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RECLAMATION, REHABILITATION, AND REJUVENATION OF MINING REMNANTS

'A study of how to repurpose Abandoned Coal Mining Land'

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APPROVAL

The study titled "***Reclamation, Rehabilitation, and Rejuvenation of Mining Remnants***" is hereby approved as an original work of **Nischay Choudhary**, enrolment no. **18E1AAARM40P089** on the approved subject carried out and presented in manner satisfactory to warrant its acceptance as per the standard laid down by the university. This report has been submitted in the partial fulfillment for the award of **Bachelor of Architecture** degree from Rajasthan Technical University, Kota.

It is to be understood that the undersigned does not necessarily endorse or approve any statement made, any opinion expressed or conclusion drawn therein, but approves the study only for the purpose it has been submitted.

__ December 2022
Jaipur

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DECLARATION

I, **Nischay Choudhary**, hereby solemnly declare that the research work undertaken by me, titled **'*Reclamation, Rehabilitation, and Rejuvenation of Mining Remnants*'** is my original work and wherever I have incorporated any information in the form of photographs, text, data, maps, drawings, etc. from different sources, has been duly acknowledged in my report.

This dissertation has been completed under the supervision of the guide allotted to me by the school. Further, whenever and wherever my work shall be presented or published it will be jointly authored with my guide.

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CERTIFICATE

This is to certify that the research titled **'*Reclamation, Rehabilitation, and Rejuvenation of Mining Remnants*'**, is a bonafide work by **Nischay Choudhary** of Aayojan School of Architecture, Jaipur. This research work has been completed under my guidance and supervision in a satisfactory manner. This report has been submitted in partial fulfillment of the award of the BACHELOR OF ARCHITECTURE degree from Rajasthan Technical University, Kota.

This research work fulfills the requirements relating to the nature and standards laid down by the Rajasthan Technical University.

Prof. **Anubhav Mittal**

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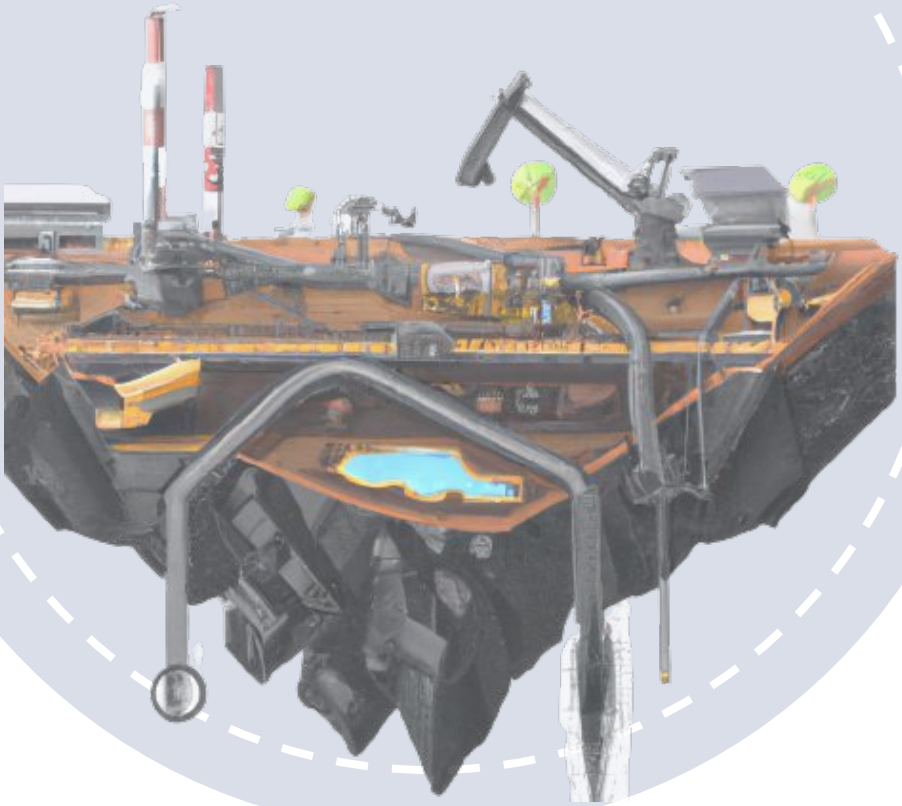
INTRODUCTION



CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Coal mines in India generate 1243.92 Billion units of energy that powers houses, industries, and institutions alike. The mining industry contributes to the annual GDP of India and facilitates various other industries' functioning. Coal India Limited (CIL) currently owns the largest fraction of the total mines in the country. Annually 778.19 MT tonnes of coal is extracted in the country. The mining industry employs a workforce of 88 Lakhs (FY 2021, Source: Statista.com) people. India is the second largest producer and consumer of coal in the world.

Therefore, as an important industry of our economy, the coal mining process is instrumental in fulfilling our country's energy needs and generates employment for lakhs of people of our country. This field is expected to increase its production and efficiency with the increase in energy demands, growing population, and rise in the industrial sector.

However, a major setback of the mining sector is the remnants of the entire process of mining that are left behind after the mine is exhausted.

There are two types of Coal mines:

- Open Cast Coal Mine

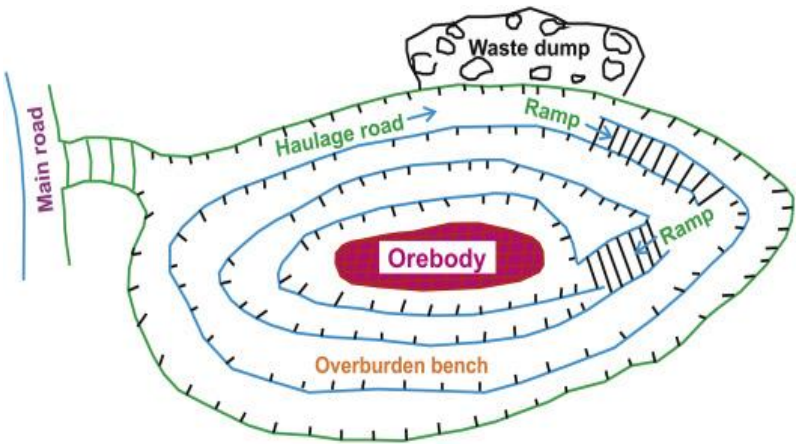


Fig.1.1 Open Cast Coal Mine Conceptual Sketch.

- Underground Coal Mine

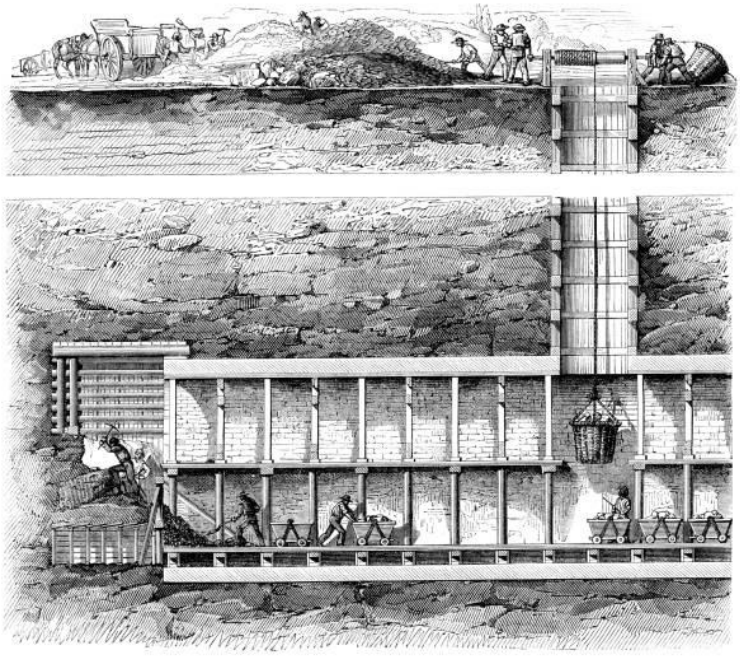


Fig.1.2 Underground Coal Mine Conceptual Sketch.

1.2 Terminologies

Re-Clamation: The Process of Claiming something back.

Re-habilitation: The process of restoration to bring an area of land back to its natural state after it has been damaged or degraded.

Re-juvenation: the process of making something more effective, modern, and successful by using new ideas and methods.

Remnants: A part of something that is left after the other parts have been used, removed, destroyed, etc.

OverBurden: The material left over from coal mining.

1.3 Criteria of Selection

Chandrapur is the coal capital of India and hence the largest cluster of abandoned mines reside in and around the city. The study would help organize data that can be a precursor in approaching the redevelopment scheme for bringing about development of abandoned mines of the region.

1.4 Hypothesis

Re-claiming, Re-habilitating, and Rejuvenating of abandoned coal mines can be instrumental in the holistic sustainable development of the site.

1.5 Subject

"A conducive study of the possible plausible ways in which mine land can be repurposed after its abandonment, to serve people, community and ecology, to restore the imbalance created during its wake"

1.6 Aim

To curate a manual for a comprehensive design strategy that can be applied or referred to while approaching redevelopment on abandoned mine land in Chandrapur - Coal Capital of India.

1.7 Objectives

Redevelopment of any kind, calls for sustainable measures as an approach to its planning and designing. Sustainability has 3 pillars that are categorized on the basis of which area of holistic development they address: Social, Economical, and Environmental.

The underlying objective is to study the possible ways in which mining land can be renewed.

1.7.1 To study the existing conditions of the coal mining land and its impact on the surrounding environment.

1.7.2 To study the means through which a coal mining land can be treated. (Re-clamation, Re-habilitation, and Re-juvenation).

1.7.3 To study and analyze the similar prototypes of the 3 R's (Case studies).

1.7.4 To study and analyze the existing Policies, and Norms for redevelopment of an abandoned Coal Mine.

1.7.5 To conclude, and recommend.

Incorporation of the following in the development process:

1.6.4 Social Sustainability - Study of ways in which the site can cater to gatherings, learning and interaction experiences for people from different backgrounds.

1.6.5 Economic Sustainability - Using the residue of mining (overdue) as the chief construction material to save cost of transportation, proposing program functions that ensure inflow of income, etc.

1.6.6 Environmental Sustainability - Proposing ways which ecological balance can be restored and maintained such as indigenous plantation, water management, etc.

1.8 Scopes and Limitations

1.8.1 The study solely focuses on Chandrapur city as its target ground for research. The developmental procedures however integrated and universal, may differ from region to region all over India.

1.8.2 Study of environmental factors: Social, Economical, and Environmental Sustainability.

1.8.3 Study of soil bearing capacity of the abandoned land (Chandrapur), and Research on the best possible typology of foundation to be proposed.

1.8.4 Coming up with a viable methodology and approach for constructing on mine grounds.

1.8.5 Study on how to make the land habitable: Indigenous Vegetation (to restore soil's capacity to retain/ percolate water), socio economic factors, revenue return, etc.

1.8.6 Holistic development program and requirements for repurposing such land that can be applied to all mining grounds.

1.9 Need and relevance of the Study

Mining is a taxing process on land and has ecological implications of micro and macro levels and concludes with complete abandonment of the land after it's exhaustion. It is imperative therefore to put the abandoned land to good use where it can serve a purpose.

An ubiquitous objective of treating an abandoned mine also requires one to restore the ecological imbalance that resulted from mining during the period it was active. Redevelopment and renewing of such land calls for a holistic development approach that takes care of social intimacy, income generation, and environmental factors into consideration.

1.10 Research Question/s

a. Guidelines from the government and DGMS on reusing mining land, and Mine Closure Plan (MCP).
b. What is the feasibility of using mining overdue (residue) as construction material for making CSEB, and Binding material for construction?
c. How can sustainability be Incorporated in the redevelopment scheme holistically?
d. What are the flora and fauna which help in restoring the capacity and quality of the soil?
e. What type of foundation is best suited for construction on mining land?

1.11 Conceptual Sections of OpenCast Coal Mine.

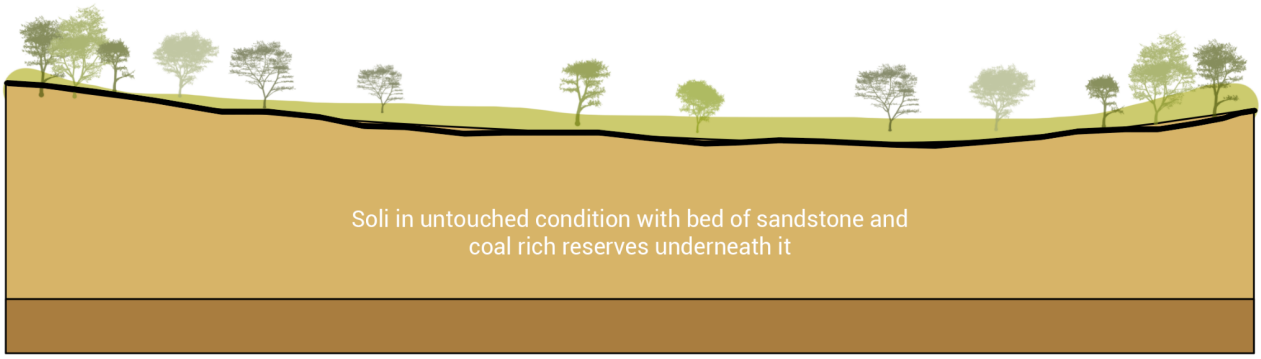


Fig.1.3 Before Mining Starts.

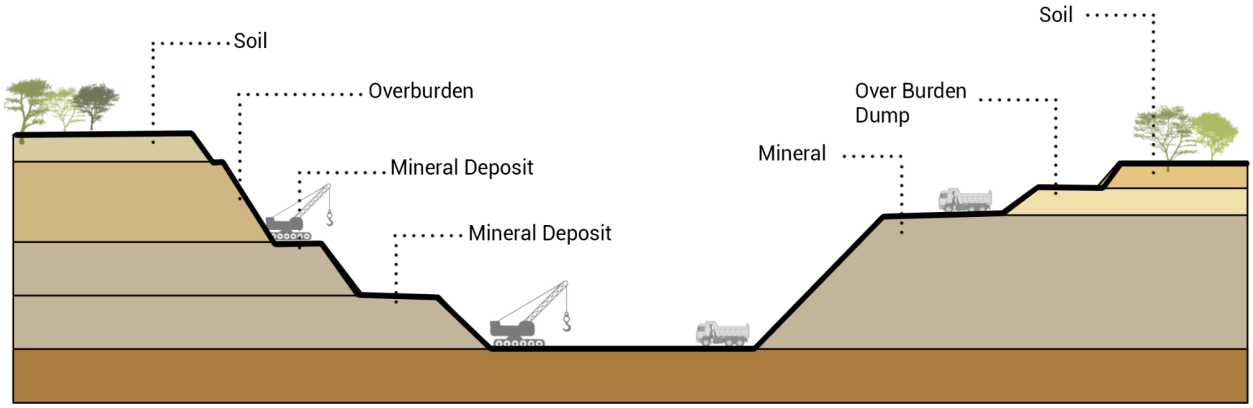


Fig.1.4 During Mining.

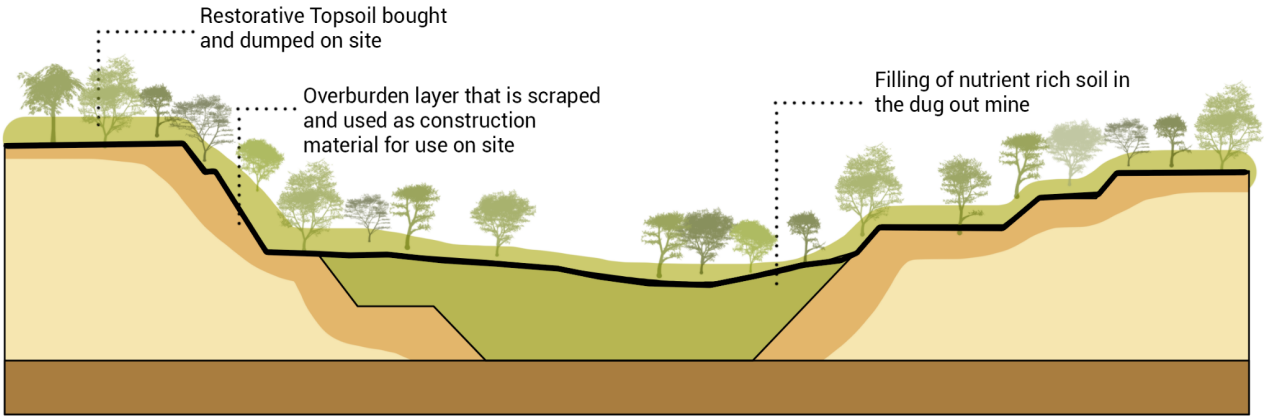


Fig.1.5 After Reclamation of the Mine.

1.11 Research Methodology

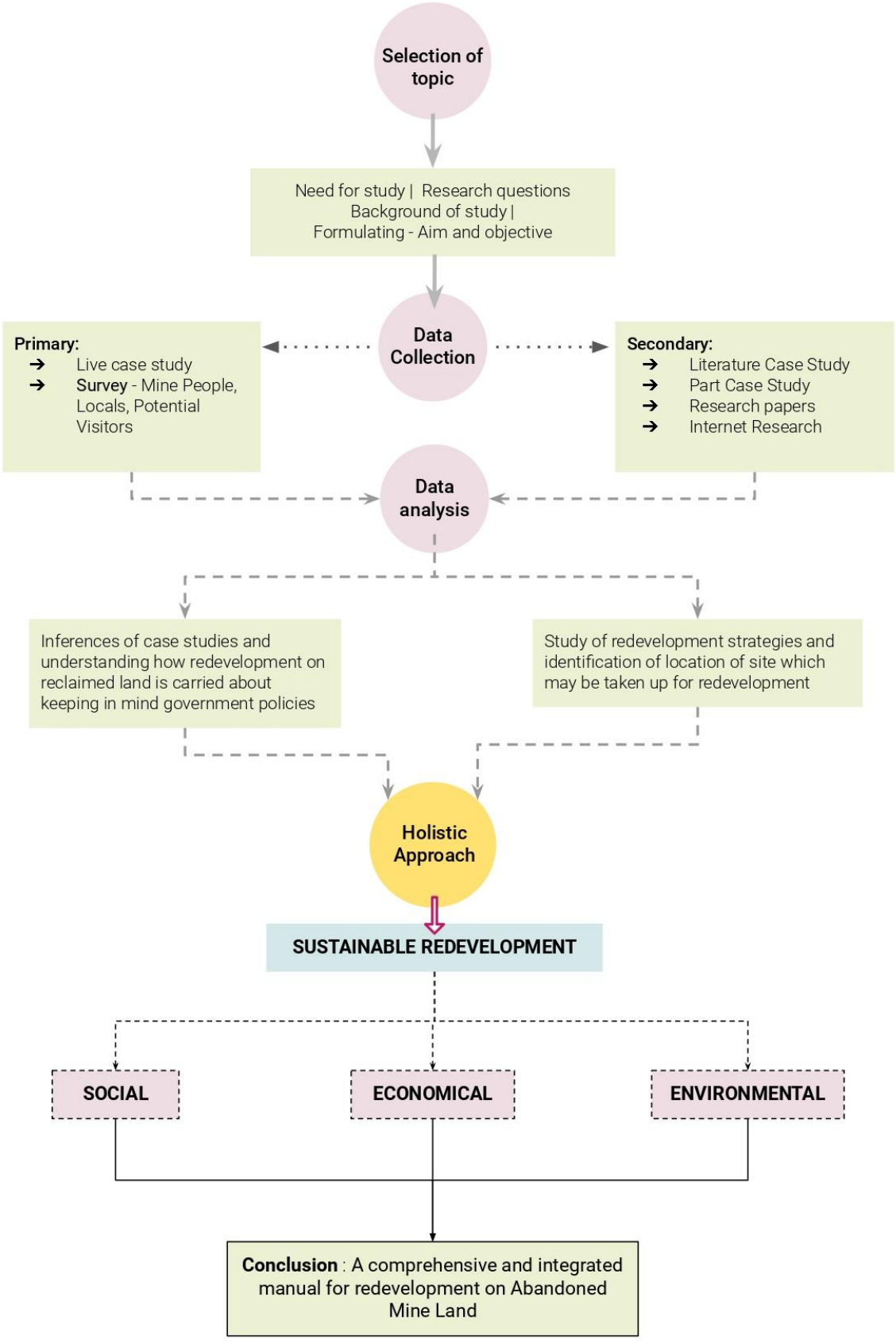
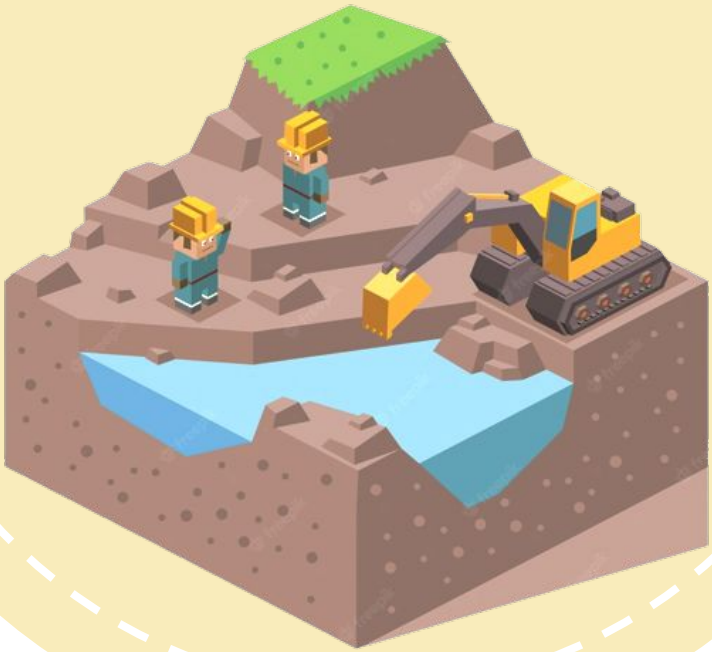


Fig.1.6 Methodology Chart.

CHAPTER 2

RECLAMATION



CHAPTER 2: RECLAMATION

2.1 Reclamation Process

Traditionally, mines have been the sole source of ore, and coal exploration has been carried out with little regard for serious ecological and environmental impacts. Therefore, the coal industry is classified as red, i.e. in the upper group of environmental degradation (Chaoji 2002), and the coal mining industry is considered for inclusion in the national super fund plan.

The main environmental impacts from mining are changes in soil stratification, reduced biodiversity, and changes in ecosystem structure and function; these changes ultimately affect water and nutrient dynamics as well as nutrient interactions (Matson et al 1997; Almas et al 2004; Ghose 2004).

The mine closure plan is specific to each mine and includes details on how the mining company will close the mine, how environmental protection will be achieved, and how to return the mine to acceptable condition for the mine, with pre-established land use purposes.

*"**Reclamation** means acquiring the possession and rights to develop a land again after the intended use of it has been exhausted or has come to an end. This process involves restoring the land to its original state or initiating the same."*

- Waste Removal
- Mitigation of degraded soil
- Restoring Land Quality
- Physical stabilization of the soil (dams, waste rock piles)
- Landscaping
- Topsoil restoration
- Return of soil to useful uses

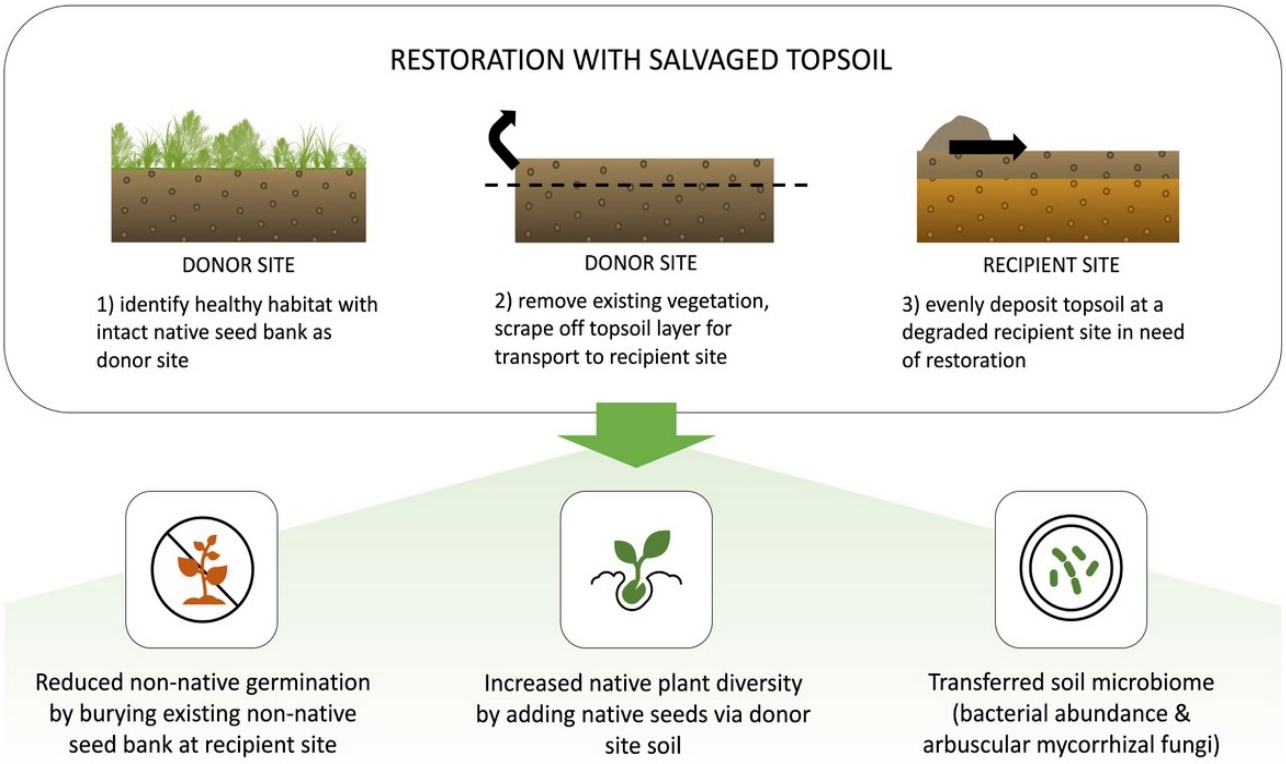


Fig. 2.1 Restoration Of TopSoil.

2.2 Reclamation Principles

Remediation: The cleanup of the contaminated area to safe levels by removing or isolating contaminants. At mine sites, remediation often consists of isolating contaminated material in pre-existing tailings storage facilities, capping tailings and waste rock piles with clean topsoil, and collecting and treating any contaminated mine water if necessary.

Restoration: The process of rebuilding the ecosystem that existed at the mine site (if any) before the disturbance. The science of reclamation has evolved from simple vegetation reclamation operations to a discipline involving the use of native vegetation to mimic the growth of natural ecosystems over a period of time.

2.3 How RECLAMATION leads to Sustainable Development?

- The processes involved in Reclamation like waste removal, restoration of land quality, etc, essentially contribute to enhancing the lithosphere conditions compromised by mining. This process leads to environmental stability and sustainability.

- Reclamation jobs involves heavy work that requires manpower to carry out and hence creates job opportunities for the people of nearby communities that would uplift their living standards and health ultimately leading to social sustainability.

Fig. 2.2 Anthropogenic soil.

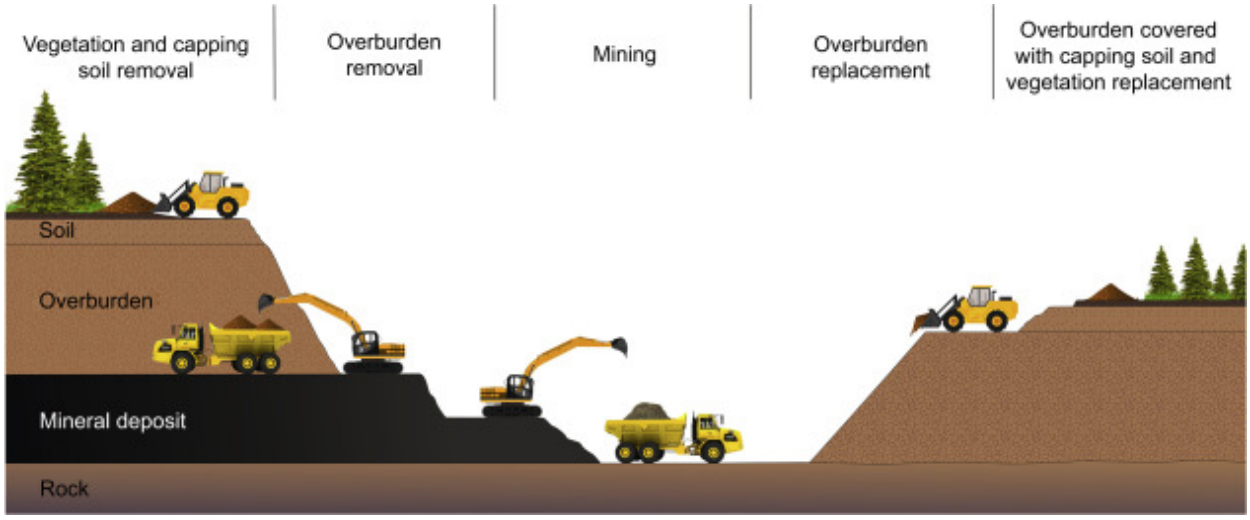


Fig. 2.3 Conceptual Cross Section of an OpenCast Coal Mine.

CHAPTER 3

REHABILITATION

CHAPTER 3 : REHABILITATION

3.1 Rehabilitation Process

The establishment of a stable and self-sustaining ecosystem, but not necessarily the one that existed before mining began. In many cases, complete restoration may be impossible, but successful remediation, reclamation, and rehabilitation can result in the timely establishment of a functional ecosystem.

For opening a new mine as a Greenfield project or increasing the capacity of brownfield projects, mine owners have to obtain a social license (SL), which is an intangible, informal approval or acceptance of the community to have the mine in the community. In the past mining operations were abandoned without closure methods without mitigating physical and environmental impacts, which have negatively influenced the ability of mining firms to obtain a social license. In the Indian scenario mining firms have to obtain prior environmental clearance (EC) for all new projects or activities listed in the Schedule to this notification; Expansion and modernization of existing projects or activities listed in the Schedule to EIA notification 2006 with the addition of capacity beyond the limits specified for the concerned sector, that are, projects or activities which cross the threshold limits given in the Schedule, after expansion or modernization; any change in the product - mix in an existing manufacturing unit included in Schedule beyond the specified range. This is consistent with the 1994 Environmental Impact Assessment (EIA) Notice, the 2006 EIA Notice as amended accordingly. These historic activities are nothing more than actions towards the closure of the mine by the former managers prior to the abandonment of the mine. Mine managers should share their closure plans in the EIA and how the closure will ensure that the community will not be harmed by mine operations, closures or post-closure conditions. . All aspects of the environment, such as soil, water, and air, are taken into account when planning closures. Mine owners are required to obtain a Mine Closure Certificate from the Coal Control Authority to ensure that reclamation and protective restoration works in accordance with the final Mine Closure Plan (MCP)/MCP have been approved. approval has been made. Rehabilitation is the main issue.

*"**Rehabilitation** means reassigning purpose to the land's resources and its function so that it may become self-sustaining and sustainable in due course."*

- Repurposing it to serve tourism or recreational activities
- Generating income
- Generating employment
- Using resources of the land like soil for use as building construction material

3.2 Rehabilitation Principle

Rehabilitation: Restoration involves returning degraded land to normal by special treatment. It is a course of action to minimize the disturbed environmental conditions created by mining activities.

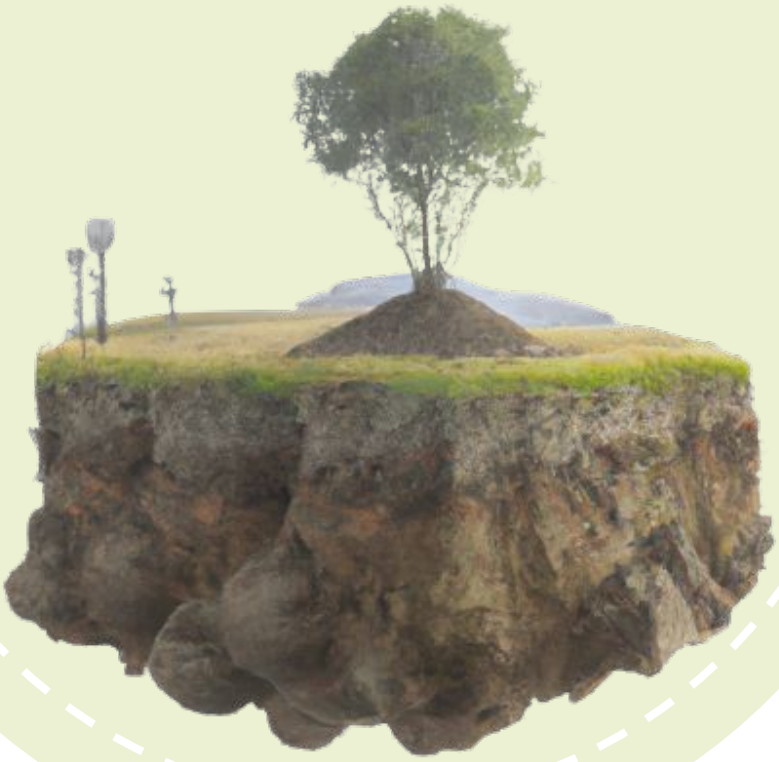
3.3 How does REHABILITATION lead to Sustainable Development?

- Mining Overburden is the loose soil waste left behind after the mining process. It is devoid of nutrients, minerals, organic matter, water retention capacity and is of no further use. Hence, a potential prospect of utilizing the overburden is in the construction process as building material. Using the waste from site in the building material leads to environmental sustainability.
- Mine Overburden can be used for making bricks, as replacement of cement or other binding material and for making pavers.
- The rehabilitation employed thousands of people as labor on site and led to social sustainability of the communities of the nearby villages.
- Since the raw material for building construction is readily available on site, the cost of transporting construction material like burnt bricks, fly ash bricks, cement, etc are cut down which leads to economic sustainability.
- Repurposing mining land to generate revenue also contributes to economic sustainability.

Fig. 3.1 Tourist at an Observation Deck of an OpenCast Coal Mine.

CHAPTER 4

REJUVENATION



CHAPTER 4: REJUVENATION

4.1 Restoration of Mine Land

An ecological restoration approach is beneficial for land reclamation on land degraded by mining in Chandrapur, Maharashtra. At present, most reclaimed land is used for agriculture and forestry. Ecological restoration should include:

1. Legislation systems;
2. Ecological risk evaluation;
3. Ecological assessment;
4. Ecological planning;
5. Financial investment and benefit distribution;
6. Clean production techniques;
7. Resource regeneration; and
8. Restoration and rebuilding of ecosystems on mine waste land.

Among them, ecological planning, engineering rehabilitation and land reclamation are the basic links. For successful restoration, new land construction is the basic framework, however, this needs to involve ecological planning, construction of contour terraces, soil erosion control, and prevention and treatment. dispose of toxic substances and cover the soil with loess. This needs to be integrated with ecological engineering to establish vegetation and create ecosystems to optimize soil productivity and soil fertility. An effective decision-making process for design optimization is an important step to successful practice and will require consultation with all stakeholders, including local people. To achieve ecological recovery, the focus must be on the use of fiscal policies (both rewards and punishments) through a legally binding system with strict enforcement.

Fig.4.1 View of an Abandoned Opencast Coal Mine.

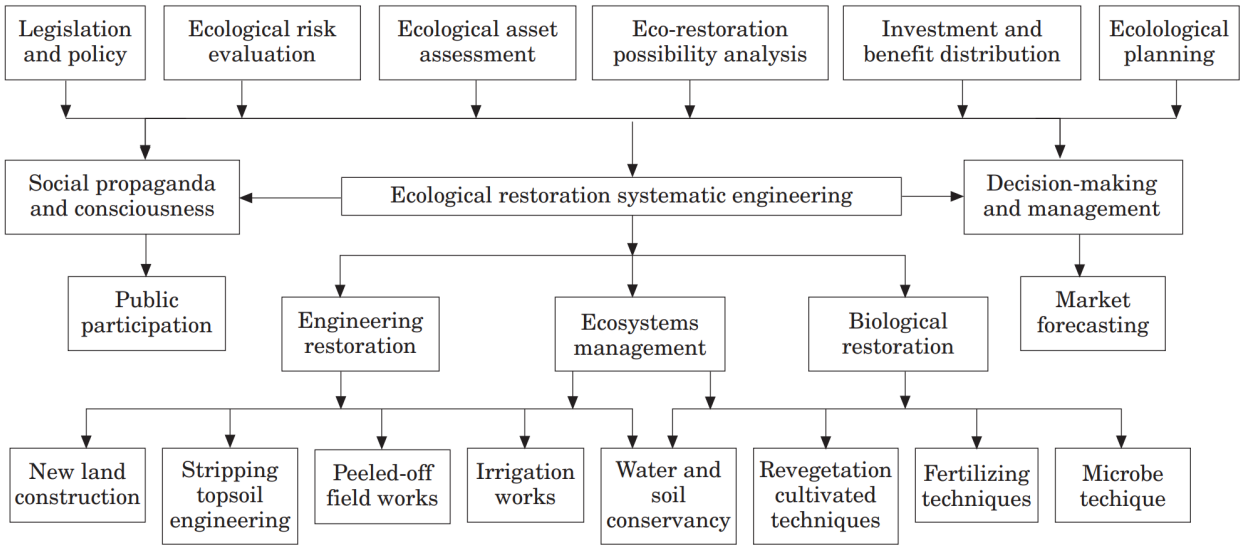


Fig.4.2 Process of Restoration.

4.2 Process for Chandrapur: Coal Capital of India

4.2.1 Soil Revival

Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	K_2O	Na_2O	P_2O_5	SO_3	LoI
Coal Mine OB (%)	58.86	29.09	4.17	1.21	0.81	1.76	3.44	0.11	0.08	0.47	6.57
Cement (C) (%)	24.98	4.84	3.02	61.24	1.42	0.48	0.39	0.29	0.8	2.5	0.07

Table 4.1 Mineral Composition of Coal Mine OverBurden.

To improve the situation in the field of soil resources protection in coal-mining industry it's important to perform:

- Continuous modernization of current mining technologies in terms of reducing soil damage rates, as well as the widest possible disturbance of overcrowded operations at inland landfills;
- Consolidation of overburden operations and dump-creation in open-pit mines with the technical stage of recultivation;

- Modernization of current and development of new and more efficient ways of technical and biological recultivation with climate and environmental conditions in mind;
- The execution of recultivation projects on the basis of full volume of initial data, including the data on composition and properties of the soil and mining rocks;
- Applications to reclamation of rock dumps include self-ignition formation technologies that, together with the weathering process, ensure the conduct of fire suppression operations as well as the conduct of reclamation works in the field;
- Opportunities to expand on-going research into the ecological status of disturbed and cultivated land, the dynamics of changing ecosystem properties and modes of formation, and the creation of artificial landscapes for different destinations.

Mining activities affect the composition of plant communities and soil properties in the mining areas, which inevitably leads to vegetation degradation and loss of soil properties. Consistent with previous studies, most soil nutrients measured in this study increased with increasing age of recovery, suggesting that the vegetative restoration approach is effective in improving Restoration of topsoil in landfills. In general, plants can affect soil nutrients, possibly by converting dead leaves to humus in the topsoil. Therefore, soil nutrients are relatively lower in the new AR, because the seedling and the soil are in the early stages of reciprocal feedback. Compared with the SMC of other restoration sites, it was found that the SMC of the newly reclaimed land (RA18) was not the lowest due to artificial irrigation after restoration. Over time, the water holding capacity gradually increases as the soil structure improves. Due to the frequent movement of heavy machinery that excavates and replaces topsoil during the reclamation process, the reclaimed mine soil is very dense, resulting in high soil mass density. In agreement with a previous study, it was found that the soil mass density in the AR of three coal mines was higher than in the NA. In addition, soil mass density was found to decrease with time since restoration, indicating recovery from soil compaction and improved soil structure. Soil pH plays an important role in ecological restoration because of its function in regulating plant nutrient availability. The soil pH value in AR was found to be higher than in NA because severely disturbed soil inevitably leads to a change in soil pH, often resulting in an increase in soil pH. Other studies have shown that soil acidification is also due to the accumulation of organic matter. In the study, the soil pH in the three coal mines was alkaline and acidification with organic matter accumulation was not obvious. The results of this study indicate that

vegetation restoration has markedly improved the plant species, total number of plants and plant species diversity in the landfill.

4.2.2 Repurposing the Land

A recent study that analyzed Korba of Chhattisgarh, India's largest coal-producing district and one of the major coal-fired power plants, revealed that there is currently more than 24,364 hectares of land, equivalent to the size of the city of Raipur. , with coal and electricity companies. . A comprehensive policy to acquire and reallocate these lands could serve as a model for the transition to a greener economy.

Fig.4.3 View of Tailings, and OverBurden.

41% of people in the mineral-rich district live below the poverty line and more than 32% of the district's population is "multidimensionally poor" with limited access to healthcare, education and basic amenities. He pointed out that a coal-centric economy has hindered the growth of other economic sectors, including agriculture, forestry, manufacturing and services. The analysis therefore indicates that its low socioeconomic status and heavy reliance on the coal economy make it highly vulnerable to unplanned closures of mines and industries.

The main determinant of industrial development in coal areas, including Korba, will be land availability and indicates that land acquisition in these areas can be difficult due to historical transfer and displacement of land and communities. An important opportunity therefore lies in the redevelopment and reuse of mining and industrial land in Korba.

Fig 4.4 Thermal powerplant just near an OpenCast Coal Mine.

Elsewhere around the world, we've seen old open pit mines turned into beautiful lakes and amusement parks. A former quarry in Shanghai, China now houses the InterContinental Shanghai Wonderland. The 5-star "groundscraper" hotel descends 16 stories vertically from the ground into the depths of the quarry. The top 2 floors are above ground level; The hotel has a total of 18 floors.

When the construction was completed, the bottom of the quarry was flooded creating an artificial lake and submerged the 2 lower floors of the hotel. Hotel guests can dine in the underwater restaurant while schools of fish float outside. It also has an underwater swimming pool, and the hotel rooms have windows overlooking the surroundings. The lake itself has a waterfall that flows through the quarry wall in front of the hotel and has a range of water sports available to guests.

4.3 Foundation

S. No.	Material Type	Material Properties			
		Test of this study			
		$\rho_{in\text{-}situ}$ (kN/m^3)	$\rho_{drained}$ (kN/m^3)	c (kPa)	(degrees)
1	Sandstone	24.86	22.35	22.44	59.49
				28.98	31.47
				20.62	57.77
	Average	24.86	22.35	24.01	49.57
2	Coal	16.35	14.34	17.44	59.77

Table 4.2 Soil testing parameters, and results.

As per the tests conducted on Site, and then matching it with the Standard codes; It was found that the best type of foundation suitable for the construction on an abandoned coal mine land is Pile Foundation.

4.3.1 Pile Foundation

Pile foundations can be used to carry a building's load through overly heavy soil to the underlying rock. Figure 6.3 shows a pile arrangement where piles of equal diameter are used throughout the foundation and each pile is designed to bear an equal load; The number of piles under each column or load-bearing wall depends on the load exerted by these units, and therefore, the arrangement of the piles in the layout approximates the load distribution of the foundation.

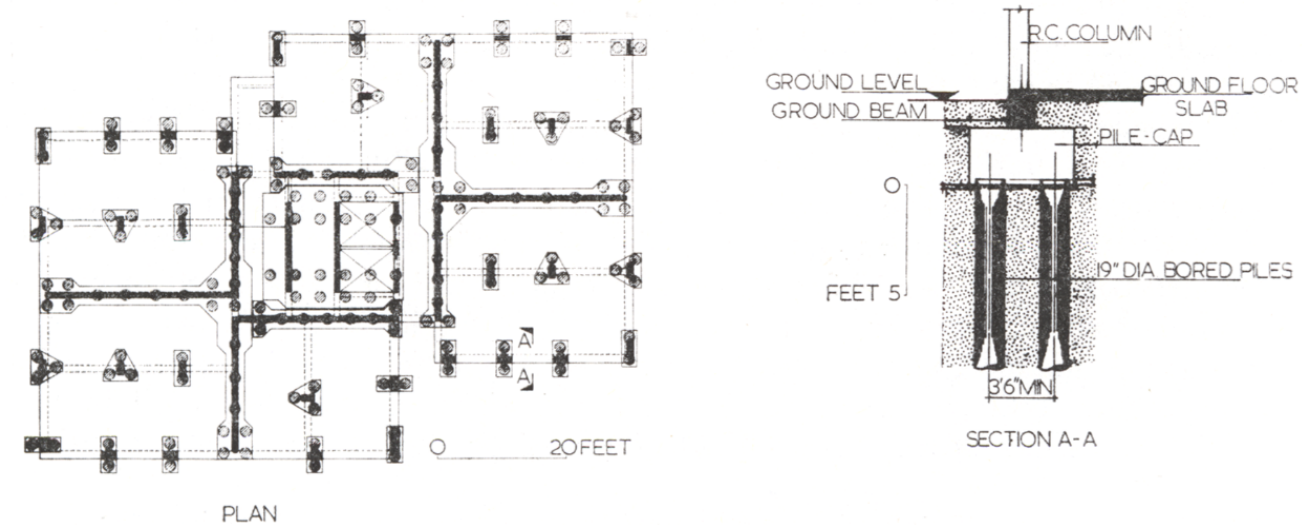


Fig 4.5 Pile Foundation- Plan, and Section.

Piles supporting individual columns or walls must be connected by pile caps (under columns), beams or slabs (under load-bearing walls), on which ground beams and ground floors are built. The ultimate limiting pitch of the pile is usually at a shallow depth below the original ground level to allow for the burial of earth beams and to facilitate the placement of necessary services in the basement.

4.4 How does REJUVENATION lead to Sustainable Development?

- Rejuvenation of the site involves processes that lead to enhanced micro climatic conditions, improvement of soil conditions, and strengthening of biodiversity and ecology of the site and its surroundings. Hence it is an important factor that leads to environmental sustainability.
- Improving the conditions of the soil and forestation start a catalytic reaction which positively affects the nearby flora and fauna.
- Proposition of bioswale is the fastest way of achieving holistic ecological development on site.

CHAPTER 5

CASE STUDIES

CHAPTER 5: CASE STUDIES

5.1 Reclamation of Piparwar opencast Coal mine, Jharkhand

Fig 5.1 Birds eye view of Piparwar Opencast Coal Mine.

- After about 30 years of operations, the mining activities in Jharkhand's Piparwar opencast coal mining project, which was spread over 1100 hectares, have stopped.
- The Central Coalfields Limited (CCL), which was operating the opencast mining project, has so far carried out reclamation work in about 272 hectares area including plantation, an eco-park and a few water bodies.
- Land reclamation is an important process of the overall mining process once the minerals from a mine are exhausted and the mine is closed.

Of the total leased area of 1,120,25 ha, the mining area of the mines is 540 ha. Of these 540 hectares, restoration works are underway on about 272 hectares and include plantations in most of this area, a small ecological park (Kayakalp Vatika) and some water bodies.

Currently, backfill work is underway on an additional 28 hectares. According to CCL officials, the rest of the mining area will be filled in and reclaimed with plantations.

Fig 5.2 Sustainability Analysis.

Officials claimed that "success of reclaiming land from logging trophies and reforesting is crucial and overwhelming in places like Ashoka, Piparwar, etc. As the crops grow, the shed soil is improved in stages to restore its fertility, and gardening activities are accomplished by adding nutrients, such as organic fertilizers, inorganic and biological.

5.1.1 How Reclamation Was Planned?

"Kayakalp Vatika is a collective effort by CCL officials to reclaim and restore degraded mining land into a hotspot of greenery and biodiversity. We planted 2,000 trees of 50 species in the eco park, which have now grown from 3 feet to 20 feet. The park has fruit trees like guava, java plum, jackfruit and some others. Trees were purchased from the Department of Forestry. Sanjay Kumar, Regional Environment Manager, Piparwar Circle, CCL, told Mongabay-India.

Land reclamation, reclamation, and restoration work in a mining area includes the return of mined land to a useful form, but is not always a one-off. It consists of backfilling the rock in the quarry to the original ground, spreading the topsoil, and cultivating the reclaimed land. It also involves the development of ponds due to some areas not being filled.

The rehabilitation and restoration process also includes implementing mitigation measures to improve land degraded by mining operations and return it to an acceptable environmental state. According to CCL, the development of an ecological park and agricultural activities are part of the overall restoration process.

Mohammad Abbas, 28, from a neighboring village of Bahera in the same district, also praised the project. “We have lived in this area for a few years now and have witnessed the scene of overloaded coal trucks leading to smog and pollution. It's much greener now. We used to spend hours inside the park with tall trees and concrete benches to sit on. We usually bring guests here whenever they visit our home,” officials said.

Fig 5.3 Top view of the Piparwar Opencast Coal Mine.

5.1.2 Can an Eco-park be part of the Reclamation Process?

Although CCL prides itself on the development of an eco-park, experts disagree on whether it should be considered part of the restoration process.

"It would be better if they turned the reclaimed land into a full biodiversity hotspot with minimal human access like a forest that only allows bird and animal viewing with guided tours like in the forest without changing the landscape," says Jayanta Bhattacharya. , Chair, Environmental Science and Engineering, Faculty Committee, IIT (Indian Institute of Technology) Kharagpur.

“Public activities should not be allowed and biodiversity should be left completely alone to develop. In some areas, a corridor should also be built for animals. Their initiative (eco-park) is like an entertainment place. When returning cleared land, it should also be remembered that the area has to be more or less unchanged and the species will be reintroduced there,” Bhattacharya told Mongabay-India.

“Farmers are now growing wheat and corn on a small portion of reclaimed land, which has given them a new livelihood. The three bodies of water serve as a source of water for agricultural lands and ecological parks. “We will also reclaim the entire land where surface mining has been stopped and turn it into an eco-friendly area,” said Anupam Kumar Rana, head of the government's public relations department. Adoption of such initiatives has been welcomed from all sides.” CCL.

5.1.3 Environmentalists caution against unplanned reclamation processes.

Environmentalists have said that cultivation may not yield the desired results if the plants are imported from outside, as they will not be able to adapt to local conditions. "It's the survival of the strongest in these areas," he added.

Concurring with a similar view, local forest department officials also said CCL needs to be aware of a few things regarding the eco-park and all reclaimed land where reforestation is taking place.

Plantations made to date include species such as jackfruit, Syzygium cumini (Jamun in India), gooseberries, tamarind, Bel berries and mahua among others.

“It would be better if CCL carried out the reforestation in close cooperation with the forest ranger. Chotte Lal Shah, Tandwa Range Forest Manager (in Piparwar) at Jharkhand Forestry Department said, we will give suggestions for them to plant better.

Shah pointed out that "only Kayakalp Vatika and tree planting is not enough" and "CCL should create a green belt around the area to ensure that people living in nearby villages are not affected by pollution" .

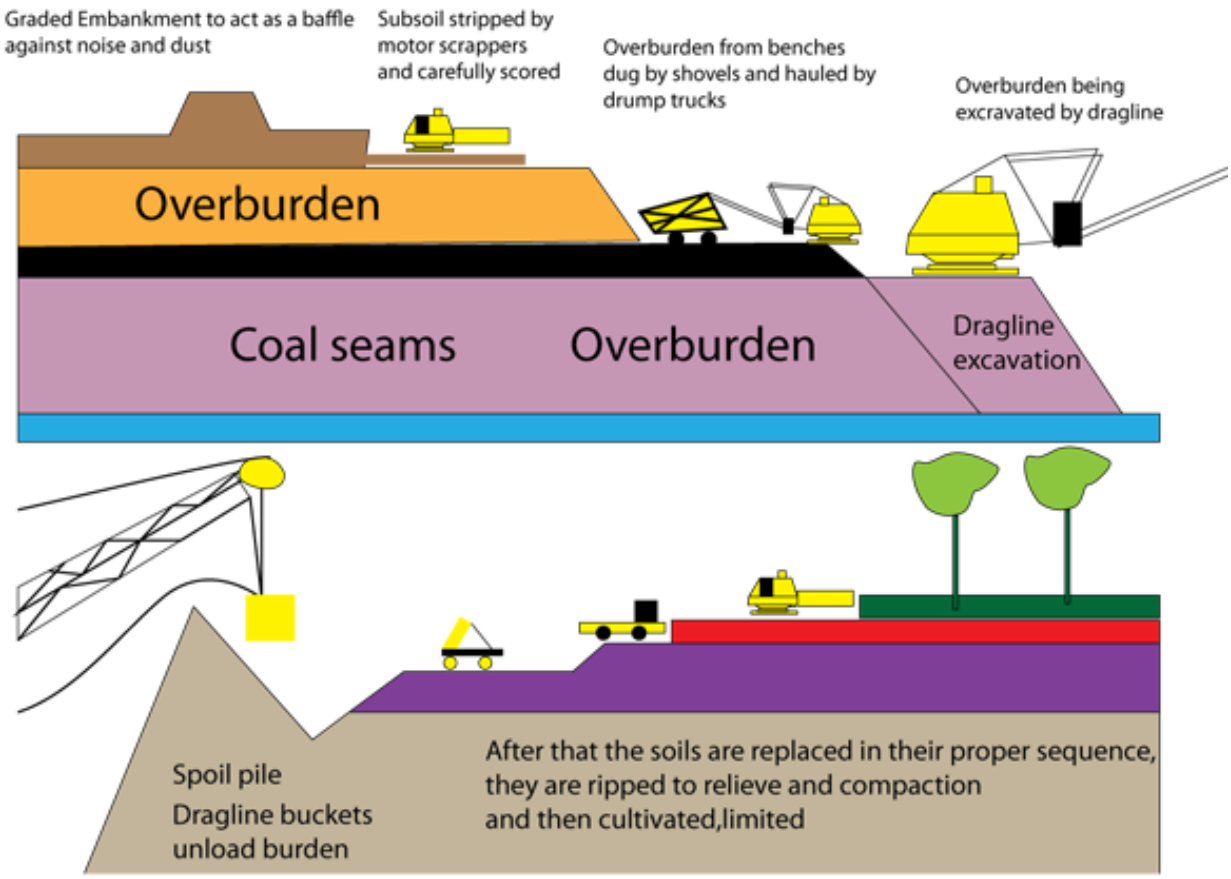


Fig 5.4 Conceptual Section of an Opencast Coal Mine.

5.2 Reclamation of Bisrampur Colliery, Chhattisgarh

Coal mining by surface mining method leads to ecological imbalance. Coal is the main source of supply for many industries. However, industrial growth is essential to meet the basic needs and certain amenities of our growing population. It is undesirable or even impossible to completely ban industrialization and abandon the fruits of technology at this stage of economic development, what is really needed is the development of techniques for environmental management and adapt eco-friendly equipment to cause as little damage as possible. environment when performing development activities.

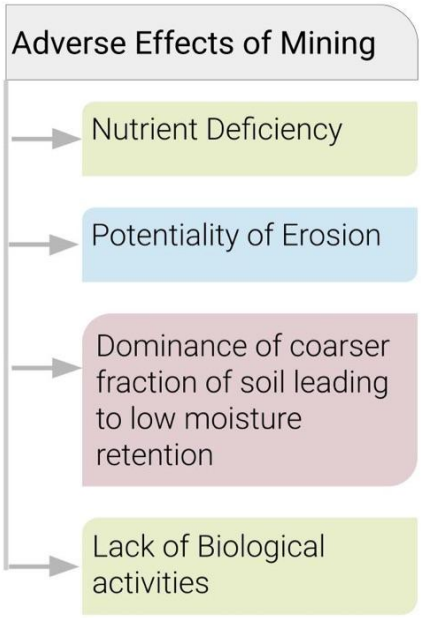


Fig 5.5 Adverse Effects of Mining.

The main problems in reclamation of mined soils are lack of nutrients, possibility of erosion, predominance of coarser fraction resulting in low moisture holding capacity and lack of biological activities. Therefore, restoration measures will necessarily include:

(a) Site assessment

- Assessment of the problem.
- Characteristic of the site-type of dumps, methodology of mining used, and status of
- Abandoned land, slope, etc.
- Major constituents of the spoils.
- Native species occurrence.

(b) Making the area conducive to supporting life system sustainably

- Use of conservation methods for increasing water regime.
- Provide facilities for habitat development and organic production.
- Use of suitable amendments and boosters for providing initial backup.
- Establishment of grasses and herbs followed by shrubs and trees.

(c) Technological inputs for sustainable utilization

- Selection of species in harmony with the site condition.
- Maintenance of biodiversity.
- Sustained productivity in relation to people's demand for fuelwood, fodder and fiber.
- Soil improvement in view of future management.

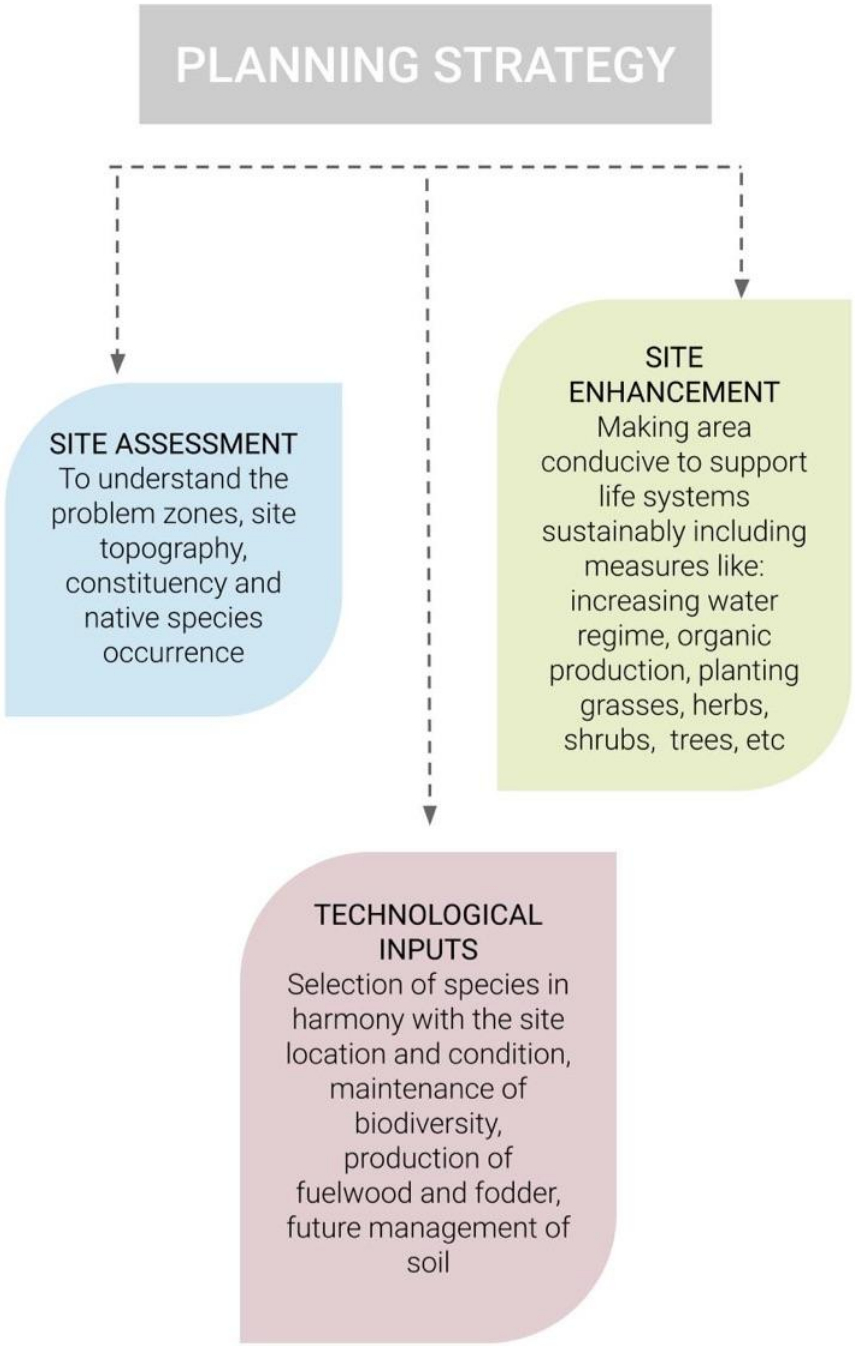


Fig 5.6 Planning Strategy.

5.2.1 How reclamation was planned?

Coal mines have a 2:1 extraction ratio (OverBurden:ore) and open pit mining is adopted in India down to a depth of 200 meters. In the coming years, coal mines with a removal ratio of up to 7:1 and extending to a maximum depth of 480 meters are expected to be exploited. In the coming years, India will have to manage 1150 million cubic meters of coal overload per year to produce the expected 230 million tons of coal from surface mining. The physical nature of the waste is often unfavorable for plant growth; Mining areas are often barren, barren, with no vegetation and no topsoil to support vegetation. Surface stabilization of barren land is extremely important in a reclamation program, especially where waste is good, conditions are arid, and there is a potential for erosion. Vegetation is the only way to achieve long-term stability.

5.2.2 Rehabilitation Strategy

The original land was lost and an ecosystem was created on the waste or underground; It seems very unlikely that the rehabilitation process could produce a self-sustaining ecosystem in a relatively short time. During surface extraction, several changes occur in the physical, chemical and microbiological properties of the soil (Kundu and Ghose 1998). Destruction of soil properties leads to reduced yield.

Due to the very slow rate of natural succession, the planting of tree species is a suitable option for developing vegetative cover in a relatively short time. Selection of species suitable for mass planting on cover soil 14 species - Acacia acacia, Acacia catechu, Acacia farnesiana, Acacia leucophloea, Acacia mangium, Acacia nilotica, Acacia Senegal, Albizia lebbeck, Albizia procera, Cassia Siamea, Dalbergia sissoo , Gmelina arborea, Pithecellobium dulce and Pongamia pinnata were seeded in a potted culture experiment using field mulch. Based on the growth ability of different tree species, 10 species were selected for the trial, namely Acacia catechu, Acacia leucophloea, Acacia nilotica, Dalbergia sissoo, Pithecellobium dulce Pongamia pinnata and one non-nitrogen fixed plant. Gmelina arborea. In the group of suitable tree species, native species are prioritized for planting. However, these species do not necessarily have the settlement properties required for germination and establishment in heavily degraded areas. For this reason, suitable exotic species can be used to initiate nutrient cycles and establish slopes. Nitrogen-fixing species have the added benefit of being able to use atmospheric nitrogen as a source of nutrients. This adds

to biomass production and ultimately. In the present study, it was observed that Acacia mangium, an exotic species, performed very well on all growth parameters. Simultaneous increases in maximum nitrogen availability were observed under Acacia mangium and minimal levels under Gmelina arborea. On the other hand, phosphorus assimilation was highest in Dalbergia sissoo and Pithecellobium dulce and minimal in Acacia catechu. The increases in available potassium, with the exception of P. dulce, D. sissoo and A. procera, were insignificant.

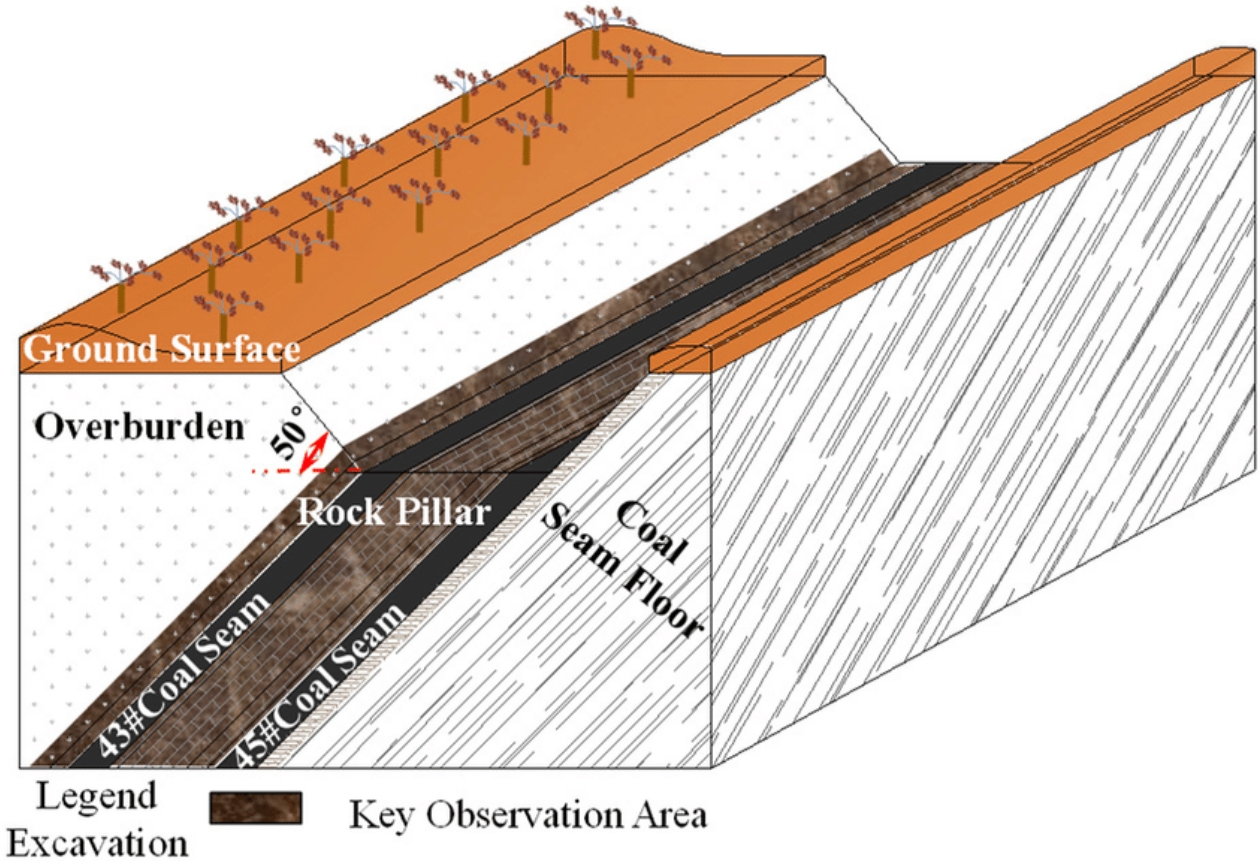


Fig 5.7 Conceptual Section of an Opencast Coal Mine.

5.2.3 Site Study

The Bisrampur mine in Chhattisgarh's Surguja district is the capital of coal production and lies between 23° 10' 05' ' to 23° 13' 30" latitude and 83° 57' 30' ' to 83° 01' 05" longitude. The terrain of the area is undulating and the main drainage of the block is through the Passang

naala which flows westward and forms a tributary of the Rehar River. Minimum and maximum altitudes range from 500 m to 540 m above sea level. rainfall was 1240 mm and maximum and minimum temperatures were recorded at 32°C and 16°C, respectively. Bisrampur has a coal measure stretching about 400 square miles in the eastern part of the relatively lowland in central Surguja district. Surguja is very generally described as an isolated basin crossed by huge hedges of hills to the north, east, and south, and protected from access to the west by the forest cover of Korea. In central Surguja, this metamorphic formation gave way to the Lower Carboniferous of the Bisrampur Coal Basin, and this was once again replaced further west by coarse sandstone, killing the evolved metamorphic rocks. born here and there. The natural vegetation of this area is tropical dry deciduous trees and is predominately Sal (Shorea robusta) abundant everywhere. There are tigers, leopards, bears, buffalo, bison and many species of deer.

5.2.4 Conclusion and recommendations

Mining land recovery is site specific. The unique properties of each litter determine the extent to which vegetation is established within the constraints of the local climate. Obtaining the right ground cover may require modification of physical and chemical properties. To develop a restoration program for biological reclamation of depleted areas of the Bisrampur Coal Mine, potted culture experiments (under controlled laboratory conditions) were conducted with cover material. for suitable plant species, organic and inorganic substances to stimulate growth. of plant species. The results obtained from the potted culture experiments were translated into the field. The reclamation experiment was conducted on an area of 13 hectares. from landfill No. 3 of the Bisrampur mine in 1993. The results obtained from the various experiments provided a suitable technological package for the biological restoration of cuttings.

CHAPTER 6

CHAPTER 6: ENVIRONMENT POLICIES

6.1 Environmental Impact Assessment (EIA)

6.1.1 Introduction

EIA identifies or evaluates the potential, beneficial and adverse impact of the coal mines project development on the environment. EIA is a systematic evaluation of the potential impacts of coal mines projects, on legislation action relative to the total environment. EIA with an objective to analyze the probable changes in the physical, biophysical and socio-economic environment of the proposed project. The prediction and evaluation of the environmental consequences enable the planner to plan better to avoid irreparable damage to the environment and ensure sustainable development. Coal is one of the most principle minerals known to be a fossil fuel. It is an organic rock which contains mostly carbon, but also hydrogen, sulfur, oxygen as well some inorganic minerals and water. Coal mining has adverse impacts on land, air, water, biodiversity, loss of livelihoods etc. due to displacement and encroachment of land. EIA is an important procedure for ensuring that the likely effects of new development on the environment are fully understood and taken into account before the development is allowed to go ahead.

Coal is a non-renewable fossil fuel Formed from the remains of plants that lived and died about 100 to 400 million years ago. Depth, thickness, and configuration of mineral resources decide the selection of mining technology (open cast or underground).Minerals exploitation progresses through four stages: Prospecting means search for deposits. Exploration: Once the deposit is assured, this is done to assess the size, shape, location and economic value of the deposit. Development - Work of preparing access to the deposit so that the coal can be extracted Exploitation Means extraction of coal. Depending on the content of volatiles, coal is classified into Lignite, Sub-bituminous coal, Bituminous coal and Anthracite. Open cast mining and underground mining (room pillar, long wall, drift, shaft, slope mining) are some types of coal mining. Proper Environment impact assessment of coal mining is very important and here we take some issues which should be considered and some mitigation measures are discussed.

6.1.2 Procedure of EIA

EIA is a systematic process that examines the environmental consequences of the developmental action in advance. The emphasis of EIA is on the prevention through continuous monitoring of air, water, vegetation, land & people of the surrounding area of the proposed project. The EIA process involves a set of steps given as follows:

1. Screening of impacts.
2. Scoping & consideration of alternatives.
3. Baseline data collection.
4. Impact prediction.
5. Environmental management plan (EMP).
6. Decision making.
7. Monitoring of air, water, noise, biodiversity, social etc seasonally and annually.
8. Assessment of alternates.
9. Public hearing.
10. Secondary data collection for air, water, noise, vehicle, social etc.

6.1.3 EIA Rules and Regulations

1. Mineral concession rules 1960 - The mineral concession rule (MCR) outlines the procedures and mining lease. The rules also stipulate that a mining plan shall incorporate, among others, a plan of the area indicating water source, limits of forest areas, density of trees, impact of mining activities, etc control devices and such measures as may be directed by concerned central and state government agencies.
2. Mineral conservation and development rules 1988 - The MCDR lay down guidelines for ensuring mining or a scientific basis, while conserving that environment at the same time. The MCDR also governs the specification in terms of submission and reporting in case of reconnaission, operations, prospecting or applying for a mining plan.
3. Environmental legislation- Environmental legislation covers many areas including comprehensive environmental impact analysis to insure that projects that are ecologically destructive are not allowed, identification of no-go areas, specific

forests and wildlife to protect by biodiversity and regulation governing mine closure and mine restoration. There are five main environmental acts, which impact mining industries in India.

i. The water (prevention and control of pollution) Act, 1974.
ii. The Air (prevention and control of pollution) Act 1981.
iii. The Environment (protection) Act, 1986.(with rules 1986 and 1987) (EPA).
iv. The Forest (conservation) Act 1980 (amended in 1988).
v. The Wildlife (protection) Act 1972(amended in 1991) .

4. ISO 14000:2008- ISO 14000 is actually a series of international standards on environmental management. It provides a framework for the development of both the system and the supporting audit program. This offers guidelines for quality and /or Environmental management system auditing. It supersedes a number of standards including ISO 14001, 14004, 19011, 14010, 14012.
5. BIS: The erstwhile Indian Standards Institution (ISI) was established in 1947 (now bureau of Indian standard) with the objectives of harmonious development of standardization activities in India. It includes IS 9679: 1980, IS 10245:1982, IS 14489:1998, IS 15793:2007, IS 18001:2007, IS 13624:1993, IS 13969:1994, IS 14476:1998, IS 6748(part-1):1973, IS 1583:2008 etc. are some of IS for environmental related monitoring and its accurate measurement to avoid any error at international forum.

6.1.4 EIA Methodology

A. Assessment of Land Environment

The impacts on land environment would be in the form of temporary or permanent change in land use pattern as well as direct and indirect impacts on surrounding land due to pollution discharge, so in such cases the EIA of soil or land the proper collection and assessment of representative soil samples, and assessment of productivity and fertility of representative soil within the study area.

B. Assessment of Noise Environment

Studies pertaining to noise environment where conducted as follows

i. Reconnaissance.
ii. Identification and characterization of noise source.

iii. Measurement of baseline noise level in the study area.
iv. Measurement of prevailing noise levels due to vehicular Movements.
v. Stabilizing existing status of noise levels in residential, Commercial, industrial areas and silence zones within the Mining zone.

C. Assessment of Land Environment

A methodologically designed air quality surveillance program (AQSE) was adopted as the basis to determine the impact assessment of the air environment. The basic considerations for EIA of air environment include –

i. Representative selection of sampling location primarily guided by the topography and micro-meteorology of the region.
ii. Adequate sampling frequency.
iii. Monitoring of the index pollutants.
iv. Proper and careful collection of surfaces.
v. Meteorological data like wind speed, wind direction, Relative Humidity, Rainfall, Atmospheric, Temperature etc.
vi. Proper management of measurement of 24 hours.
vii. Average concentrations of SO2, NOx, HC, SPM, RSPM, PM10 & PM2.5 etc parameters.

D. Assessment of Water Environment

For the proper assessment of EIA on water environment is conducted as-

i. Proper collection of surface as well as ground water for determining the quality of water within the study area.
ii. Proper assessment of planktonic environment (phytoplankton & zooplankton) of enumeration, indices and distribution of rivers and ponds.
iii. Proper and careful data collection of water quality parameters which if found within the study area.

E. Assessment of Social Environment

Social environment assessment can be monitored through studying the social status around the coal mining project annually. This can be done through door to door surveys on the basis of evaluating matrices based on the social amenities and resources and effectiveness of the proposed project. Public response through meeting, awareness camp and questionnaire survey. The quality of life must be

evaluated annually and assessed in context of local, regional and national level. This helps in up gradation and improvement of in and around environmental conditions of coal mining projects.

6.1.5 EIA Constraints

The process of EIA and criteria to identify constraints to development of project area has been designed below.

1. Land use policies and resource management initiatives that pertain to the project.
2. Abnormal traditional land use.
3. All known trap lines.
4. The environmental setting.
5. Cumulative environmental impacts of the region.
6. Cumulative social impact of the region.
7. Results of projects specific or regional monitoring.
8. Potential for new or additional technology to increase resource recovery at a later time.
9. Potential for changes in the regulatory regime.
10. Possibility of lack of complete monitoring and compliance of EC conditions no cross check system to validate the monitoring.
11. For the EIA process conducting there is no good technical evaluation, measuring the quality of EIA reports, reliable baseline secondary environmental data of that area.

6.1.6 EIA Economics

The process of EIA is to perform seasonally, annually and wisely in accordance with environmental components. This has to be reviewed and evaluated by outside agencies and scrutinized intensively for continuous improvement process and maximum benefits to the coal mining project surroundings. An approximate expenses cost of Rs: 6-18 lacks annually to perform this study depending upon the project size and area to be covered with environmental components included for EIA.

6.1.6 EIA Future Scope

EIA is having a very useful practice in the upcoming future because the developing countries are progressive towards a harmful and less health supporting future. The life sustaining measures are mostly required which can only be recovered by EIA.

The EIA report shall be prepared considering applicable regional and national legislations, code of practice, guidelines, policies, standard and directives. As it was introduced in 1994 where it relied on an institutional framework that has a strong supportive legislative, administrative and procedural setup.

6.1.7 EIA Conclusion

In order to save our ecosystem it is very necessary to have well planned mining thus, EIA plays a vital role in these situations. It tells how to exploit the coal for humans wisely, thus EIA has a great impact on a country's development. It has been recognized that India is well in adopting legal provisions, which are very essential for the future. Strengthening of the EIA process thus, further recommended project level EIA needs immediate attention but efforts should also be targeted. Such an initiative could help in filling up the gaps and co-ordination between various governments authorities planning and execution of the coal mine in our country.

6.2 Environment Management Plan

6.2.1 Mitigation and Environment management plan

EMP is a framework for the implementation and execution of mitigation measures and alternatives. Ideally EMP should covers all phases of project development i.e. Preconstruction, Operation of mine and Decommissioning of the mine. It is a Documented plan Containing details of impacts, recommended mitigation and monitoring measures etc and Legal document based on which the performance is monitored.

1. Top soil management - The best practices for topsoil management is toScrap the topsoil prior to drilling and blasting, Scraped topsoil should be used immediately for plantation/agriculture, If it is not possible to use the topsoil immediately, then it should be stacked at a designated area, Storage must be done in a pyramidal form, with garland drains all around.
2. Overburden management - If an external overburden dump is unavoidable, then it should be stabilized with biological reclamation .Excavation from a new pit should begin after an existing pit has been exhausted. This would ensure that the overburden and interburden generated is used for backfilling the exhausted pit, instead of being dumped elsewhere.Till a pit is exhausted, the overburden should be compacted and stacked in specific locations in low lying, non-mineralized zones within the lease area.Vegetation should be planted over the dump slopes as early as possible.The height and slope of the overburden dumps should be maintained to prevent slope failure.Sedimentation tanks should be constructed to treat run-off from external overburden dumps. For external overburden dumps, the bench height should not exceed 10 meters and the final dump height should not be more than 60 meters. For Gondwana period rock strata, the slope should not exceed 28 degrees.
3. Subsidence management - Planned subsidence by considering surface structures and human lives, as in the case of long-wall mining. Preparation of a subsidence management plan and its approval by the regulatory agency. The plan should ensure the following:Simultaneous stowing of the de-coaled area. Compensation to and rehabilitation of the affected people. Fencing of

the subsidence zone during active mining operation to prevent unintended entry into the affected area. Reclaiming the subsided area by afforestation. Regular monitoring and inspection of subsidence areas to detect any subsidence and taking the necessary steps.Preparing a subsidence monitoring programme that covers the impact of subsidence on surface and groundwater (quality and quantity) and its management.

4. Management of water pollution - Use of mine seepage water (after treatment) for different purposes, Construction of gabion wall, garland drain, siltation pond, wherever appropriate and Coal stockpiles, overburden and topsoil should be selectively placed in a stable area which is less prone to erosion.
5. Mitigation measures for air pollution – Fixed and mobile water spraying on the haulage roads. Asphalting of the road junction meeting public roads. Covering of the trucks carrying ore with tarpaulin. Wheel wash system. 9 inch free board for all the trucks. Green belt around the mining area as a physical barrier.
6. Mitigation of noise and vibration – Use of closed and advanced blasting technology like shock tube technology Conducting blast only during day time, use of hydraulic drills and provision of sound insulated chambers for workers deployed on machines producing higher levels of noise like bulldozers, drills etc.

   Enclosing crusher units in covered buildings to minimize sound propagation. Providing silencers or enclosures for noise generating machines such DG sets, compressors etc.

   Creating a green belt around potential noise prone areas and provision of protective devices like earmuffs/earplugs to workers, who are exposed to high levels of noise and reducing the exposure time of workers by practicing worker rotation.
7. Mine closure plan - A good mine closure plan should include the following:A detailed final closure plan to create productive and sustainable land use,The plan must be accepted by mine owners, regulating agencies, and local communities, A plan to protect the health and safety of the surrounding

habitat and A plan to eliminate/contain all possible sources of pollution post-mining.

Dust Collection Efficiency	Plant Species		
	Herbs	Shrubs	Trees
Low <10%	1.*Amaranthus hypchondriceus* (Chaulai) 2. *Gardenia jasminoides* (Crape Jasmine) 3. *Cestrum nocturmum* (Rat Ki Rani) 4. *Chrysanthamum species* (Crown Daisy)	1.*Thuja species* (Moyur Pankhi) 2.*Ravuvoifia serpentine* (Serpgandha) 3.*Withania somnifera* (Ashawagandha) 4.*Acanthus species* (Acanthus)	1.*Nyctanthese arbortritis* (Harsingar) 2.*Abis pindrow* (Silver fire) 3. *Accacia nelotica* (Babool) 4.*Holarrhena antidysentrica* (Kurchi) 5. *Clerodenrum inerme* (Glorry bower) 6. *Ficus bengalensis* (Banyan) 7.*Miliusa tomentosa* (Kari Leaves) 8.*Thespesia populania* (Ran Bhindi)

Table 6.1 Plant species for the revival of the environment. Dust Collection Efficiency based Low, Moderate & High Dust Capturing Herbs, Shrubs and Trees.

6.3 Compliance report of Padmapur OpenCast Mine against Environmental Clearance.

Table 6.2 Specific conditions of Environmental Clearance.

S. No.	ENVIRONMENTAL CLARANCE CONDITIONS / DETAILS	COMPLIANCE
i.	Top Soil, if any shall be stacked properly with proper slope at earmarked site(s) and shall be kept active and shall be used within One Year of the generation for reclamation and development of green Belt.	Top soil Excavated has already been used for carpeting dead OB Dumps viz; 3, 4, 5, & 6 which have been shown in the enclosed plan. All these OB Dumps have been biologically reclaimed & vegetation grown has become self sustaining. At present top soil is being concurrently sprayed over dump 8.
ii.	Of the Total 42.084 M.M^3 of Overburden generated over the Balance Life of the Mine, 18.60 M.M^3 of the OB would be stored in the Balance Area of 44.097 Hectares in ex OB Dump Area of 206.387 Hectares, which shall be Biologically Reclaimed using a Mix of Native Species. The Ultimate Slope of the Active Dumps shall not exceed 28 ^{0}. Monitoring & Management of reclaimed Dump Sites shall continue until the vegetation in all the dumps becomes self-sustaining. Compliance Status shall be submitted to the Ministry of Environment & Forests and its Regional Office located at Bhopal on Yearly Basis.	FOR THE PERIOD FROM **01.10.2021 To 31.03.2022** **EXTERNAL OB DUMP.** **QUANTITY. : NIL** **AREA : NIL** **BACKFILLING** **QUANTITY. : 0.249 M. M ^{3}** **AREA : 2.35 Ha** Active Dump Slopes Being Maintained As Per Norms. The Area & Quantity against Backfilling & External Dumps are measured Quarterly, with records thereof being maintained in a Bound Paged Book.
iii.	Catch Drains and Siltation Ponds of appropriate sizes shall be constructed to arrest silt and sediments flows from Soil, OB & Mineral Dumps. The water so collected shall be utilized for watering the Mine Are, Roads, Green Belt Development etc. The Drains shall be regularly de-silted and maintained properly. The Garland Drains (Size, Gradient & Length) and Sump Capacity shall be designed keeping 50% Safety Margin over and above the peak sudden rainfall and maximum discharge adjoining the Mine Site. Sump Capacity shall also provide adequate retention period to allow proper settling of Silt Material.	Catch drain (2 mtr x 2mtr)around OB Dump with length of 1650 m has been constructed for arresting silt / flows from OB Dump. Similarly sedimentation pond (26 mtr x 16.50 mtr x 2.40 mtr) for arresting sediments coming with mine pumped out water has also been put into operation. The pumped out water is made to pass through the sedimentation pond & clear water is used for watering plants, roads. Garland drain having length of 700 m around Sector-III quarry has already been constructed. The catch drain mentioned above serves the purpose of garland drains for external OB Dumps.
iv.	The Dimensions of the Retaining Wall at the Toe of the Dumps and at Benches within the mine. Check Run-Off and Siltation shall be based on the Rainfall Data.	As indicated above, the run –off from the OB Dumps are collected in the catch drains made around the periphery of the dumps & run off from OB Benches is collected in garland drains around quarry which caters to peak rainfall & as such construction of retaining wall at the toe of the dumps & OB benches is not required.
v.	Drills shall be Wet Operated Only.	YES. Total of 04 nos of drills are in operation and all are fitted with dust extractors and are wet operated.
vi.	Controlled Blasting shall be practiced with use of Delay Detonators. The Mitigating Measures for control of Ground Vibrations and to arrest the Fly Rocks and Boulders shall be implemented.	Controlled Blasting Being Practiced, with Use Of Delay Detonators and Ground Vibration being monitored on regular basis.

S. No.	ENVIRONMENTAL CLARANCE CONDITIONS / DETAILS	COMPLIANCE
vii.	Water Sprinkling System (Mist Spray Type) to check Fugitive Emissions from Crushing Operations, Conveyor System / Rope-way, Haulage Roads, Transfer Points etc. shall be installed and operated effectively at all times of operations.	All Working Places are being water sprinkled daily. 36 nos . mist sprays perforations is provided in CHP to control dust emission. 15 nos. of sprinkler provided on coal transportation road and spraying of water vthrough mobile water (departmentally) done daily over Haul roads and Coal Transportation Road. 2 Nos of Mobile water tanker deployed.
viii.	An Area not less than 290.472 Hectares shall be brought under Afforestation, which includes Reclaimed External OB Dumps (162.290 Hectares), Back-filled Area (93.862 Hectares) along the Mine Lease Boundary, along Roads & Infrastructure, Embankment, Green Belt, Danger Zone and Area for rationalization area within the Lease and within the Township by planting native species in consultation with the local DFO / Agriculture Department. The density of the trees shall be around 2500 Plants / Hectare.	OB Dump excavated from the quarry area has been dumped on the surface & the locations of the dumps have been shown in enclosed plan. Total of 833030.00 no of plantation done on 217.8 Ha of land. Out of this 6.00 Ha Plantation has been done in backfilled area and rest plantation done on OB dumps along road and infrastructure, Embankment etc. Species planted includes Peltafarm, Gulmohar, Karanj, Shisoo, Neem, Acacia, Mango etc.
ix.	A Progressive Mine Closure Plan shall be implemented for management of Quarry Area of 147.100 Hectares, out of which 93.862 Hectares shall be back-filled and maintained by Planting native species, in consultation with the local DFO / Agriculture Department. The density of the trees shall be around 2500 Plants per Hectare. The Balance 53.238 Hectares of the De-Coaled land, which is being converted into a Water Reservoir, shall be gently sloped along the upper benches, terraced and reclaimed with plantation. The outer periphery of the Water Reservoir shall be fenced.	Progressive Mine Closure activities are carried out on regular basis. Backfilled quantity for last five years is as follows: 2013-14 — 0.554 2014-15 — 0.515 2015-16 — 0.949 2016-17 — 2.757 2017-18 — 0.300 2018-19 — 2.784 2019-20 — 2.567 2020-21 — 2.392 2021-22 — 1.138 The de-coaled void which is to be converted into a water reservoir would be carried out at the closure of mine. Presently the mine is active and working.
x.	The Company shall not use Groundwater for the Mining Operations.	No groundwater is used for mining
xi.	ETP of Adequate Capacity for the expansion project shall also be provided for workshop and CHP wastewater.	ETP of capacity 150 KLPD already Provided & being maintained in Proper working order.
xii.	Besides carrying out regular periodic health check of the workers, 10% of the manpower identified from the workforce engaged in active mining operations shall be subjected for Check Up of Occupational Diseases and Hearing Impairments, if any at NIOH Ahmadabad and the relevant reports shall be sent to the DGMS.	Being Complied.
xiii.	A Final Mine Closure Plan along with the details of Corpus Fund shall be submitted to the Ministry of Environment and Forests and its Regional office at Bhopal.	Mine closure Plan has been approved by Board on 06.02.2014 and Escrow account was opened. Details of A/C are as follows: A/c No. 8973161003314 New A/c No. 0897107600000859 Amount: Rs 73,99,77,176.00 (as on 31.03.2022) However Final Mine Closure is not envisaged at present. Moreover the present quarry limit is likely to extend further in the dip side resulting in further increase in life of mine.

Table 6.3 General conditions of Environmental Clearance.

S. No.	ENVIRONMENTAL CLARANCE CONDITIONS / DETAILS	COMPLIANCE
i.	No Change in Mining Technology and scope of working shall be made without the prior approval of the Ministry of Environment and Forests.	Mining is opencast by mechanized method involving shovel dumper as per approved given in FC.
ii.	No Change in the Calendar Plan including Excavation, Quantum of Mineral Coal and Waste shall be made.	NOTED
iii.	Four Ambient Air Quality Monitoring Stations shall be established in the core zone as well as in the buffer zone for RPM, SPM, SO2, NOx & CO monitoring. Location of the stations should be decided based on the meteorological data, topographical features, and environmentally and ecologically sensitive targets in consultation with the State Pollution Control Board. In addition, Heavy Metals, such as Hg, Pb, Cr, As etc. from the SPM / RSPM shall be monitored at least twice in a year. The Data thereof shall be recorded properly.	There are four numbers of ambient air Monitoring stations already established, namely: a. Manager Office, Quarry IV - Core zone. b. Warwat Village. c. Kitadi Village - Buffer zone. d. Vichoda Rayatwari Village. These stations have been established as per meteorological data & in consultation with MPCB. The Ambient Air Quality monitored at these stations is as per the Environment Protection (Amendment) Rules - 2000.
iv.	Water Spraying Arrangements on Haul Roads, Wagon Loading, Dump Trucks, Loading & Unloading Points shall be provided and properly maintained.	BEING PROVIDED & MAINTAINED AT ALL THE WORKING PLACES as 36 nos. mist sprays is provided in CHP to control dust emission. 15 nos. of sprinkler provided in coal transportation road and spraying of water through mobile water departmentally) is done on regular basis. 2 no. of Mobile tankers deployed.
v.	Data on ambient air quality (RPM, RSPM, SO2, NOx, CO) shall be regularly submitted to the Ministry including its regional office at Bhopal and the States Pollution Control Board / Central Pollution Control Board once in six months.	The data on ambient air quality are regularly submitted to MPCB & MOEF, Regional Office-Bhopal on Quarterly basis. Report for **October-2021 to March-2022** are enclosed as Annexure – IV.

S. No.	ENVIRONMENTAL CLARANCE CONDITIONS / DETAILS	COMPLIANCE
vi.	Adequate measures shall be taken for control of noise level below 85 dBA in the work environment. Workers engaged in blasting and Drilling Operations, Operations of HEMM etc. should be provided with ear plugs / muffs.	In order to control excessive noise during operations regular maintenance of all HEMM as well as supply of protective gears namely, Ear plugs & muffs are carried out. In addition, regular monitoring on every fortnight is being done as per environment protection amendment rule 2000 & data recorded & submitted as quarterly report & the results are within permissible limits.
vii.	Industrial waste water (workshop and waste water from mine) shall be properly collected / treated so as to confirm to the standards prescribed under GSR 422 (E) dated 19 May 1993 and 31st December 1993 or as amended from time to time. Oil and grease trap should be installed before discharge of workshop effluents.	Workshop ETP of 150 KLPD capacity is in operation with pre-settling tank, drain, oil & grease trap, sedimentation tank & clear water tank. The treated effluent is reused for washing of HEMM & there is no discharge of effluent to outside Nallah. Mine discharge water is made to pass through sedimentation pond before being let to outside Nallah. Regular water quality monitoring is carried out by CMPDIL on behalf of WCL & by MPCB. as per Environment Protection Rules - 2000 of MoEF.
viii.	Vehicular Emissions shall be kept under control and regularly monitored. Vehicles used for transporting the mineral shall be covered with Tarpaulin and optimally loaded.	BEING IMPLEMENTED.

<table>
<tr><th>S. No.</th><th>ENVIRONMENTAL CLARANCE CONDITIONS / DETAILS</th><th>COMPLIANCE</th></tr>
<tr><td>ix.</td><td>The Environmental Quality Parameters shall be got analyzed from the recognized Environmental Laboratory or shall be established with adequate number and type of Pollution Monitoring and Analysis Equipment in consultation with the State Pollution Control Board.</td><td>A full-fledged Environmental Laboratory (An ISO - 9000 : 2008 Certified) already exists at CMPDIL Nagpur with qualified multi-disciplinary team of engineers along with adequate number of field staff for carrying out all the environmental monitoring of all WCL projects including this project.</td></tr>
<tr><td>x.</td><td>Personnel working in dusty areas shall wear protective respiratory devices and they shall also be provided with adequate training and information on Safety and Health Aspects.</td><td>Protective health & safety gears are provided to workmen exposed to dust, namely, Dust mask, Helmets, Safety Boots, and Goggles as per DGMS specifications. The workers are regularly given training on safety & health aspects (Statutory requirement under mines act).
Approx. 223 workers of Padmapur OCP are sent for Periodical Medical Examination every year under Health Surveillance Programme. The same is repeated every 5 years.
<table>
<tr><th>Year</th><th>Departmental Employee</th></tr>
<tr><td>2016</td><td>325</td></tr>
<tr><td>2017</td><td>298</td></tr>
<tr><td>2018</td><td>305</td></tr>
<tr><td>2019</td><td>186</td></tr>
<tr><td>2020</td><td>265</td></tr>
<tr><td>2021</td><td>47</td></tr>
</table></td></tr>
<tr><td>xi.</td><td>A separate environmental management cell with suitable qualified personnel shall be set up under the control of Executive, who will report directly to the head of the organization.</td><td>At project level, Environmental management cell is headed by Sub Area Manager & is assisted directly by Project Nodal Officer (ENV) / Sr. Manager (Civil). At Area level, General Manager (Operation) heads the cell assisted by Area Nodal Officer (ENV). At WCL HQ / Corporate level the General Manager(Environment) heads the environment department assisted by multi disciplinary team of qualified & trained engineers.</td></tr>
<tr><td>xii.</td><td>The funds earmarked for environmental protection measures should be kept in separate account and should not be diverted for other purposes. Year wise expenditure should be reported to the ministry and its regional office located at Bhopal.</td><td>The funds earmarked for environmental protection measures are kept separate & are not used for any other purpose. The expenditure under capital head till date & under revenue head for current year as well as progressive has been given earlier in this report. (Part - III)</td></tr>
</table>

S. No.	ENVIRONMENTAL CLARANCE CONDITIONS / DETAILS	COMPLIANCE
xiii.	The regional office of this ministry located at Bhopal shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer(s) of the Regional office by furnishing the requisite data /information/ monitoring reports.	Full co-operation from project authorities will be extended to officers of Environment Ministry, Bhopal, by furnishing the Requisite Data / Information / Monitoring Reports.
xiv.	A copy of clearance letter will be marked to concerned panchayat / local NGO, if any, from whom any suggestion / representation has been received while processing the proposal.	A copy of clearance letter is submitted to Sarpanch of Padmapur Gram Panchayat vide Letter No. WCL / CHA / CGM / ENV / 1051 / 1773, Dated : 02.08.2009.
xv.	State Pollution Control Board shall display a copy of the clearance letter at the regional office, district industry centre and Collector Office / Tahsildar's office for 30 days.	EC submitted to S.R.O., MPCB, vide Letter No. : WCL / CHA / CGM / ANO /ENV / 1050 / 4589, Dated : 03.08.2009.
xvi.	The project authorities shall advertise at least in two local newspapers widely circulated around the project, one of which shall be in the vernacular language of the locality concerned, informing that the project has been accorded Environmental Clearance & a copy of the clearance letter is available with the state pollution control board and may also be seen at website of the Ministry of Environment & Forests at http:// envfor.nic.in. The Compliance Status of Environmental Clearance Conditions shall also be uploaded by the Project Authorities in their websites so as to bring the same in public domain. The Monitoring Data (Air, Water, Noise & Soil) shall also be displayed at the entrance of the Project Premises and Mine's Office and in Corporate Office and also be uploaded in the Website.	** Advertisement displayed in two Regional / Local newspapers namely "THE HITAVADA,' English, Dated : 22.07.2009 and "HINDI / MARATHI MAHAVIDARBHA", Dated : 22.07.2009, Compliance status of FC Conditions is regularly submitted to MOeF & CC offices and uploaded on the WCL website. Monitoring data as obtained by CMPDIL is regularly being displayed at Sam office.

Area Nodal Officer (Environment),
Chandrapur Area.

G. M. (Mining) / Sub Area Manager,
Padmapur Opencast Mine.

CHAPTER 7

RETHINKING CONSTRUCTION MATERIAL

CHAPTER 7: RETHINKING CONSTRUCTION MATERIALS

7.1 Manufacturing of Bricks from Coal Mine Overburden

7.1.1 Abstract

Mining waste is a big problem for the mining industry, there is no choice but to recover it. One such waste is an overcrowded dump commonly known as a landfill. It is a type of soil that is extracted by digging. The landfill consists of small coal-based heavy metal particles and has no nutrients, so this type of soil is of no use. The use of the ob landfill is for the production of bricks and building blocks that can replace traditional building bricks. For this, suitable traditional brick manufacturing processes were followed prior to conducting geotechnical tests on the landfill, when deemed appropriate, brick casting was performed and continued. Continuously, tests for bricks are carried out according to Indian standards and finally a compression analysis test. are also made to ensure that the bricks can withstand compressive forces when used in construction.

7.1.2 Introduction

Mining causes destruction of natural ecosystems by removing soil and vegetation and burying them in waste landfills. Restoring exploited lands can in fact be viewed broadly as rebuilding ecosystems and restoring the ability of land to capture and maintain basic resources. In ecological restoration planning, it is imperative that goals, objectives, and success criteria are clearly established to allow for systematic restoration to be implemented, while recognizing that these may require some later modifications to the orientation of the recovery area. Although ecological theory lacks general laws with universal applicability at the level of ecosystem organization, ecological knowledge has high heuristic power and applicability to regenerative goals. location-specific. However, monitoring and management are essential, as uncertainty in the recovery plan can never be overcome.

7.1.3 Methodology

The method applied in the present work has been divided into four parts, namely ob dump screening and screening, ob dump geotechnical testing, brick casting as well as ob dump brick testing and hardening. Overloading landfill sampling was carried out in Bastacolla

area, Jharia coal basin, Dhanbad, Jharkhand. Approximately 35 kg of excess waste was collected from the sampling area for this study. Screening and screening of the collected landfill sample is carried out in the laboratory. Geotechnical tests such as density, density, moisture, compaction, permeability, grain size analysis, plastic limit and shrinkage limit are performed at the geotechnical laboratory. After that, the water is mixed at a rate of 10% by weight and the bricks are cast, then they are left to dry in the air overnight, and then fired in a muffle furnace at 11,000°C. The final tile fit test has been performed. Tests performed are compressive strength test, water absorption test, bubbling test, impact test, strength test, hardness test and structural test. . Based on these test results, conclusions were reached.

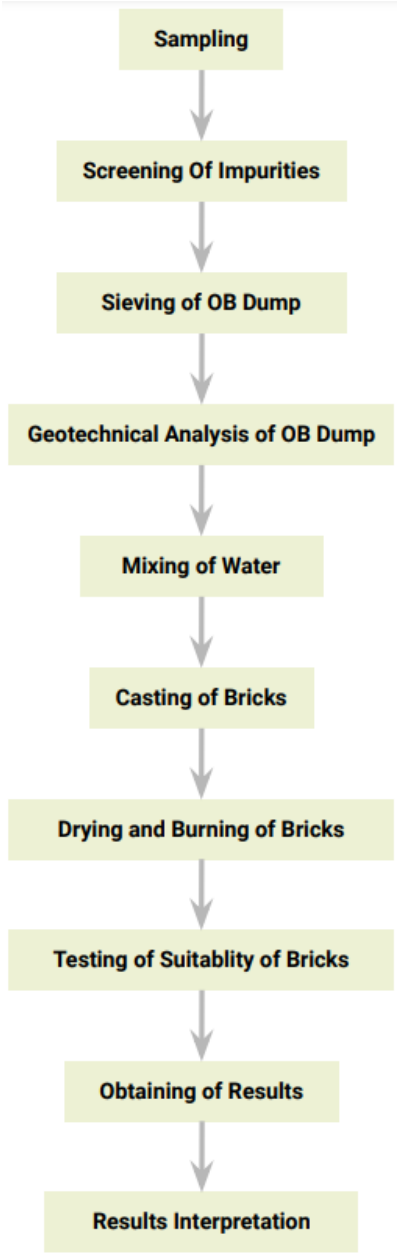


Fig 7.1 Methodology Flow Chart.

Fig 7.2 Overburden(OB) in Opencast Mine.

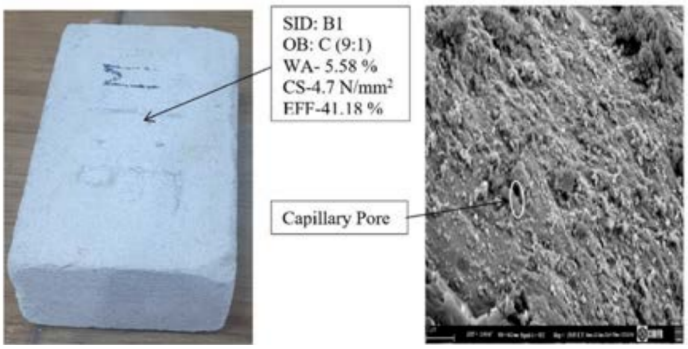


Fig 7.3 Brick made from Overburden (OB).

Fig 7.4 View of Waste Dumps.

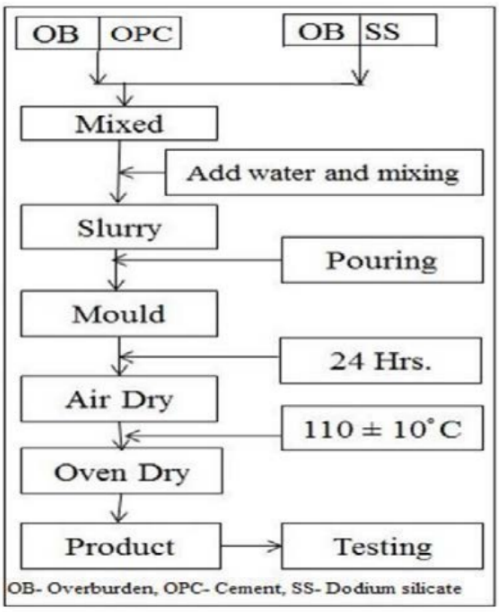


Fig 7.5 Flowchart of the manufactured Bricks process.

Table 7.1 Sieve analysis data of Coal Mine Overburden(OB).

Type of soil	Sieve Size (mm)	Weight retain on each sieve(gram)	Weight retain on each sieve (%)	Cumulative	Finer (%)
Coarse sand	4.75	3.21	0.536	0.536	99.464
	2.00	6.95	1.194	1.73	98.27
Medium sand	0.425	444.66	76.399	78.129	21.871
Fine sand	0.075	117.17	20.131	98.26	1.74
Silt and clay	Passing 0.075	10.12	1.738	99.998	0.002

Table 7.2 Physical properties of Coal Mine Overburden(OB).

Property	Specific gravity	Bulk Density (g/cm^3)	Porosity (%)	Fineness modulus	Moisture content (%)
Composition	2.22	1.30	25	2.79	7.01%

Table 7.3 Chemical composition (%) of Coal Mine Overburden(OB).

Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	K_2O	Na_2O	P_2O_5	SO_3	LoI
Coal Mine OB (%)	58.86	29.09	4.17	1.21	0.81	1.76	3.44	0.11	0.08	0.47	6.57
Cement (C) (%)	24.98	4.84	3.02	61.24	1.42	0.48	0.39	0.29	0.8	2.5	0.07

7.1.4 Result

- Compression Strength Test: - The compressive test was performed on five bricks and the average of it was taken into consideration. The Average Compressive Strength is 67.22 kg/cm2 .
- Water Absorption Test: - The two water absorption tests were performed and the average value of both were taken into consideration. The Average Water Absorption of the brick samples are 22.48% .
- Efflorescence Test: - Nil. There is no deposit of any salt even after repeated wetting.
- Impact Test: - Five bricks were chosen randomly and dropped from the height of 1 meter and not a single brick got broken. So the bricks are of good impact value and acceptable for construction work.

- Soundness Test: - Two bricks are chosen and they are struck with one another. Then the sound produced was a clear metallic sound and the brick did not break.
- Hardness Test: - For this test finger nail is used and with the help of that we try to make scratches on the randomly chosen sample brick but no mark was made on the brick by the scratch action.
- Structure Test: - Five bricks were chosen randomly and they were fractured and closely examined. There were no holes or cracks found.

7.2 Use of Coal Overburden as fine aggregates in Concrete Paving Blocks

7.2.1 Abstract

The objective of this work was to study the use of coal waste for the production of concrete bricks. The methodology took into account the following steps: coal mine waste sampling; weight separation of the density fraction between 2.4 and 2.8; raw material crushing and particle size analysis; technological characteristics of materials and production of concrete pavers. The results show that the coal waste considered in this work can be used to replace ordinary sand as fine aggregate for paving concrete. This practice can contribute to cleaner coal production.

7.2.2 Introduction

Through the gravity-concentration processes of this waste coal, three output streams can be generated:

1) low density materials (relative density < 2.4) and a wide range of carbon wastes including shale and carbon shale;

2) intermediate material (2.4 < relative density < 2.8) consisting mainly of siltstone and sandstone; and

3) a pyrite-rich (relative density > 2.8) high-density material.

Currently, several initiatives have been taken in Brazil to reprocess some coal waste mines with the aim of recovering a portion of the raw carbon for energy production and, instead, to pyrite to produce sulfuric acid. However, there is still material of medium density, which accounts for about 40% to 50% of the volume of coal mine waste and can be considered as a geosynthetic material that can be used in civil and agricultural construction. Karma.

Another serious problem is that the civil engineering production line uses a large amount of raw materials. In recent years, rapid development has led to an increased demand for river sand, which is widely used as a fine aggregate for construction. Sand extraction from riverbeds and banks can cause adverse environmental impacts, such as bank erosion, river bed degradation and river water quality deterioration.

Therefore, the purpose of this work is to study the use of coal waste as fine aggregate to produce concrete paving bricks. The paper briefly reviews key relevant environmental and technical parameters and focuses on waste coal recycling The present study was carried out from a scientific point of view as part of an effort to develop a process Effective coal cleaning focuses on reducing the pollution problems associated with coal waste worldwide.

Table 7.4 Properties of the conventional quartz sand aggregate and the coal waste aggregate

Property	Conventional quartz sand aggregate	Coal waste aggregate
Particle size (mm)		
Size distribution	0.15 to 4.0	0.15 to 4.0
D90	2.0	3.0
D50	0.4	1.0
D10	0.15	0.15
Density (kg/dm^3)		
Real	2.6	2.3
Apparent	1.6	1.3
Particle shape	Rounded and sub-rounded	Angular
Color	Yellowish	Grayish
Mineralogical composition	Quartz—SiO_2 (major mineral phase)	Quartz—SiO_2 (major mineral phase), Kaolinite—$Al_4(OH)_8(Si_4O_{10})$, Illite—$(K, H_3O)(Al, Mg, Fe)_2(Si, Al)_4O_{10}[(OH)_2, (H_2O)]$, Gypsum—$CaSO_4.2H_2O$.
Elemental composition (%)		
C	ND	2.6
H	ND	0.8
N	ND	0.1
S	ND	1.9
Si	63.7	47.0
Fe	1.0	7.5
Al	1.7	14.0
Mn	0.03	0.2
Ca	0.4	4.2
K	3.1	5.5

Table 7.5 Properties of the concrete blocks for paving considering different levels of substitution of river sand by coal waste.

Property	Substitution of river sand aggregate by coal waste aggregate				
	0%	25%	50%	75%	100%
Water/cement ratio	0.35	0.37	0.39	0.43	0.44
Compressive strength (MPa)					
7 days	28.1 ± 2.8^a	33.0 ± 3.4^b	34.2 ± 1.3^b	28.3 ± 1.6^a	24.8 ± 4.6^a
28 days	39.5 ± 2.9^a	37.6 ± 1.6^a	36.6 ± 1.4^a	31.2 ± 2.7^b	27.3 ± 3.1^b
90 days	40.7 ± 0.3^a	36.2 ± 5.2^b	34.1 ± 4.4^b	29.0 ± 3.8^c	27.2 ± 4.8^c
Abrasion resistance (mm)					
28 days	6.6 ± 0.0^a	7.5 ± 1.3^a	7.9 ± 0.0^a	8.1 ± 0.5^a	11.44 ± 3.0^b
Water absorption (%)					
28 days	4.9 ± 0.0^a	5.3 ± 0.1^a	5.4 ± 0.0^a	6.9 ± 0.6^b	8.0 ± 0.8^c
Colorimetric properties					
28 days					
L^*	57.5 ± 2.7^a	55.4 ± 5.3^a	52.7 ± 4.1^a	53.2 ± 3.3^a	53.1 ± 3.0^a
a^*	-0.1 ± 0.2^a	0.3 ± 0.5^b	0.6 ± 0.3^b	0.4 ± 0.2^b	0.4 ± 0.1^b
b^*	7.4 ± 1.4^a	6.2 ± 1.8^a	7.6 ± 1.5^a	7.8 ± 1.6^a	6.4 ± 0.6^a
Mass of fine aggregates of coal waste consumed per area of pavement (kg/m^2)	0.0	12.1	24.2	36.4	48.5

Average ± standard deviation. Values with the same letters compared horizontally do not differ significantly from each other.

Table 7.6 Acid generation prediction results of the raw waste, coal waste fine aggregate and the concrete paving blocks with 0% , and 50% of substitution of , 25% river sand by coal waste aggregate.

Parameter	Raw waste	Coal waste aggregate	Concrete paving blocks		
			0% Substitution	25% Substitution	50% Substitution
Total S (%)	7.0	1.9	0.5	0.4	0.9
AP (kg $CaCO_3$/t)	218.8	60.8	15.7	12.2	27.5
NP (kg $CaCO_3$/t)	0.0	0.0	241.0	430.0	488.2
NNP	−218.8	−60.8	225.3	417.8	460.7
Formation of AMD	Yes	Yes	No	No	No

7.2.3 Result

Mineral fine aggregates produced from coal waste have quartz as the primary crystalline phase. The presence of kaolin, illite and gypsum was also detected. The particles have an angular shape due to the rock breaking process. Regarding the presence of sulfur, the concentration in the fine aggregate was determined to be 1.9%. This element is considered harmful to concrete and most international standards recommend that the amount of sulfates and sulfides in aggregate for concrete production should not exceed a value of 1%. Regarding the materials used in this work, it is recommended to use fine aggregate produced from coal waste at a replacement rate of river sand not exceeding 50%.

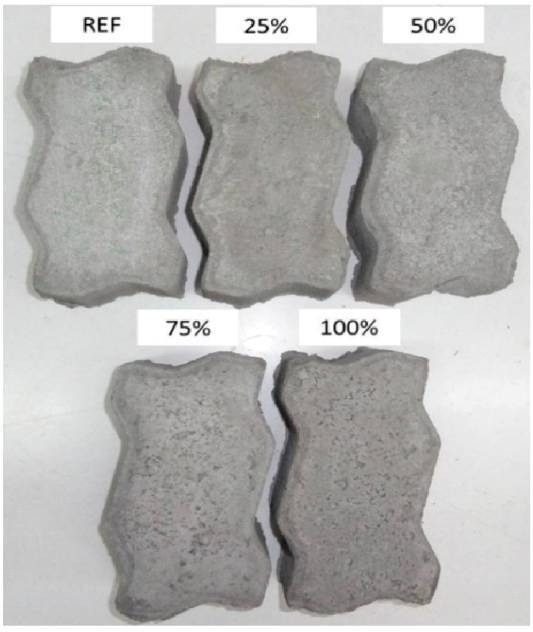


Fig 7.6 Bricks made from Mine Overburden(OB).

7.2.4 Conclusion

The results show that it is possible to process coal waste from the carbon storage in Santa Catarina-Brazil and obtain recycled fine aggregates that can be used in civil construction. Concrete paving blocks produced with 25% and 50% recycled coal waste as an alternative to river sand show positive results in terms of mechanical strength. Using waste coal as fine aggregate to produce concrete block bricks is technically feasible and environmentally beneficial. This practice can contribute to clean charcoal production and enable socioeconomic development in the regional context. The need for sand deposition can be minimized and part of the coal residue can be used, thereby reducing the volume of waste coal deposition. We believe this process can be applied to reduce environmental problems in coal production in Brazil and other parts of the world.

7.3 Coal-Mining Tailings as a Pozzolanic Material in Cements Industry

7.3.1 Abstract

Generating large volumes of waste is common practice in the mining industry. Large amounts of these wastes are also a source of kaolinite-rich materials that accumulate in landfills, causing severe environmental degradation and visual impacts on the landscape. The consequences of coal waste pile up necessitate the study of innovative ecological solutions and the assessment of waste types. In addition, the environmental benefits of reusing a large amount of contaminated waste are also clear. Therefore, the goal of this investigation is to expand the current knowledge about new silicon-aluminum minerals and their puzolan activity. Four raw waste samples were characterized for chemical composition (by ICP/MS analysis), morphology (by SEM/EDX analysis) and mineralogy (by XRD analysis) prior to thermal activation. to convert waste that is inert at different temperatures into cement-based materials. characteristic. The results of XRD analysis after activation confirm that the kaolinite content is completely converted into metakaolinite. Coal waste samples showed a sufficiently reliable level of puzolan activity for use as an additive in industrial cement.

7.3.2 Materials

The study area in El Bierzo County, Province of León (Spain), is a 310 km2 coal basin in an area that has been mined since the mid-19th century. The mineralogy of the coal samples consists mainly of mica. /illite, with quartz, kaolinite, and pyrophyllite as additional major components. In some areas, carbonate pockets appear to interrupt the coal streak. Four types of samples were selected from the mines of Sociedad Anónima Hullera Vasco—Leonesa, Santa Lucía, León, Spain. The first sample consists of mining waste (coal) (mantle and waste rock, raw waste), low level mined, including topsoil and topsoil, waste rock and low grade minerals . Large quantities of these inert materials were found piled up in landfills in the vicinity of the coal mine. The remaining three samples (“waste”) are coal waste from a coal flotation treatment that separates coal from crushed fine particles. Three samples were classified according to particle size: coarse (12.00 to 0.50 mm), fine (0.50 to 0.05 mm) and very fine (<0.05 mm) coal waste samples.

7.3.3 Methods

Four samples were characterized to determine their chemical composition (most common elements, trace elements, total organic carbon, sulfur and loss on ignition) and morphological and mineralogical characteristics (total and clay minerals). Different modes of thermal activation were applied to the samples. All samples were ground in an agate mortar for homogenization. Above (heating from 500°C to 900°C) C, over 2 h in an electric furnace) for the transformation of inert waste into materials with cementitious properties.

- The chemical characterization was performed with Inductively Coupled Plasma Mass Spectrometry (ICP/MS) (Perkin Elmer, Waltham, MA, USA) prior to having immersed the sample in an acidic solution (ICP-MS Elan 6000 Perkin Elmer Sciex with an AS91 autosampler, Perkin Elmer, Waltham, MA, USA).
- The mineralogical composition was determined by X-ray diffraction (XRD, Siemens, Munich, Germany) with the powder method and the <2 μm fraction with the oriented aggregate method; in both cases completing the diffractograms in a Siemens diffractometer D-5000 fitted with a Cu anode. The characterization of the bulk samples was performed with the Rietveld method.
- The scanning electron microscopy (SEM) morphological observations and the energy dispersive X-ray (EDX) microanalysis were performed with an FEI electronic microscope equipped with an energy dispersive X-ray spectrometer (source of W, DX4i analyzer and Si/Li detector).

The Pozzolanic Activity Determination reveals the pozzolanic activity of a pozzolan/calcium hydroxide (lime) system using solid waste after application of an accelerated chemical method. After 1, 7, and 28 days of reaction, waste products were washed with acetone and dried in an electric furnace at 60°C. C, Pozzolanic reaction was completed within 24 hours. The slaked lime content was determined by the difference between the CaO concentration (mmol/l) of the initial saturated lime mortar (17.68 mmol/l) and the content of the same compound in the solution at regular time intervals.

Table 7.7 Chemical analysis of the four raw tailings samples.

Oxides (%)	Tailings			Coal Refuse
	Very Fine	Fine	Coarse	
SiO_2	32.99	41.35	43.12	49.79
Al_2O_3	19.90	9.37	12.16	21.77
Fe_2O_3	4.09	4.13	4.21	4.07
MnO	0.13	0.11	0.10	0.08
MgO	0.87	0.65	0.59	0.64
CaO	11.44	15.21	16.20	3.84
Na_2O	0.35	0.32	0.25	0.13
SO_3	0.83	0.92	0.77	0.27
K_2O	2.11	2.18	2.27	2.74
TiO_2	0.57	0.46	0.65	1.07
P_2O_5	0.26	0.16	0.22	0.13
Loss on ignition	26.47	25.14	19.46	15.18
TOTAL	100.01	100.00	100.00	99.71
Organic carbon	24.27	21.54	18.14	16.04

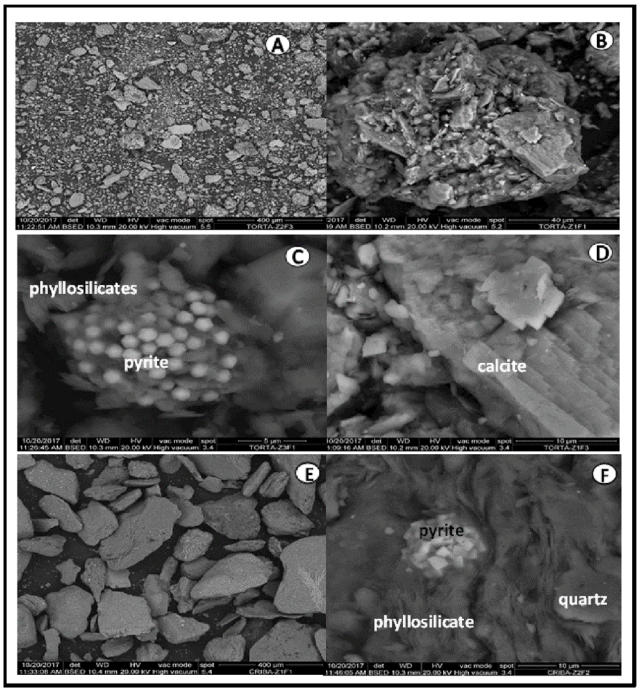


Fig 7.7 Scanning electron microscopy (SEM) analysis: (A) aggregates of variable size in very fine-grade raw tailings sample; (B) porous aggregates in very fine–grade sample; (C) sheets of phyllosilicates with cavities containing idiomorphic pyrite crystals in the very fine–grade sample; (D) rhombohedral exfoliation calcite crystals in very fine–grade sample; (E) homogeneous size of aggregates in fine-grade sample; (F) phyllosilicates, quartz, and pyrite crystals in fine-grade sample.

7.3.4 Conclusion:

- Four types of coal mine tailings (ultra-fine, fine and coarse coal tailings, and coal waste) are recovered from an abandoned coal mine landfill near Santa Lucia in the province of León, Spain. , studied. One of them was chosen because of the presence of a large amount of waste and the possibility of being used as an additional additive to pozzolan cement.
- Four coal waste samples were thermally activated at 600 degrees. C, for 2 h in an electric oven to improve pozzolanic properties. The temperature chosen has advantages from both an economic and energy point of view.
- X-ray diffraction analysis confirmed that all K converted to MK (pozzolan specified in commercial cement production standards) within 2 hours of heating at this temperature (600°C/2 hours). The
- Results show that coal waste after the activation process has sufficient pozzolanic activity for use as a pozzolanic additive in industrial cement, highlighting the potential of this process to remove polluted waste from the environment.

CHAPTER 8

ANALYSIS

ANALYSIS (CROSS RELATIONSHIPS DIAGRAM)

PARAMETERS	RECLAMATION			REJUVENATION			REHABILITATION		
DESIGN	**Soil for Construction**	**Waste Reuse**	**Recycling the Land Components**	**Improving Soil Condition**	**Revival of Micro Climate**	**Restoring Biodiversity and Ecosystem**	**Repurposing land for revenue generation**	**Use of Mine Soil for CSEB Bricks**	**Socio - economic development**
CASE STUDY 1: Piparwar Opencast Coal Mine	Officials sent the overburden to underground mines for filling.	-	-	Should have Collaborated with the forest department	Plant species brought from outside, as they were not able to adjust to the local conditions	Should not have opened a public park, should have left space for migratory birds and other animals for the eco-system to work smoothly	Kayakalp Vatika and plantation is not enough	-	CCL should create a green belt around the area to ensure that people residing in neighboring villages are not affected by pollution
CASE STUDY 2: Bisrampur Colliery, Chattisgarh	Officials sent the overburden to underground mines for filling.	-	-	Organic amendments assist plant establishment by moderating surface temperature, decreasing erosion, increasing cation exchange capacity and detoxifying toxic metals	Mulching materials will alter the surface microclimate and help conserve soil moisture during seedling establishment	Appropriate exotic tree species can serve to start nutrient cycling and establish slopes	-	-	-
CONSTRUCTION	The overburden, and Tailing from mine process are suitable for using as a construction material like Pavements, and Bricks with the correct proportions.			-			Mine Overburden as cement replacement in predefined proportions		
STRUCTURE	-			-			Pile foundation is most suitable according to the Results of Slope Stability test done on the Site.		
SUSTAINABLE DEVELOPMENT									
ECONOMIC SUSTAINABILITY	•The site context in question is a hot spot for tourist activities and frequents people from all over the country. Recreational activities would ensure a influx of revenue to the site and its neighbourhood. •Development projects are a sure way of providing people of nearby villages a mean of livelihood and generate passive means of livelihood thereoff			-			• The materials used to construct structures on site will be locally sourced, which will in turn reduce the cost of transportation. • Development being a labour intensive process would ensure employment for people for the neighbouring villages bringing economic stability into households.		
SOCIAL SUSTAINABILITY	The process of reclamation of land will make the neighbouring villagers understand it and implement it on their farm lands to improve soil quality for agriculture.			-			• Proposing water sport activities • Giving people an Educational Experience about Mining processes and technology		
ENVIRONMENTAL SUSTAINABILITY	Planting of herbaceous monocots with fibrous root systems such as citronella, lemon grass, Saccharum spontaneum, lianes and shrub species accelerate the ecological processes in an adverse mine OB environment.			The top soil of the mine land is loose and unusable for the growth of plant. Therefore, use of the top soil as construction raw material will reveal the workable rich soil of the layer beneath.			The repurposing of land for the use of human and flora fauna alike, will ensure the restoration of the micro-ecosystem of the site resulting in enhanced livability of the nearby areas as well.		

CHAPTER 9

CONCLUSION, AND RECOMMENDATION

CHAPTER 9: CONCLUSION, AND RECOMMENDATIONS

9.1 Reclamation:

- The top soil disturbed by coal mining is unstable and does not support life. Therefore, it is wise to put the top soil to use for construction material. Example: Fine aggregates for concrete, perforated bed for lining in bioswale, brick construction, pozzolanic material in cement , pavement block, etc.
- Using the plantation of local species, it takes around 9 years for the soil to get replenished with the required nutrients to sustain natural life, and ecosystem.

9.2 Rejuvenation:

- Indigenous species of trees contribute greatly to the revival of soil, and Micro climate.
- Following are the Indigenous species which are to be used:
    - Citronella
    - Lemon grass
    - Saccharum spontaneum
    - Lianes
    - Shrub Species
- Greenfield development carried out on land that caused environmental degradation is the best way to go about the development. Greenfield development involves giving back large portions of the land for letting flora and fauna thrive on it.

9.3 Rehabilitation:

- The site context in question is a hot spot for tourist activities and frequents people from all over the country. Recreational activities would ensure an influx of revenue to the site and its neighborhood.
- Development projects are a sure way of providing people of nearby villages a means of livelihood and generate passive means of livelihood thereoff.

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