Exploring Business Opportunities in Biomass & MSW Torrefied Pellets in NCR

Mentor: Sh. Satish Upadhyay, *ED Fuel, NTPC & Mission Director, SAMARTH*

Dharmesh Kumar Kewat[a*], Abhinav Kumar[b#], Zubin Anand[c#], ,
[a,b & c] Executive Biomass, NTPC & Mission Executive, SAMARTH, Ministry of Power
** Author, # Co-Author*

ABSTRACT

This research paper explores the business opportunities arising from the production and utilization of torrefied Agro-residue & Municipal Solid Waste (MSW) charcoal pellets in the National Capital Region (NCR) of India. Biomass torrefaction, a thermal process that converts biomass into a coal-like material, enhances the energy density and hydrophobic properties of the biomass, making it a more efficient and sustainable fuel alternative. The study identifies economically viable locations for setting-up of torrefaction units on the basis of Raw material availability, focusing on selected districts in Haryana and Punjab. The paper examines potential industries for off-take, including high energy-intensive sectors such as steel manufacturing, pharmaceuticals, textiles, cement, paper and pulp, food processing, and metal smelting. Additionally, it highlights the role of thermal power plants in biomass co-firing and the establishment of Eco-Fuel Centers to distribute torrefied biomass pellets to small and micro businesses. A detailed cost analysis of torrefied biomass pellet production is provided, covering capital cost components, manufacturing costs, and vendor profit margins. The study proposes a DBFOT (Design-Build-Finance-Operate-Transfer) business model, where entrepreneurs design, construct, finance, and operate the torrefaction units, with the Investor, maintaining a strategic oversight and off-take agreements. The paper concludes with a summary of Raw material assessments, prospects for the torrefied biomass pellet industry, and recommendations for stakeholders to capitalize on the identified business opportunities.

Keywords: Biomass Torrefaction, Torrefied MSW Charcoal Pellets, Business Opportunities, National Capital Region (NCR)

1. INTRODUCTION

The National Capital Region (NCR) faces significant environmental challenges, primarily due to the high incidence of stubble burning, which contributes to severe air pollution and health hazards. Additionally, the region generates substantial amounts of municipal solid waste (MSW), which are often inadequately managed. Traditional disposal methods of MSW, such as open burning and landfilling, exacerbate environmental degradation and greenhouse gas emissions.

To address these issues, biomass torrefaction presents a promising solution. Biomass torrefaction is a thermal process that converts biomass into a coal-like material known as torrefied biomass. This process involves heating the biomass in an oxygen-deprived environment, enhancing its energy density, hydrophobic properties, and grindability. As a result, torrefied biomass can be used as a sustainable and efficient fuel alternative, offering significant environmental benefits by reducing carbon emissions and providing a renewable energy source.

By converting agro-residue and municipal waste into high-energy-density pellets, this approach tackles multiple problems simultaneously:

- Reduction of Air Pollution: Utilizing agro-residue for pellet production mitigates the need for stubble burning, thereby reducing air pollution and associated health risks.
- Waste Management: Transforming municipal solid waste into valuable energy resources helps in effective waste management and reduces the burden on landfills.
- Renewable Energy Source: Torrefied biomass pellets serve as a renewable and cleaner alternative to conventional fossil fuels, contributing to energy security and sustainability.

- Economic Opportunities: Establishing torrefaction units and promoting the use of torrefied pellets create new business opportunities, stimulate local economies, and generate employment.

This research paper aims to provide a comprehensive analysis of the business potential and environmental benefits of this innovative solution, offering valuable insights for stakeholders, including policymakers, entrepreneurs, and industry leaders.

2. POTENTIAL LOCATIONS FOR TORREFACTION UNITS

2.1. Criteria for Selection

Identifying suitable locations for torrefaction units is crucial for ensuring economic viability and operational efficiency. The selection process is guided by several key criteria: availability of surplus agro-residue, particularly from stubble burning, to ensure a steady supply of raw material; targeting districts with high stubble burning incidents to reduce air pollution and provide alternative use for agro-residue; considering the economic feasibility of transporting biomass within a reasonable distance; ensuring necessary infrastructure and accessibility, such as roads, power supply, and proximity to industrial clusters; and preferring areas with supportive policies and regulations for renewable energy projects and waste management to facilitate project implementation and operation.

2.2. Feasible Districts

Based on the above criteria, several districts in Haryana[1] and Punjab[2] have been identified as feasible locations for establishing torrefaction units. These districts not only have abundant agro-residue and high stubble burning incidents but also possess the necessary infrastructure and supportive policy frameworks to ensure the success of the torrefaction projects.

State	Districts feasible for new units	Surplus Agro-residue (LMTA)
Haryana (03)	Fatehbad, Kaithal, Jind	006.335
Punjab (17)	Sangrur, Firozpur, Bathinda, Moga, Muktsar (Sri Muktsar Sahib), Patiala, Barnala, Tarn Taran, Mansa, Faridkot, Ludhiana, Fazilka, Amritsar, Jalandhar, Kapurthala, Fateghgarh Sahib, Gurdaspur	118.472

Table 1. Feasible locations for establishing torrefaction units.

By strategically selecting these locations, the project aims to maximize environmental benefits, enhance economic viability, and contribute to sustainable development in the region. Establishing torrefaction units in these districts will help reduce air pollution, manage waste effectively, and create new business opportunities, thereby driving economic growth and improving public health in the NCR region.

2.3. MSW Potential

As major concentration of population of National Capital Region (NCR) resides in National Capital Territory (NCT) of Delhi. NCT of Delhi which is having an estimated population of more than 2 corers, spread across 11 districts and 272 wards, which is managed by three (03) Urban Local Bodies (ULBs). MSW generations is around 11328 TPD and processing and recycling capacity (March'23) was only 8229 TPD [3]. There is a processing capacity gap is around 27.4% amounting to 3099 TPD, and if we consider 35% materials of unprocessed MSW, which can be recovered for Waste to Energy amounts to around 1100 TPD.

2.4. Feasible Project Areas

The unprocessed MSW of NCT as stated in para 2.3, poses a great business opportunity for MSW to Charcoal business ventures and enhance our waste management ecosystem along with giving boost to circular economy and energy security. The sites which have been identified for the project lacking uncontrolled garbage dumpsites and sanitary landfills are stated below:

Sl. No.	Name of Dumpsite	Area in Acres	Legacy Waste Lakh Metric Tonnes)	RDF Waste % in LW	Currently under use (TPD)	Surplus Quantity for Torrefaction (LMT)
1.	Ghazipur	70 acres	84.12	15-20 %	1000 TPD [4]	8.96- 13.17
2.	Bhalaswa	36 acres	71.71	10 %	10,000 TPD [5]	3.52
3.	Okhla	46 acres	42.34	5-10 %	137 TPD [6]	1.62-3.73

Table 2. Quantitative Analysis of Major MSW sources

3. EXPLORING BUSINESS OPPORTUNITIES FROM THE PRODUCTION OF TORREFIED PELLETS

The production of torrefied Biomass or MSW charcoal pellets unlocks a multitude of business opportunities across various sectors. These opportunities not only drive environmental sustainability but also deliver substantial economic benefits. Here are some key business opportunities that can be explored:

3.1. High energy intensive industries

High energy-intensive industries can adopt torrefied biomass pellets to meet their energy needs sustainably. Investors can set-up their torrefaction units targeting the following Industries. This reduces reliance on fossil fuels and lowers their carbon footprint. Here are some prominent industries, listed state-wise:

State	Industry Sector	Key Companies	Primary Fuel Type	Remarks
Haryana	Cement	UltraTech Cement	Coal, Alternative Fuels	UltraTech Cement has been increasing its use of green energy, aiming for 85% green energy by 2030.
	Steel Manufacturing	Jindal Steel & Power Ltd. (Hisar)	Coal, Natural Gas	Focusing on reducing its coal dependency and increasing renewable energy usage by 50% in the next few years
	Pharmaceuticals	Sun Pharma, Ranbaxy Laboratories (Faridabad)	Coal, Electricity	-
	Textile & Garments	Vardhman Textiles (Panipat)	Natural Gas, Coal	Vardhman Textiles has been focusing on sustainability, and efforts to reduce their carbon footprint
Punjab	Cement	Ambuja Cement (Rupnagar)	Coal, Waste-derived Fuels	-
	Paper & Pulp	Trident Group (Barnala)	Biomass, Coal	Trident Group has been focusing on sustainability, with significant investments in renewable energy sources
	Pharmaceuticals	Nectar Lifesciences Ltd. (Patiala)	Diesel, Biomass	Nectar Lifesciences has been working on improving its energy efficiency and reducing its carbon footprint
	Food Processing	Cremica Food Industries Ltd. (Phillaur)	LPG, Coal	Cremica has been focusing on energy efficiency and sustainability, with efforts to

				reduce energy consumption and improve operational efficiency
	Metal Smelting	Avon Cycles Ltd. (Ludhiana)	Coal, Electricity	Avon Cycles has been working on improving its energy efficiency and reducing its environmental impact
Uttarakhand	Steel Manufacturing	Tata Steel Processing & Distribution Ltd.	Electricity, Coal	Tata Steel has been focusing on sustainability, with efforts to reduce energy consumption and increase the use of renewable energy sources
Uttar Pradesh	Cement	ACC Cement (Tikaria)	Coal, Petcoke	Working on reducing its carbon footprint and increasing energy efficiency
	Ceramics	Somany Ceramics Ltd.	Natural Gas, Diesel	-
	Sugar & Distilleries	Bajaj Hindustan Sugar Ltd. (Multiple)	Bagasse, Coal	Bajaj Hindustan has been focusing on using renewable energy sources like bagasse to reduce its carbon footprint

Table 3. Targeted high Energy Intensive Industries for consuming Torrefied pellets.

3.2. Thermal Power Plants (TPPs)

3.2.1. Opportunities within NCR

Thermal power plants can significantly benefit from the co-firing of torrefied biomass pellets with coal. This practice not only reduces coal consumption but also lowers greenhouse gas emissions. Key opportunities include:

a. Biomass Co-firing Mandate: Thermal power plants can comply with biomass co-firing mandates by integrating torrefied pellets into their fuel mix. This helps in reducing carbon emissions and improving plant efficiency.
b. Targeted Thermal Power Plants: Specific plants such as Panipat TPS (Haryana) and Talwandi Sabo TPS (Punjab) can be targeted for guaranteed off-take of torrefied pellets, ensuring a steady demand and market for the product.

As per the Biomass co-firing mandate, following Thermal Power plants(TPPs) can be targeted for guaranteed off-take:

Org.	Plant Name	State	Total Capacity (MW)	Annual req. of Biomass @5% for cofiring at 60% PLF & SCC=0.75	
				LMT	TPD
HPGCL	Panipat TPS	HR	710	1.40	383
Vedanta	Talwandi sabo TPS	PB	1980	3.90	1069
			Total	5.30	1452

Table 4. Targeted Thermal Power Plants for consuming Torrefied pellets.

3.2.2. Opportunities across India

Apart from the above TPPs other NCR and adjoining TPPs may also use the Torrefied Biomass pellets offered at a price par with non-Torrefied pellets. Following Thermal Power plants(TPPs) can be targeted for off-take of Torrefied Biomass/MSW Pellets:

S.N.	Organisation	Plant Name	State	Total Capacity (MW)	Annual req. of Biomass cofiring with respect to 3-year coal consumption FY 21-24		Surplus Biomass available (LMTPA)
					5% LMTA	10% LMTA	
1	NTPC	Dadri	Uttar Pradesh	1820	2.96	5.92	216
2	UPRVUNL	Harduaganj TPS		1265	1.6	3.2	
3	NTPC	APCPL, Jhajjar	Haryana	1500	2.6	5.2	109
4	HPGCL	Hisar TPS		1200	1.66	3.32	
5	HPGCL	Yamuna Nagar TPS		600	1.23	2.46	
6	HPGCL	Panipat TPS		710	1.36	2.72	
7	Apraava	Jhajjar TPS		1320	2.48	4.96	
8	Vedanta	Talwandi sabo TPS	Punjab	1980	3.64	7.28	223
9	L&T	NPL Rajpura TPS		1400	2.88	5.76	
10	PSPCL	Ropar TPS		840	1.1	2.2	
11	PSPCL	Lehra TPS		920	1.14	2.28	
	Total (within 300 km of NCR)			13555	22.64	45.28	548

Table 5. Torrefied Pellet requirement in TPPs across India

3.3. Eco-Fuel centres

Establishing Eco-Fuel centres can create new business opportunities by providing a convenient distribution network for torrefied biomass pellets. These centres can cater to small and micro businesses that use industrial boilers or large ovens. Key opportunities include:

1. Distribution Network: TPPs can set up designated retail stores using third-party yards to distribute torrefied pellets. These centres can be strategically located near industrial clusters, highways, and business hubs to ensure easy access for small enterprises.
2. Targeted Small and Micro Businesses: Eco-Fuel centres can specifically target small and micro businesses such as food processing units, dhaba /restaurant chains, and small-scale product processing units. By offering a sustainable fuel alternative, these centres can help businesses reduce their carbon footprint and operational costs.
3. Omni-Channel Approach: The business model can incorporate an omni-channel approach, featuring in-store pickup, direct bulk delivery services, and online ordering for bulk procurement. This enhances convenience and accessibility for businesses seeking sustainable fuel options.

3.4. Generating Carbon Credits

The production and utilization of torrefied biomass pellets offer significant environmental benefits, which can be monetized through carbon credits. Key opportunities include:

1. Carbon Removal Methods: Torrefied charcoal can be used for biochar sequestration, which involves adding biochar to soil to sequester carbon. This method generates carbon credits that can be sold in the voluntary carbon market (VCM).
2. Carbon Reduction Methods: Co-firing torrefied pellets with coal in thermal power plants reduces carbon emissions, generating carbon credits upon co-firing beyond the mandated targets can be sold in the voluntary carbon market.
3. Revenue from Carbon Credits: Businesses can generate additional revenue by selling carbon credits earned from carbon removal and reduction methods. Potential buyers include companies like Microsoft, JPMorgan Chase & Co., Swiss Re Group, Nasdaq Inc., and Shell, which are actively purchasing carbon credits to offset their emissions.

3.4.1. A comparison between Carbon Removal & Carbon Reduction Methods.

Parameter	Torrefied Charcoal/Biochar Plant	Torrefied Charcoal Plant with Pelletization
Plant Capacity (TPD)	100	100
Estimated Project Cost (crores) [7]	18	20
Surplus Biomass Utilization (Tonnes)	65,454.5	65,454.5
Conversion Losses (%)	45%	45%
Yearly Production Capacity (Tonnes/Year)	36,000	36,000
Production Cost (Rs/tonne)	9,000	12,054
Total Production Cost (crores/year)	32	43
Carbon Sequestration/Reduction	2.5 tonnes CO2/tonne of biochar [8]	1.2 tonnes CO2/tonne of pellet co-firing
CO2 Removal/ Reduction Potential (Tonnes/year)	90,000	43,200
Carbon Price ($/Tonne CO2 Equivalent)	$80 [9]	$ 63 [10]
Revenue (Rs. in crores)	57.6	21.8
Estimated Pellet Price (Rs/tonne)	-	12,000
Estimated Coal Price (Rs/tonne)	-	4,000
Net Profit (crores)	25.6	-
Additional Liability (crores)	-	7.19
Project Cost (crores)	18	20
Scenario Analysis	• Production Cost: Rs 32 crores/year • Revenue: Rs 57.6 crores/year • Net Profit: Rs 25.6 crores/year • CO2 Removal Potential: 90,000 MT/year	• Production Cost: 43 • CO2 Reduction Potential: 43,200 tonnes/year • Carbon Price: $63/MT CO2 • Additional Liability: Rs 7.19 crores due to higher

	• Carbon Price: $80/tonne CO2	cost of torrefied pellets & lower carbon price.
Advantages	• High CO2 removal potential. • Significant revenue from carbon credits. • Positive environmental impact through carbon sequestration in soil.	• Potential for carbon reduction by substituting coal. • Utilization of surplus biomass.
Challenges	• High initial project cost. • Dependence on the voluntary carbon market for revenue.	• Higher production cost. • Low carbon price in voluntary carbon market.

Table 6. Comparison between Carbon Removal & Carbon Reduction Methods

3.4.2. Scenario Analysis for Utilization of Biochar/Charcoal

a. Scenario Analysis I: Utilization in NTPC Ltd.'s Mining Area(Talaipalli, Chhattisgarh)
   - Objective: The biochar produced from its torrefied charcoal projects may be use as a landfill in its mining area, aiding in site reclamation and acting as carbon sink tanks.
   - Underground Mining Production Capacity: 0.72 million tonnes per year (7,20,000 tonnes per year)
   - Requirement Analysis:

Calculation Step	Formula/Details	Result
Number of Pellet Plants Required	7,20,000 MT / 36,000 MT/year	20 plants
Total Cost for 20 Projects	32 crores x 20	₹640 crores
Carbon Removal Potential	7,20,000 MT x 2.5	18,00,000 Tonnes CO2/year
Revenue from Carbon Credits	$80 x 80 x 18,00,000	₹1152 crores
Freight Charges [11]	2000 km x ₹1.86 x 7,20,000	₹268 crores
Net Profit	₹1152 crores - (₹640 crores + ₹268 crores)	₹244 crores

Table 7. Financial Analysis for Carbon Sequestration in Coal Mines

b. Scenario Analysis II: Local Landfilling and Distribution to Farmers
   - Objective: To mitigate transportation costs, identify local landfilling sites or distribute biochar to local farmers for use as soil amendment, enhancing carbon sequestration.
   - Benefits:
     - Cost Reduction: Lower transportation costs by using local sites.
     - Soil Amendment: Biochar improves soil quality and sequesters atmospheric carbon.
     - Improved Net Profit Margin: Local sequestration significantly enhance profitability.

4. CAPEX & OPEX: TORREFIED BIOMASS PELLETS

4.1. Assumptions

Items	Assumptions
Production Capacity of Machines	3 Tonne per Hour (TPH)

Total Area of Plant (incl. Storage)	10.66 Acres
Running Hours and Days	16 Hours per day & 270 Days
Cost of Equipment	Rs 180.00 Lacs per TPH Ring dye type pellet machine
Cost of Land (per Acre)	Rs 20 lac for purchase and Rs 70000 p.a. for Lease
Avg. Calorific value of Pellet	4,200 Kcal/ Kg
Interest Rate on Term Loan & Working Capital	@ 12% per annum each
Repayment period of Term Loan	5 years excluding implementation period and Moratorium period
Income Tax rate (p.a.)	17%
Discount Rate (p.a.)	8.40%
Depreciation (p.a.)	9.5% on Plant & Machinery & 3.17% on Building based on straight line method. (up to 95% depreciation)

Table 8.a. Assumptions for setting-up Torrefied Pellet plant

4.2. Capital Cost Components

Capital Cost Components	Details	Value (Rs Lacs)
Land	Cost of 1.5-acre Land @ 20 Lacs/acre	30
Building & Other Civil Works	Main plant & warehouse	51.18
Plant & Machinery (incl. torrefier)	@ ~180 lacs per TPH	539.90
IDC & Preoperative expenses	Consultancy, Legal & Misc. expenses, Insurance	11
Margin for Working Capital @ 25%	for 3 months	66.98
Capital Cost (Project cost) (Rs. in Lakhs)		699.06

Table 8.b. Capital Cost Components for setting-up Torrefied Pellet plant

4.3. Break-up of Price Components for Torrefied Biomass pellets in NCR:

P1	Raw Material Expenses				
	Cost of Raw Material (Rs/MT)	Landed cost of raw material (Considering a loss of 55% @Rs 2500 /MT)			5556
P2	Cost of Manufacturing				
	C1	Interest expenses (Rs/MT)	Term loan on Cost of Project & Working capital expenses for 6 months @12% each		549
	C2	Power & Fuel (Rs/MT)	@ 0.15 kWh consumed per kg of pellets @ Rs 10/ kWh	1500	3082
		Repairs & Maintenance (Rs/MT)	Based on inputs from Pellet Machine Manufacturers	1125	

		Wages (Rs/MT)	5 skilled labors@ Rs 800/day 10 unskilled labors @ Rs 500 /day	253	
		Salary & Administrative cost (Rs./MT)	Includes cost components like insurance, office supplies, accounting, clerical work, information technology, etc. and salary of 2 managers @ Rs 5 lakhs annually	154	
		Storage (Rs/MT)	Cost of Leased Land for Storage @ Rs 70,000 per acre annually	50	
	C3	Depreciation (Rs/MT)	Depreciation for Plant & Machinery (10 years) & Building (30 years)		416
Cost of Pellet Production (Rs./MT)					4108
P3	Vendor Profit (Rs/MT)				1247
Total Price			(Rs/MT)		10850

Table 8.c. Operational Cost Components for producing Torrefied Pellets

5. CONCLUSION

5.1. BCG Matrix for Biomass & MSW Torrefied Pellets Business opportunities

Figure 1. BCG Matrix for Biomass & MSW Torrefied Pellets Business opportunities

5.2. Business model for venturing torrefied biomass pellet production and sale.

A business opportunity for investors and power-producing firms to diversify into sustainable energy solutions using the DBFOT (Design-Build-Finance-Operate-Transfer) model. This model allows private entrepreneurs to design, construct, finance, and operate torrefied biomass pellet production units, with strategic oversight and off-take agreements maintained by the overseeing entity. The facilities will be transferred to the overseeing entity after a specified period.

Key Components:

a. Project Development
   - Location Identification: Identify suitable locations in Haryana and Punjab for torrefaction units based on agro-residue availability and market proximity.
   - Proposal Submission: Invite entrepreneurs to submit proposals outlining their design plans, technology solutions, and operational strategies.

b. Design and Construction

- Entrepreneur Responsibilities: Selected entrepreneurs will design and construct the torrefied biomass pellet units according to specified sustainability standards.
- Technical Assistance: Provide technical assistance or guidance to ensure that designs align with best practices in biomass processing.

c. Financing
- Securing Financing: Entrepreneurs will secure the necessary financing to cover the project's construction and operational costs.
- Incentives: Offer partial funding, guaranteed off-take agreements, or tax benefits in collaboration with governments.
- Revenue-Sharing: Implement revenue-sharing models where the overseeing entity receives a share of profits.

d. Operation
- Operational Period: Entrepreneurs will operate the facilities for a predetermined period (e.g., 10-15 years), managing all aspects of production, quality control, and sales.
- Oversight: Ensure off-take and monitor operations to ensure compliance with environmental standards and production efficiency.

e. Transfer of Ownership
- Seamless Transition: Transfer ownership and operational responsibilities to the overseeing entity, including all knowledge, technology, and equipment.

f. Marketing Distribution and Sale
- Sales Channels: Set up networks to market torrefied biomass pellets to high-energy intensive industries and thermal power plants.
- Eco-Fuel Centers: Establish Eco-Fuel Centers to provide direct access to small and medium enterprises, promoting the adoption of biomass pellets as a sustainable fuel alternative.
- Biochar Carbon Credit: Participate in carbon credit initiatives, selling credits to companies like Microsoft, JPMorgan Chase & Co., and others.

REFERENCES:

1. *Biomass Mapping for Power Generation for Haryana, IISC Bangalore*
2. *Generation and Management of Crop Residues in Punjab, PAU, Ludhianahttps://www.isadp.in/publication/download-pdf/228*
3. *https://www.dpcc.delhigovt.nic.in/uploads/pdf/SWMCPPT1pdf-0580c09121d08b4d24f254273ace8fc7.pdf*
4. *http://www.indiaenvironmentportal.org.in/files/file/Ghazipur-landfill-report-NGT-July-2022.pdf*
5. *https://theprint.in/india/bhalswa-landfill-delhi-l-g-flags-off-40-trucks-of-inert-and-rdf-waste-to-be-reused-by-nhai-and-cement-plants/1290940/*
6. *https://timesofindia.indiatimes.com/city/delhi/delhi-cement-firm-to-help-mcd-get-rid-of-rdf-at-landfill/articleshow/93863821.cms*
7. *As per the data collected from Manufacturers by SAMARTH Mission*
8. *Biochar Carbon Credit Analysis - BF Reports 2022 (pacificbiochar.com)*
9. *https://scijournals.onlinelibrary.wiley.com/doi/10.1002/bbb.2614*
10. *https://www.researchgate.net/publication/274710140_Energies*
11. *Rail: Freight by rail is INR 1.86 per ton-kilometre*
12. *Microsoft to Acquire 10,000 Credits from Biochar Startup Bio-Logical — OPIS | Morningstar*
13. *SUEZ and First Climate announce at Viva Technology the signing of forward contract with Microsoft for delivery of biochar carbon removals from Carbonity - SUEZ Group*
14. *https://carboncredits.com/shell-to-buy-22500-biochar-removal-credits-from-the-next-150/*
15. *Biochar Carbon Credit Analysis - BF Reports 2022 (pacificbiochar.com)*
16. *Creams_Report – CREAMS (iari.res.in)*
17. *Company-wiseOBR.pdf (coal.gov.in)*
18. *https://scijournals.onlinelibrary.wiley.com/doi/10.1002/bbb.2614*