

# Environmental Sustainability and Cleaner Perspectives - A Challenging Experience from Lignite Mining Industry in India

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**Abstract:** Mining of lignite causes pollution of Environment and ecological damage if unattended. Being conscious that environmental regeneration is the foundation on which Productivity has to be built, N.L.C. started investing on Eco Care long back and it continues. Early investment in Environment protection has resulted in steady growth. N.L.C.'s futuristic vision is to be in the vanguard among the contributors to the community, environment and the Nation by developing and utilizing industrial and human resources to the optimum. Untiring efforts are being put in Mines (NLC as a whole) to maintain and sustain the ecological balance arising due to the continuous mining activity. The Neyveli's Environmental Management System is becoming a symbolic role model for any of the opencast mines in the South-East Asia.

**Keywords-** Lignite, mining, Sustainability, Environmental, protection.

## I. INTRODUCTION

Mining is an important industry for economic development but operation of the mines may harm surrounding environment as well as to the population. The lignite deposits in South India were found extensively in late 1930's while drilling for irrigation purposes. The estimated reserve of lignite as on 31.03.12 is about 42 billion tonnes, of which 80 % was in the southern State of Tamil Nadu. India is one of the top ten brown coal producers in the world. Geological Survey of India (GSI) proved the lignite resources in Neyveli in 1943. In 1956, Govt. of India formed Neyveli Lignite Corporation Limited for commercial exploitation of lignite. Now NLC is a 'Navratna' company functioning under the control of Ministry of Coal. . It has now become a major Energy source of supplying Power to the Southern States. Its core business is lignite mining and Thermal Power generation. NLC operates three highly mechanised opencast Lignite Mines (28.5 Million Tonnes per Annum) at Neyveli and one Lignite Mine (2.1 Million Tonnes per Annum) at Barsingsar, Rajasthan with a total capacity of **30.6 MTPA**. Three Thermal Power Stations (2490 Mega Watt) at Neyveli and one Thermal Power plant in Barsingsar, Rajasthan (250 Mega Watt) with a total capacity of **2740 MW** which would shortly increase to 3240MW.with the addition of 500 MW in Thermal Power Station-II Expansion. The unique feature of NLC is steady growth with excellent track record of not only producing lignite mining and power generation but also protecting the environment and maintaining ecological balance. Keeping mining operations environmentally safe and clean from the start is more cost-effective.

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Instead of cleaning up and restoration of ecosystem destruction or human health effects, NLC investment into sustainable practices which saved money in the long role.

## Lignite Mining Operations at Neyveli

The salient features of open cast lignite mines and linked power generation of NLC which are in operation is given below Table 1:

Table 1 - The salient features of open cast lignite mines

Particulars	TAMILNADU			RAJASTHAN	
	Unit	Mine – I	Mine - IA	Mine II & Expn.	BARSINGSAR
Mining Area	Sq. Km.	27.0	12	41.22	3.89
Capacity / Annum	MT	10.5	3.0	15	2.1
Lignite Reserve	MT	429	120	595.69	53
OB Thickness	Mts.	45 to 110	55 to 110	45 to 103	44 to 118
Lignite Thickness	Mts.	8 to 26	6 to 24	8 to 22	15 to 25
Average Stripping Ratio	Tons: M <sup>3</sup>	1: 5.5	1: 7.0	1: 5.5	1: 4.81
Mining Started on	Date	20.05.1957	30.07.2001	14.04.1981	07.08.2006
Lignite First Exposed	Date	24.08.1961	24.03.2003	30.09.1984	21.05.2007
Overburden Excavated*	MM <sup>3</sup>	1631.53	210.57	1332.29	55.60
Lignite Mined *	MT	298.92	26.91	212.41	1.471
Linked Power Station	Name	TPS-I(600 MW) & TPS-I Expn. (2 X 210 MW)	ST-CMS (250 MW)	TPS – II (7 X 210 ) TPS –II Expn. ( 2 x 250) MW	Barsingsar Thermal Power Station (2x125 MW)
Generation Capacity	MW	1020	250	1970	250

As on 1<sup>st</sup> April 2012

Total Lignite Production Capacity: 30.6 MT

Total Power Generation Capacity: 3240\*\* MW

Age of Lignite – 25 Million years

\*\* including TPS-II Expansion & excluding ST-CMS

## II. ENVIRONMENT IMPACT OF MINING OPERATIONS

Lignite mining at Neyveli is carried out by open cast mining techniques with high mechanization for excavation, transportation and disposal. Lignite is covered by overburden consisting of different types of clay and hard abrasive Cuddalore sand stone. The thickness of the overburden is from 55 to 100 metres. The overburden is removed by specialized mining equipments such as bucket wheel excavators, conveyors, tripper cars & spreaders etc., Mining operation is a continuous process and the overburden soil removed is filled in the de-coaled area. The average thickness of the lignite is about 10 to 20 metres. Neyveli being an artesian area, the aquifer exerts an upward thrust of around 8 kgm/sq.cm. For successful mining of lignite, depressurization of aquifer is essential. Large scale pumping is continuously done to avert heaving of the mine floor and consequent flooding of mine pit. Strip mining eliminates existing vegetation destroys the genetic soil profile, displaces or destroys wildlife and habitat, alters current land uses, and to some extent permanently changes the general topography for the area mined.



The removal of vegetative cover, stockpiling overburden, hauling of soil and lignite increase the quantity of dust around mining operations. Dust, vibration and diesel exhaust odors are created (affecting sight, sound, and smell). Soil removal from the area to be surface-mined destroys many natural soil characteristics, and reduces its biodiversity and productivity for agricultural. Soil erosion and wash-off from the spoil heap formed from the soil excavated and dumped at dumping sites affects drainage and water bodies. Pumping of ground water may affect the water level in nearby wells and underground aquifer.

- Surface mining of coal causes direct and indirect damage to wildlife. Pit and spoil areas are not capable of providing food and cover for most species of wildlife. Mobile wildlife species like game animals, birds, and predators leave these areas. Invertebrates, reptiles, and small mammals may be destroyed. The community of microorganisms and nutrient-cycling processes are upset by movement, storage, and redistribution of soil. Many wildlife species are dependent on vegetation growing in natural drainage areas. The vegetation provides essential food, nesting sites and cover from predators.

In the open cast mines like the one at Neyveli the presence of the above factors are considerable. The magnitude of environmental effect by mining could be imagined, if all the potential lignite in the area were to be tapped, then about 480 sq.kms. will have to be covered by excavation and nearly 25% of this area will be additionally required for spoil banks. Confronted with multi-various pollutants as indicated above the environment management demands much more greater efforts than while dealing with a single pollutant factor or two.

The problem in Neyveli mine is compounded with the factor that blasting is done for loosening the soil to relieve pressure, from the abrasive Cuddalore sand stone, off bucket Wheel Excavators. The overburden removal is carried out in 4 benches at different levels and each system has BWE, mobile transfer conveyor, conveyor system, tripper – spreader combination. The environmental management in mining at Neyveli is done in the following areas with great alacrity and result orientation. A view of operation of Lignite mine is given in Figure 1.



Figure 1 : view of lignite mine in operation

### Environmental Management

To combat the above impacts, NLC has taken appropriate control measures. The details are given below :

#### Dust Suppression

The NLC has adopted continuous mining operation with SME such as BWE, conveyor, Tripper cars, spreaders etc. All are electrically operated equipments and hence during operation the dust emission in this system is comparatively low.

The major dust emanating sources are due to movement of crawler equipments like dozer, pipe layer, mobile cranes and transport vehicles plying through the haul roads.

Methods adopted for reducing generation and dispersal of dust are:

- Minimizing dust at the critical generating points: excavation is done by using sharp teeth of BWE and timely changing of the teeth; a system of teeth changing is instituted as a part of maintenance schedule.

- Using sharp drill bits for blast hole drilling.

- Spraying water on roads and outside surfaces through mobile tankers or sprinklers for quenching dust.

- To the extent possible, providing dust free roads within the mine area for movement of trucks and conventional mining equipments.

- Providing protective respirators and masks to the operators, who are working in dusty areas.

Studies conducted hitherto reveal that the dust concentration is within threshold limit.

The lignite stacks in the bunker is being made wet with permanent sprinkler arrangements and water spraying, In addition to that special spraying systems are installed in the conveyors transporting the lignite.

The lignite handling systems in the Power Stations are having arrangements to contain the dust by effective sprinkling and spraying arrangements. Automatic Dust Suppression system have been installed in all the Thermal Power Stations covering the Dust emanating areas including Bunkers, Grinding Mills, etc.. Emission Control: Electrostatic Precipitators (ESPs) of more than 99% efficiency have been installed in all the three power stations of NLC to remove the ash particles from the outgoing flue gas. The stack heights are also as per the prescribed norms for effective disposal of other gases like SO<sub>x</sub> and NO<sub>x</sub> at wider range. To monitor the pollution in the stack emission, Online SPM and gas analyzers are installed. Apart from this, periodical survey by the State Pollution Control Board is also being carried out and so far, no abnormalities were reported. Dust suppression on haul roads by water spraying from water lorries is seen in Figure 2.



Figure 2 - Dust suppression on haul roads by water spraying from water lorries

#### **Ground Vibration**

Blasting operation creates disturbances in the terra-firma and is likely to transmit vibrations to the buildings closeby. However, as the soil is wet and the high overburden dumps is on the mine periphery, the effect of vibration in the township is not so keenly felt.

Regular checks and monitoring are done to minimize the vibration by controlled blasting using the latest electronic detonators.

### Noise and Vibration Control

The noise level is generally kept reduced below the permissible level by adopting certain remedial measures. Noise created by the machineries are muffed with silencers to modulate noise to tolerable level. Providing thick tree belt around the periphery of mine to screen the noise.

Reducing the exposure time of workmen in higher noise level working area. Checking of noise level in the machineries periodically i.e., once in the month to ensure that the noise level is in the threshold limit value of 85 db for a continuous period of 8 hrs. working. In the case of blasting, the effect of the shock / vibration is controlled at the mine surface level itself by adopting the use of milli second delay action detonators and milli second detonating relays. There is therefore, no danger of vibration being carried on to the nearer structures / Buildings.

### Balancing of Water Table

NLC is pumping ground water from the deep confined aquifer for safe lignite mining. The pumping is regulated on the scientific pattern and the drawal of water is as per the restriction laid down by Ministry of Environment and Forests, Government of India. While NLC is restricting drawal of ground water, it has no control over the industrial and agricultural requirement of the surrounding mostly in the hands of private people. Even for the pumping from NLC mines and to safeguard the water balance in the region, it has taken many proactive steps so that with the growth of NLC's operation in Neyveli region, the balance in ground water is largely maintained.

### Land Reclamation

Excavation of soil for the purpose of extracting lignite are a pre-requisite for mining operation. NLC is acquiring land for its mining activities in a phased manner from the adjacent villages by paying suitable compensation as per Government rules and norms. The Neyveli Lignite Mines at Neyveli is using Specialized Mining Equipments and in the process of mining lignite several hectares of land is disturbed every year. Even at the Project formulation stage, NLC has planned for refilling and reclamation of mined out area. The concept of reclamation is given due importance in NLC even at a time when the environmental awareness in Indian Mining sector was at a primitive stage. The soil excavated is backfilled in dumps and slope is stabilized by Conventional Mining Equipments.

The back filled areas with sterile soil are reclaimed by adopting different methods. The land is reclaimed for agricultural, horticulture crops and development of forestry, pasture land etc. N.L.C. has undertaken various collaborative projects with Ministry of Coal (S&T) in co-ordination with Annamalai University, Central Fuel Research Institute, Dhanbad, Tamil Nadu Agricultural University, Coimbatore and Madras University, Chennai, etc. So far, a total area of about 2104 ha. of land is reclaimed for agricultural, horticulture crops and a total area of 1926 ha. was afforested in all the three mines. An orchard has been developed in an area of 100 ha. by planting different varieties of fruit trees and also herbal cultivation is undertaken in the reclaimed area to cater to the needs of the Ayurvedic dispensary of NLC and also public. The yield

from this land is as good as the produce from natural and normal agricultural lands. The reclamation statistics of mines is given in Table 2.

Table 2 - Reclamation statistics of mines

Unit	Mine-I	Mine-IA	Mine-II
Mine area	2700 ha.	1091 ha	4416.61 ha.
Mined out area	1864.6 ha.	321.4 ha	1878.45 ha.
Out side dump area	478.14 ha.	Over the existing Mine-I dump	1601.52 ha.
Area reclaimed	1420 ha.	171.1 ha.	460.5ha.
Area afforested	1342.0 ha.	126.17 ha.	402.0 ha.
No. of trees planted	70,28,336	72,472	10,18,000
<b>Other activities</b>			
(a) Water body	15.0 ha	4.04 ha	55 ha
(b) Crop cultivation	16.0 ha	8.0 ha	8.0 ha
(C) fruit bearing trees	5.0 ha	4.04 ha	50 ha

### Integrated Farming Systems (IFS)

Integrated Farming System an innovative concept has been adopted in reclaiming the mine spoil areas. The sustainable integration of different agriculturally related enterprises such as grain crops, commercial crops, vegetables, flowers, medicinal plants, fodder crops, fruit trees, etc., with animal components such as cattle, birds, goats, aquaculture, etc., bio-gas generation, azolla and mushroom cultivation, provides ways to recycle products and by-products of onecomponent serves as input to another linked component and reduce the cost of production. Further this farming system approach helps to sustain crop productivity in mine spoil with increased profitability and employment generation. Cattle rearing through Integrated farming System

### Slope Stabilisation

The external over dumps created during the initial opening of the Mines cuts are causing a lot of environmental problems. In order to fulfill social obligations, that the huge quantities of mines spoil dumped over a large area should be converted into vegetative one making it fit for habitation, a Project namely **SLOPE STABILISATION** of the Mines Over Burden dumps has been undertaken with the collaboration of Tamil Nadu Agricultural University, Coimbatore, South India. These dumps were terraced to different Benches with proper drainage facilities and irrigation facilities and suitable species are identified for plantations in the slopes in order to have soil compatibility and also for green belt. In order to have proper moisture on the slopes, drip irrigation system has been deployed and the slopes are being stabilized. N.L.C. on its own has taken up efforts to stabilize newly created slope in Mine-I A using, used coir mats and other local retaining materials (Figures 3 & 4).



Figure 3 - Slope Stabilisation



Figure 4 - Paddy Field in the Reclaimed Area

**Water management**

**Ground Water**

To depressurise the deep aquifer below Lignite field, a certain quantity of ground water is to be pumped out and is diverted to the Thermal Power Plant Lakes for Industrial use. For safe mining operation, ground water is pumped out continuously round the clock through bore wells located at predetermined points. Over the years, through continuous study and implementation of new methods, the quantity of water pumped out has been reduced considerably. The water level is continuously monitored through observation wells for proper ground water management.

**Storm Water**

Major portion of the storm water, collected in sumps is due to rain and seepage from the Mines. This storm water is collected in sedimentation sumps and the part of the clear water from Mine-I is pumped to a modern Water Treatment Plant and treated water is supplied for domestic purpose to the Township. Similar treatment plant of 15000 GPM is under construction to treat the storm water from Mine-II, for utilization in the Thermal Power Station-II Expansion (2 x 250 MW) and for Thermal Power Station-II. Ground water pumping is avoided and the ground water is conserved. Further, the clear storm water from Mines is supplied to surrounding villages for agricultural activities. This in a great way reduces the ground water pumping, avoids wastage of water into the ground and conserves the ground water.

**Green Belt Development, Plantation and Nursery in Township and industrial Units**

N.L.C. is maintaining thick and massive green belt in its Industrial Units and Township. Township is maintaining greenery by planting trees like Neem, Eucalyptus, etc. including fruit bearing trees like mango, jack fruit, etc. Besides this, the circumferential areas of Township have been developed with Eucalyptus, acacia and cashew plantations, to maintain ecological balance. Green Belt development have been taken up and completed in the left out areas of Power Plants. Since the available areas within the Plants have been covered fully, additional plantations are being taken up in the vacant areas in Township.

**Horticulture**

There are four Nurseries maintained in the Township by N.L.C. Horticulture Department for raising saplings of fruit bearing trees, flowering trees and shrubs. Herbal gardens are developed in all the three Mines to an extent of one acre in each Mine. Nurseries to develop various plants and herbal plantation have been created in all the three Mines. Around 18.9 million trees have been planted in and around Neyveli Township and Production Units which helps in maintaining clean environment, dust suppression, noise control, lowering the atmospheric temperature and maintaining ecological balance

III. ENVIRONMENTAL MONITORING SYSTEM

**Ambient Air Quality Monitoring**

Adopting the Central Pollution Control Board (CPCB) guidelines, N.L.C. has installed 13 permanent Ambient Air Quality (AAQ) Stations in and around the Industrial Units, Residential Colony and peripheral areas of Neyveli, (Figure 7) and is continuously monitoring the pollutants like SPM, SO<sub>x</sub> and NO<sub>x</sub> for 24 hours on alternate days throughout the year. AAQ measured values are compared with CPCB standards and its found to be well within the limits. The monitored results of the Ambient Air Quality monitored at thirteen locations is given in Annexure-1. The location of the Ambient air Quality monitoring station is given below. The Ambient Air Quality in and around Neyveli for the period 2011-12 is given in Table 3..

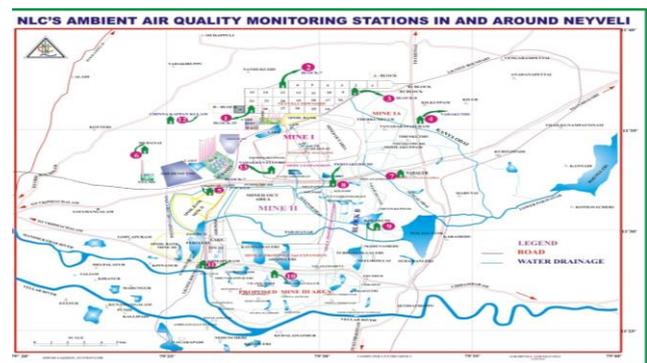


Figure 7 – NLC’s Ambient air quality monitoring stations in and around Neyveli



Table 3 - Ambient Air Quality in and around Neyveli for the period 2011-12

Sl. No	Location	SO <sub>2</sub> µg/nm <sup>3</sup>	NO <sub>x</sub> µg/nm <sup>3</sup>	PM10 µg/nm <sup>3</sup>
1	Block-29	0.86	13.96	40.39
2	Block-6	0.86	13.70	39.03
3	Block-8	0.83	13.58	40.90
4	Vadakkuthu	1.12	13.70	42.27
5	Umangalam	0.75	13.76	40.89
6	Mudhanai	0.58	13.64	43.19
7	Vadalur	0.74	13.98	44.08
8	Periyakurichi	0.68	13.98	48.86
9	Kulakkudi	2.74	17.45	37.69
10	Sathapadi	3.44	18.38	38.40
11	Kammapuram	4.24	19.11	48.49
12	Chinnakappankulam	4.11	19.88	47.22
13	Vaddakkuvellur	4.50	19.85	41.62
Threshold limit in PPM		100	80	80
Average		1.96	15.77	42.54

Tamil Nadu Pollution Control Board, the Statutory Authority is also monitoring regularly every year the AAQ and the measured values are well within the norms prescribed. In addition, work place air quality monitoring is also conducted at three locations inside the mines and the results are given in **Annexure-II** which are also within permissible limits. Repairable dust monitoring is made in occupational areas for periodical assessment. The results of the respirable dust monitoring are given in Annexure-III which is also within the permissible limits. Keeping pace with the developments in air quality monitoring, On no on line Continuous Monitoring Ambient Air Quality Station with all modern facilities is introduced and results are displayed at 5 prominent locations in the Neyveli Township for the benefit of the Public (Table 4 & 5).

Table 4 - Workplace Air Quality in monitoring inside the mines for the year 2011-2012

YEAR	Location	PM <sub>10</sub>	SO <sub>2</sub>	NO <sub>x</sub>
2011-12	New Shift Office	72-92.5	0.1 - 1.5	11.9- 35
	Control Tower	63-92	0.1 - 13	11.1-37.2
	Administrative Office	63-73	0.2 - 15	14.8-35
Threshold limit in PPM		100	80	80

Table 5 - Respirable dust monitoring inside mines for the period 2011-12

Sl. No.	Location	Dust concentration (mg/nm <sup>3</sup> )			
		Aug-06	Apr-09	Jan-10	Feb-11
1	Bunker Stacker	0.27	0.15	0.45	0.24
2	Lignite Bench _BWE 1571	0.21	0.10	0.27	0.21
3	Surface bench – BHD – IR 18	0.76	0.12	0.70	0.43
4	Surface Bench-New Spreader-1	0.47	0.23	0.33	0.36
5	Surface bench BWE 1421	0.35	0.12	0.23	0.42
6	Top bench – New BWE MAN 1	0.44	0.30	0.32	0.32
7	Top bench – New Spreader II	0.32	0.21	0.34	0.42
8	Road side – Opposite to SS	0.54	0.20	0.25	0.12
9	BHD yard road side	0.47	0.13	0.42	0.27

The threshold limit of Respirable dust concentration 3 mg/nm<sup>3</sup>

### Effluent Monitoring

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Effluent discharges from the mines are periodically (monthly) collected and analysed to assess the effluent quality to meet the Standards prescribed by State Pollution Control Board.

### Water Monitoring

The underground water is also monitored by taking samples from the dug wells in and around Neyveli and tested every quarter. A number of observatory wells are also drilled around Neyveli Region for monitoring purposes. A number of check dams at Mines spoil bank, Township and nearby villages have been constructed for effective harvesting and recharging of rainwater.

### Meteorological Monitoring

Wind speed, direction, rainfall, humidity, temperature, etc. are monitored daily throughout the year. One number automatic weather station is installed by India Meteorological Department (MD) which is functioning continuously logging meteorological parameters.

### Corporate Social Responsibility

NLC is one of the public sector undertakings that has begun to address CSR concerns since inception. However, Govt of India came out with guidelines on the CSR in the year 2010; As per the guidelines profit making companies have to allocate not less than 1% of Profit After Tax in the annual budget towards Corporate Social responsibility. The CSR umbrella in NLC covers the entire gamut of community development – rehabilitation (Figure 10 & 11), relief, women empowerment, philanthropy. The annual budget allocation and expenditure is given in Table 8.



Figure 10 - Tricycle given to physically disabled person



Figure 11 - CMD, NLC issuing

Table 8 - CSR Funds Allocation and Expenditure

Year	Profit After tax (PAT) in the previous year (Rs. In Crores)	Budget allocation for CSR (Rs. In Crores)	Expenditure on CSR (Rs. In Crores)	
			Actual	%
2010-11	1247.46	12.48	13.23	106.01
2011-12	1298.33	13.00	14.09	108.38
2012-13	1411.33	16.00	2.81	

upto Aug' 12

The company which has set bench marks towards Social Sustainability has provided Reliable source of Power for over 5 decades to the southern States. Its Profits grown from Rs.566.78 to Rs.1247.46 crores in the last 4 yrs.(129%)

#### IV. CONCLUSION

Mining of lignite causes pollution of Environment and ecological damage if unattended. Being conscious that environmental regeneration is the foundation on which Productivity has to be built, N.L.C. started investing on Eco Care long back and it continues. Early investment in Environment protection has resulted in steady growth. N.L.C.'s futuristic vision is to be in the vanguard among the contributors to the community, environment and the Nation by developing and utilizing industrial and human resources to the optimum. Untiring efforts are being put in Mines (NLC as a whole) to maintain and sustain the ecological balance arising due to the continuous mining activity. The Neyveli's Environmental Management System is becoming a symbolic role model for any of the opencast mines in the South-East Asia.