II (JVR OC-II) represent major mining operations in the Sathupally area. JVR OC-I operated at a capacity of 2.50 million tonnes per annum (MTPA) from 2005, while JVR OC-II commenced production in 2017-18 at a capacity of 5.00 MTPA.

1.2 Geographical Context

The study area is situated within the Godavari River Basin, India's second-largest river basin, which covers approximately 312,812 square kilometers. The basin is characterized by diverse topography including the Western Ghats, Deccan Plateau, and Eastern Ghats. The region experiences a tropical monsoon climate with annual precipitation averaging 426.7 mm in some areas, with 75-90% occurring during the monsoon season (June-September).

The geological composition of the basin includes Gondwana formations containing thick coal seams, Cuddapah and Vindhyan metasediments, and Archean granites. This rich geological structure has made the region a significant coal-producing area but also creates environmental vulnerabilities.

2. Environmental Impacts on Water Resources

2.1 Water Quality Degradation

Recent comprehensive studies of water quality in lakes and discharge points adjacent to Sathupalli opencast coal mines have revealed severe contamination. Water samples from the Sathupalli centre mine exhibited highly acidic conditions with pH levels ranging from 2.2 to 4.9 (mean: 3.8), while other sites showed pH ranges from 5.6 to 7.3 (mean: 6.6).

Potentially toxic elements (PTEs) found in high concentrations include:

- Chromium (Cr)
- Cadmium (Cd)
- Arsenic (As)
- Mercury (Hg)
- Lead (Pb)

These concentrations frequently exceed Bureau of Indian Standards (BIS) permissible limits for drinking water, posing serious health risks to local populations dependent on these water sources.

2.2 Acid Mine Drainage

Opencast mining operations generate Acid Mine Drainage (AMD), characterized by:

- Low pH content
- Elevated sulphate concentrations

AMD can persist for 5 to 20 years after mine closure, continuing to deteriorate water quality long after active mining ceases. The acidic water outflow affects surface and groundwater systems throughout the catchment area.

2.3 Impact on Godavari River Basin

The Wardha basin, a tributary system within the Godavari Basin, experiences critical pollution due to coal mining activities. Mining operations routinely dispose of mud from coal mines and ash from associated thermal power plants into river systems, severely degrading water quality for downstream users.

Studies of heavy metal contamination in the Godavari River Basin have identified elevated concentrations of nickel and copper beyond permissible limits at multiple monitoring stations. Iron and zinc were found to be the most abundant metals, with iron concentrations reaching the highest levels. The contamination are from multiple sources including:

- Agricultural runoff
- Native soil erosion

- Industrial discharges
- Mining effluents

3. Air Quality and Atmospheric Impacts

3.1 Particulate Matter Pollution

Opencast coal mining dominates India's coal production and generates significant air pollution, particularly Suspended Particulate Matter (SPM) (Mixture of tiny solid or liquid particles =10mm diameter). The primary sources of dust generation include:

- Topsoil removal and overburden handling
- Coal extraction operations
- Loading and unloading activities
- Transportation of coal and materials
- Blasting operations
- Exposed mining surfaces

Mining areas exhibit high pollution potential due to SPM, with both total dust and respirable dust posing serious health risks to workers and nearby residents.

3.2 Health Implications

Health studies indicate strong associations between airborne particulate matter from mining operations and adverse health outcomes:

- Restricted airways and reduced lung capacity
- Reduced lung function
- Increased cardiovascular disease risk
- Coal workers' lung disease
- Increased cancer risk
- Neurotoxic effects

The occupational hazards extend beyond mine workers to affect residential communities within the mining area's sphere of influence.

3.3 Seasonal Variations

Air quality exhibits significant seasonal variations, with dust concentrations typically higher during dry periods. The monsoon season (June-September) provides some natural dust suppression, but mining operations continue year-round, maintaining elevated pollution levels.

4. Climate Change Contributions

4.1 Greenhouse Gas Emissions

Opencast coal mining contributes to climate change through multiple pathways:

Direct Emissions:

- Diesel consumption by heavy machinery (excavators, haul trucks, loaders)
- Electricity consumption for mining operations
- Coal handling and processing activities
- Transportation emissions

Life cycle assessments of opencast coal mine production indicate that dust represents the most serious environmental impact category (36.81% contribution), followed by global warming (29.43%) and acidification (22.58%).

Indirect Emissions:

- Vegetation removal and ecosystem destruction
- Soil organic carbon depletion
- Coal mine fires (when they occur)

4.2 Ecosystem Services Degradation

Studies of opencast mining areas demonstrate dramatic declines in Ecosystem Services Value (ESV):

- Mean ESV values decreased by 89.45% over 30-year periods in some mining regions
- Biodiversity protection services significantly declined
- Climate regulation capacity reduced
- Gas regulation services deteriorated
- Soil formation and retention capacity diminished
- Water supply services degraded
- Waste treatment capacity compromised

The degradation of these ecosystem services directly impacts the region's climate resilience and adaptation capacity.

4.3 Local Climate Modifications

Mining operations alter local climate conditions through

- Changes in albedo (surface reflectivity) due to vegetation removal and exposure of darker coal and rock surfaces
- Alterations to local hydrological cycles
- Modified temperature patterns in mining areas
- Changes in evapotranspiration rates
- Dust generation affecting local atmospheric conditions

5. Soil Use and Soil Cover Changes

5.1 Landscape Transformation

Analysis of land use/land cover changes in the Godavari coalfields reveals significant transformations over time:

Major Changes Observed:

- Expansion of mining areas
- Reduction in forest cover
- Decrease in agricultural land
- Increase in barren land and waste dumps
- Growth of built-up areas
- Alterations to water bodies

The need to remove large amounts of overburden to access coal deposits contributes to extensive landscape degradation. In the Antaibao opencast coal mine in China (a comparable operation), the average annual land destruction reached 6.6×10^4 hectares.

5.2 Biodiversity Impacts

Mining activities severely disrupt ecosystems through:

- Direct habitat destruction
- Fragmentation of wildlife corridors
- Disruption of ecological timing and species interactions
- Formation of large dump areas unsuitable for most species

Studies in the Lankapally Reserve Forest of Sathupally Forest Range have documented impacts on herpetofaunal assemblages and other wildlife populations in the Eastern Ghats region.

5.3 Soil Degradation

Opencast mining fundamentally alters soil properties:

- Destruction of original soil profiles
- Loss of organic matter
- Changes in soil texture and structure
- Altered water holding capacity
- Modified nutrient cycling
- Increased erosion susceptibility

The fragile ecosystems of the region, characterized by low vegetation coverage and high soil erosion rates, become even more vulnerable following mining disturbance.

6. Socioeconomic Impacts on Local Communities

6.1 Displacement and Resettlement

The expansion of opencast coal mining operations has resulted in:

- Displacement of rural communities
- Disruption of traditional livelihoods
- Inadequate compensation for lost land and resources

The NTR Colony in Sathupalli, situated approximately 617 meters from the crest of JVR OC-I mine, exemplifies communities living in proximity to mining operations. Approximately 700 houses in NTR Nagar potentially experience direct impacts from mining activities.

6.2 Livelihood Transformations

Research on mining-affected communities in Telangana reveals complex livelihood changes:

Lost Livelihoods:

- Cessation of farming activities
- Reduced access to forest resources for hunting, food gathering, and non-timber forest products
- Disruption of traditional water supply sources
- Loss of pastoral lands

New Opportunities:

- Formal employment in mining operations
- Informal coal-based livelihoods
- Service sector employment supporting mining infrastructure
- Construction and transportation jobs

However, the growth of coal extraction over time creates increased community dependence on coal-based livelihoods, raising concerns about long-term sustainability and economic vulnerability.

6.3 Health and Safety Concerns

Communities near opencast mines face multiple health and safety challenges:

Direct Impacts:

- Water contamination affecting drinking water sources
- Noise and vibration from blasting operations
- Structural damage to buildings from vibrations
- Increased accident risks

Occupational Hazards:

- Mining accidents

- Exposure to coal dust
- Risk of equipment-related injuries
- Long-term respiratory diseases

Community Health Issues:

- Respiratory ailments from air pollution
- Waterborne diseases from contaminated sources
- Stress and mental health impacts from environmental degradation and livelihood loss

6.4 Infrastructure Stress

Mining operations place significant demands on local infrastructure:

- Road damage from heavy vehicle traffic
- Dust accumulation on roads requiring increased maintenance
- Strain on local services and facilities
- Need for new transportation infrastructure
- Requirements for water supply and waste management systems

The construction of a 54.1 km railway line from Sathupalli to Bhadrachalam Road (Kothagudem) and a modern Coal Handling Plant with 10 MTPA capacity represents significant infrastructure development, but also indicates the scale of operations and their requirements.

7. Regulatory Framework and Compliance Issues

7.1 Environmental Clearance Process

Mining projects require environmental clearances under India's Environment Impact Assessment (EIA) Notification, 2006. However, regulatory challenges include:

- Instances of excess coal production beyond permitted limits
- Delays in implementing mine closure plans
- Violations of Environmental Clearance conditions

The Expert Appraisal Committee (EAC) has rejected proposals for mine expansions citing premature applications, inadequate impact assessments, and violations of environmental norms.

7.2 Section 106 Agreement Limitations

The Section 106 Agreement establishes rules and regulations for mining operations to protect area residents. However, significant weaknesses exist:

- Violations of enlisted rules do not result in penalties or consequences for companies
- Limited accountability mechanisms
- Insufficient monitoring and enforcement
- Inadequate community representation in decision-making

Legal challenges by environmental groups have exposed these loopholes, though structural reforms remain pending.

7.3 Monitoring and Reporting

Environmental monitoring requirements include:

- Air quality monitoring at mine sites and nearby communities
- Water quality testing of discharge points and nearby water bodies
- Noise and vibration monitoring
- Biodiversity assessments
- Compliance reporting to regulatory authorities

However, gaps in monitoring, inconsistent enforcement, and limited public access to data constrain effective environmental protection.

8. Mitigation and Remediation Measures

8.1 Current Abatement Practices

SCCL and other mining companies implement various pollution control measures:

Air Pollution Control:

- Water spraying on haul roads and mining areas
- Tarpaulin covering of coal transport trucks
- Dust extraction systems at key points
- Plantation of trees and vegetation barriers
- Controlled blasting techniques

Water Management:

- Wastewater treatment facilities
- Sedimentation ponds
- Recycling of mine water
- Construction of modern Coal Handling Plants with environmental safeguards

Community Programs:

- Free LPG supply to employees to reduce air pollution
- Distribution of free saplings for plantation
- Environmental education in company schools
- Eco Samman Awards for environmental contributions

8.2 Land Reclamation and Restoration

Reclamation of mined land represents a critical process, though often inadequately addressed:

Reclamation Approaches:

- Backfilling of mine voids with overburden
- Topsoil replacement
- Re-vegetation with native species
- Soil amendment and fertility restoration
- Erosion control measures

Challenges:

- Failed reclamation of significant mined areas
- Slow recovery of ecosystem functions
- Limited success in restoring pre-mining productivity
- Insufficient funding and technical capacity
- Long timeframes for ecosystem recovery

8.3 Improved Mining Technologies

- Clean coal transportation methods
- Increased processing efficiency
- Belt conveyors as alternatives to truck transport
- Advanced dust suppression technologies
- Energy-efficient equipment
- Real-time environmental monitoring systems
- Precision mining techniques to minimize overburden

9. Comparative Analysis and Global Context

9.1 Underground vs. Opencast Mining

Comparative analysis reveals differential impacts:

Opencast Mining:

- Greater landscape degradation
- Larger land area requirements
- More visible environmental impacts
- Lower worker safety risks compared to underground
- Higher production efficiency

Underground Mining:

- Acid mine drainage issues
- Subsidence risks
- Higher worker safety hazards (accidents, pneumoconiosis)
- Less surface disturbance
- Lower dust generation at surface
- More complex operations

9.2 International Best Practices

Global mining operations provide lessons for Indian coalfields:

- Comprehensive pre-mining environmental assessments
- Advanced water treatment technologies
- Progressive rehabilitation concurrent with mining
- Community engagement and benefit-sharing mechanisms
- Stronger regulatory frameworks and enforcement
- Transition planning for post-mining economic development

10. Future Outlook and Recommendations

10.1 Climate Change Adaptation

Given India's climate commitments and the European Green Deal's influence on global energy transitions, the coal sector faces significant pressures:

- Declining competitiveness of coal energy
- Increasing carbon emission charges
- Pressure for mine closure and rehabilitation
- Need for just transitions for mining-dependent communities

10.2 Recommendations for Sustainable Mining

For Mining Companies:

1. Implement comprehensive environmental management systems with real-time monitoring
2. Invest in advanced pollution control technologies
3. Develop concurrent reclamation programs rather than post-closure approaches
4. Enhance community consultation and benefit-sharing mechanisms
5. Transition to cleaner technologies and energy-efficient equipment
6. Establish robust water treatment and recycling systems
7. Create biodiversity offsets and conservation programs

For Regulatory Authorities:

1. Strengthen enforcement of environmental regulations with meaningful penalties
2. Improve monitoring capacity and public transparency
3. Reform Section 106 Agreement to include enforceable consequences
4. Mandate comprehensive life cycle assessments for mining projects
5. Establish independent environmental audits
6. Require adequate financial assurance for reclamation
7. Develop regional cumulative impact assessments

For Communities and Civil Society:

1. Enhance environmental literacy and awareness
2. Strengthen community-based monitoring programs

3. Participate actively in environmental clearance processes
4. Document and report environmental violations
5. Support legal challenges to inadequate environmental protection

For Researchers and Institutions:

1. Conduct long-term environmental monitoring studies
2. Develop improved reclamation and restoration techniques
3. Assess cumulative impacts across the Godavari Basin
4. Evaluate health outcomes in mining-affected populations

10.3 Pathway to Just Transition

As coal mining inevitably declines due to climate imperatives:

1. Develop alternative economic opportunities for affected communities
2. Invest in skills training and education programs
3. Promote renewable energy development in mining regions
4. Establish rehabilitation funds for post-mining landscape restoration
5. Ensure adequate social safety nets for displaced workers
6. Recognize and preserve local ecological knowledge

11. Conclusion

The opencast coal mining operations in Sathupally and surrounding catchment areas of the Godavari River Basin present a complex picture of environmental degradation, climate impacts, and socioeconomic transformation. The evidence clearly demonstrates:

1. **Severe Water Contamination:** Mining operations have substantially degraded water quality through acid mine drainage and potentially toxic element contamination, affecting both surface and groundwater resources critical for human consumption and ecosystem health.
2. **Significant Air Quality Impacts:** Dust generation from mining activities creates serious health risks for workers and nearby communities, with documented associations with respiratory, cardiovascular, and other diseases.
3. **Climate Change Contributions:** Mining operations contribute significantly to greenhouse gas emissions through direct energy consumption and indirect ecosystem destruction, while simultaneously reducing the landscape's climate resilience and adaptation capacity.
4. **Landscape Transformation:** Extensive land use changes have destroyed ecosystems, fragmented habitats, degraded soils, and created long-term environmental liabilities requiring decades for potential recovery.
5. **Community Impacts:** Local populations face displacement, livelihood disruption, health hazards, and inadequate compensation, while simultaneously becoming increasingly dependent on coal-based economic activities.
6. **Regulatory Inadequacies:** Despite environmental regulations, enforcement gaps, weak accountability mechanisms, and inadequate monitoring allow environmental degradation to continue.

Moving forward, the Sathupally region requires a fundamental reorientation toward sustainable resource management, stronger environmental protection, community-centered development approaches, and realistic planning for the inevitable transition away from coal dependence. The lessons from Sathupally resonate across India's coalfields and globally, highlighting the urgent need to balance energy needs with environmental protection and climate action while ensuring just outcomes for mining-affected communities.

The pathway forward must integrate improved mining practices with robust environmental protection, genuine community participation, and long-term planning for economic diversification and ecological restoration. Only through such comprehensive approaches can the region hope to repair past damages and build a more sustainable and equitable future.

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Note: This research paper synthesizes available scientific literature, regulatory documents, and case studies related to opencast coal mining in Sathupally and the Godavari Basin catchment areas. Further primary research and field studies would enhance understanding of specific local impacts and appropriate mitigation strategies.