

USE OF FLY ASH IN AGRICULTURE: INDIAN SCENARIO

By

Dr. Vimal Kumar
Adviser

Centre for Fly Ash Research & Management (C-FARM)
(Former Mission Director & Head, Fly Ash Unit,
Dept. of Science & Technology,
Govt. of India)
New Delhi-110016 (INDIA)

AGRICULTURE COAL ASH USE

MENU

1. Dependence of Indian power sector on coal
2. Ash generation & utilization scenario
3. Efforts made for last 20 years
4. Glimpses of current status
5. Work done in agriculture area
6. Impact on yield and soil health
7. Impact of heavy metals / trace elements and radio nuclides on soil, water, produce and plant parts
8. Current status
 - I. Positive indicators
 - II. Impediments
9. Way ahead

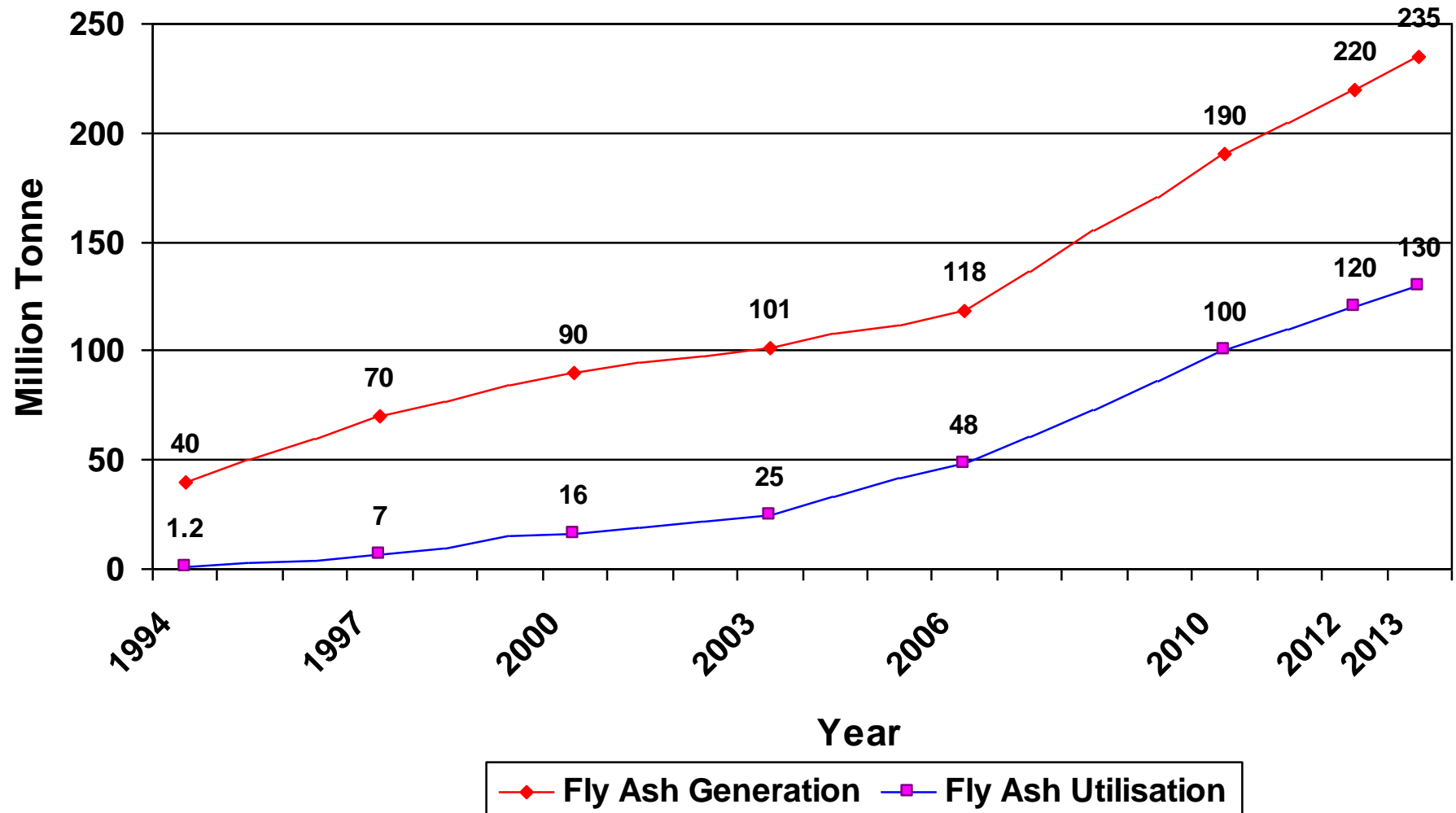
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Indian Power Sector – Dependence on Coal (MW)

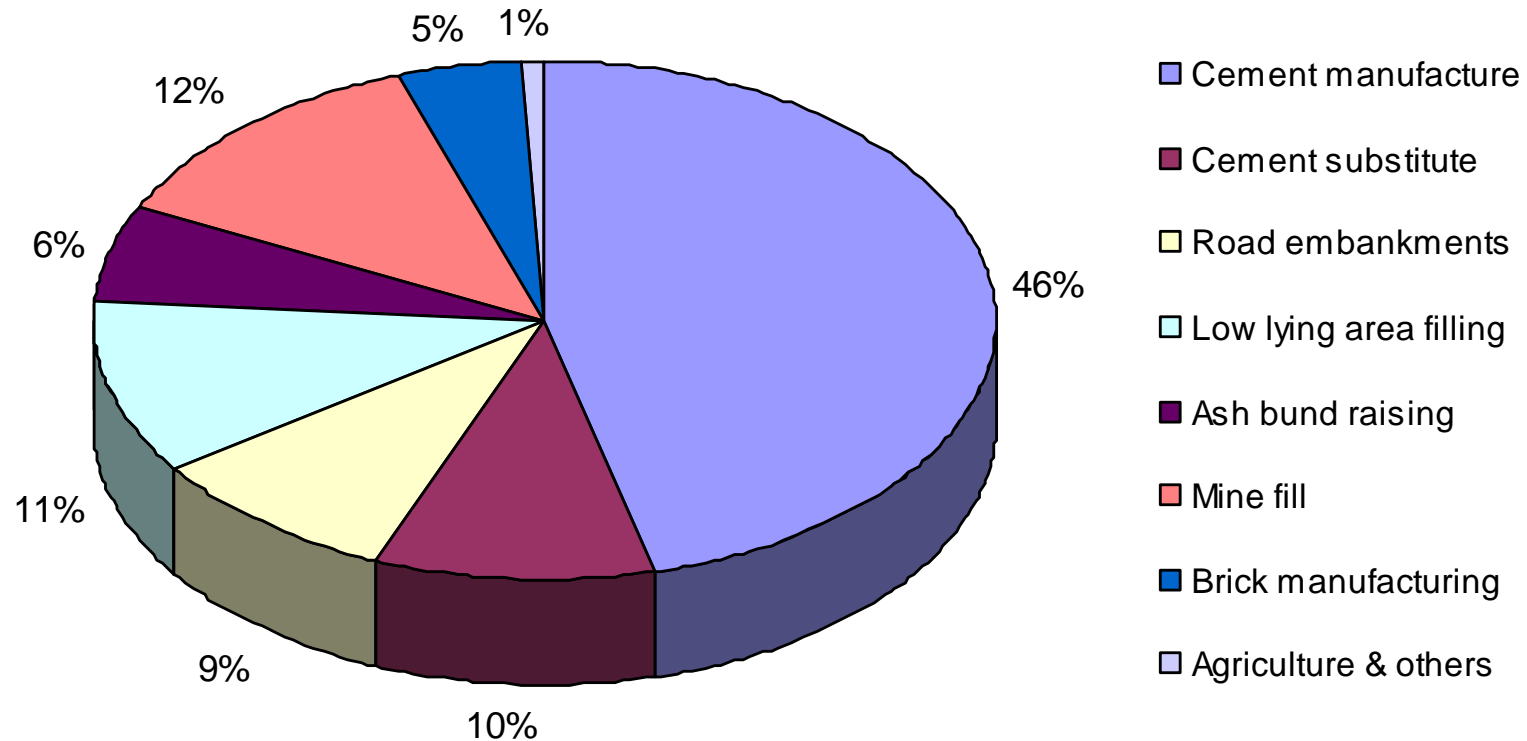
Sl. No	As on	Thermal				Grand Total
		Coal/lignite (% of G. Total)	Gas	Diesel	Total	
1.	31.12.47	756 (55.5)	0	98	854	1362
2.	31.03.61 (End of the 2 nd Plan)	2436 (52.4)	0	300	2736	4653
3.	31.03.74 (End of the 4 th Plan)	8652 (51.9)	165	241	9058	16664
4.	31.03.85 (End of the 6 th Plan)	26311 (61.8)	542	177	27030	42585
5.	31.03.90 (End of the 7 th Plan)	41236 (64.8)	2343	165	43764	63636
6.	31.03.97 (End of the 8 th Plan)	54154 (63.1)	6562	294	61010	85795
7.	31.03.02 (End of the 9 th Plan)	62131 (59.2)	11163	1135	74429	105046
8.	31.03.07 (End of the 10 th Plan)	71121 (53.8)	13692	1202	86015	132329
9.	31.03.12 (End of the 11 th Plan)	112022 (56.1)	18381	1200	131603	199877

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ASH GENERATION & UTILIZATION GRAPH



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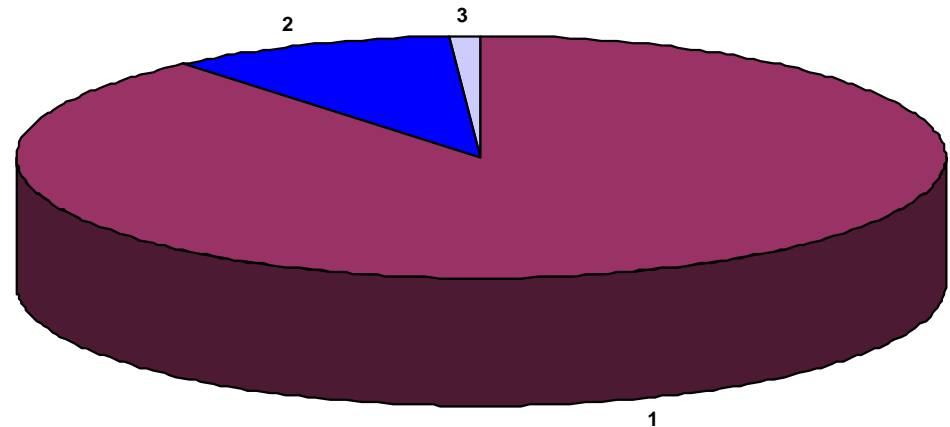
UTILIZATION AREAS – 2013

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Fly Ash Utilization Scenario – 1994

Utilization : 1 Mn.T/year

- 1** Cement Manufacture /
- 89% Substitution
- 2** Low Lying Area Fill
- 10%
- 3** Brick Manufacturing
- 1%



NATIONAL OVERVIEW: AREAS OF UTILIZATION

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PERCEPTION OF FLY ASH (Prior to Fly Ash Mission)

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PERCEPTION

- A waste material
- Of no use
- Hazardous
- Radioactive
- Contains heavy metals Hg, Pb, As, Cr, Ni, etc.
- Carcinogenic
- Leads to bronchitis, skin diseases, etc.
- Pollutes water
- Pollutes air
- Requires large stretches of land for dumping
- A cost centre for TPPs

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FORMATION OF GROUPS & COMMITTEES

1970s to 1990s

- Empowered Group for Waste Management 1975
- High Power Committee for Industrial Solid Wastes
1982
- National Waste Management Council 1990

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ACTIONS AT DST

- Fly Ash Subject picked up by Department of Science & Technology, Govt. of India (1991)
- Techno-Market Survey Report (1991-1992)
- Proposal for Fly Ash Mission (1993)
- Approval of Fly Ash Mission (1994)

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THRUST AREAS

UTILISATION

- Roads & Embankments
- Building Components
- Hydraulic Structures
- Agriculture Related Studies & Applications
- Minefills

SAFE MANAGEMENT

- Ash Pond Management
- Reclamation of Abandoned Ash Ponds

FACILITATION

- Characterisation of Fly Ash
- Handling and Transportation
- Research & Development

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PARTICIPATIVE APPROACH

All Projects are undertaken with the involvement (not only association) of:

- Industry
- Regulatory Bodies
- R&D
- Academia
- TPP
- Socio-economic aspects

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IMPLEMENTATION STRATEGY

- Identification of Facilities & Experts
- Development of projects and implementation plans
- Regular monitoring and steering
- Scale up demonstrations
- Facilitation for large scale applications
- Setting up standards, specifications and guidelines
- Dissemination of information and setting up of facilitating agencies

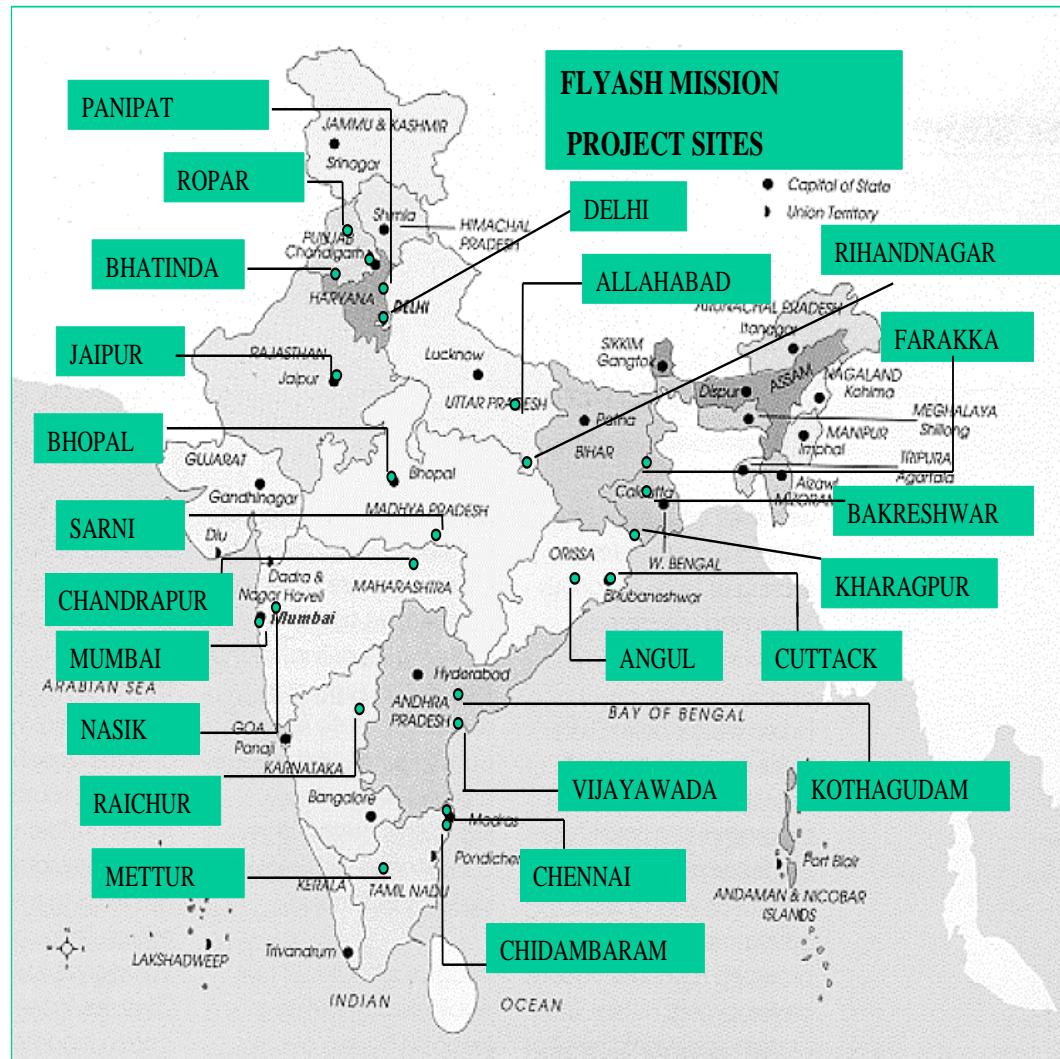
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RESOLUTION OF MIND SET

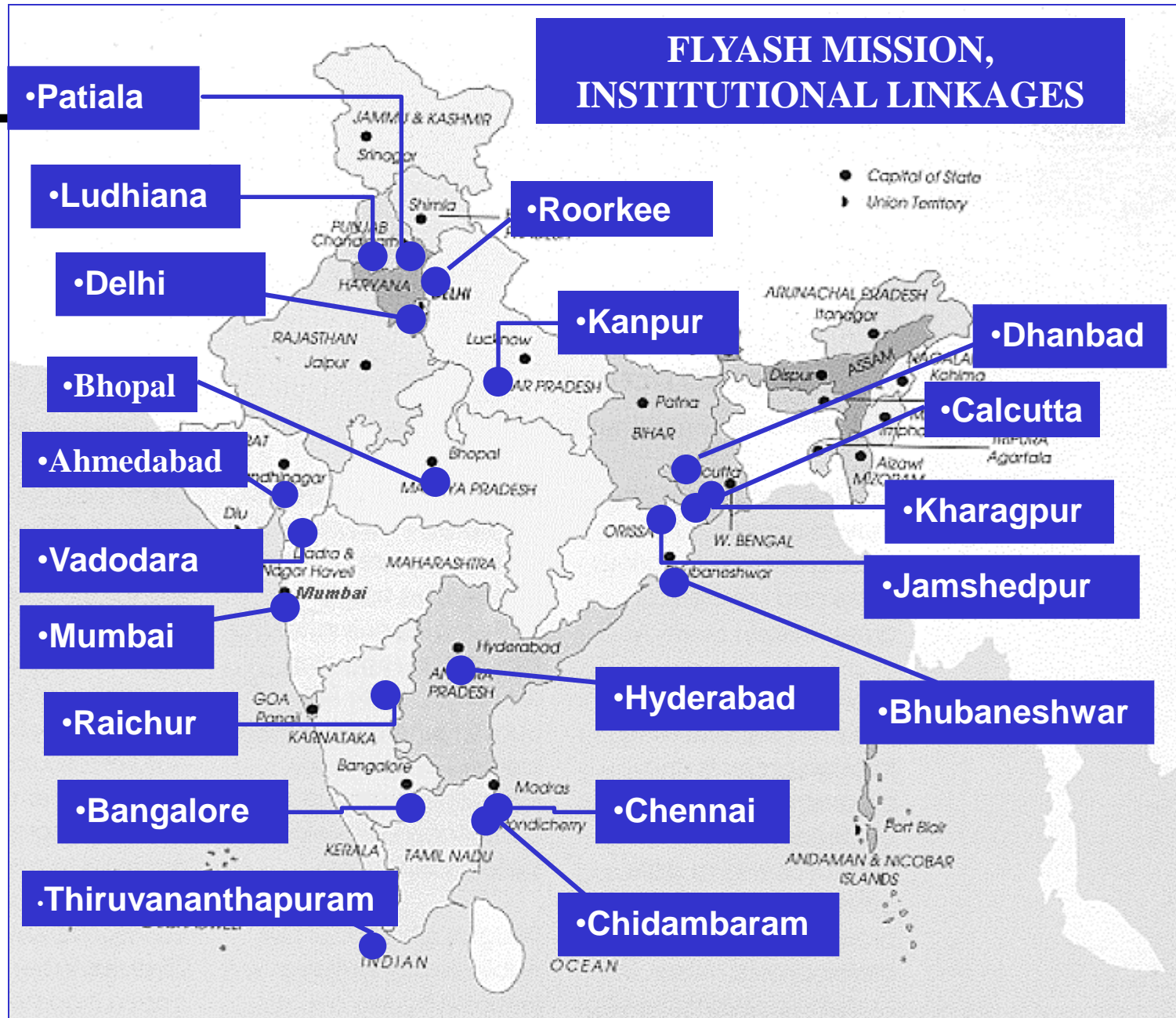
- i. Small group meetings
- ii. One-to-one meeting with opinion leader
- iii. Debate and discussion forums
- iv. Press conference
- v. Popular articles in print and press media
- vi. Discussions and broadcasts through radio and TV media
- vii. Formation of core groups in important stakeholders organization.

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SPREAD OF PROJECTS



FLYASH MISSION, INSTITUTIONAL LINKAGES



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MAJOR UTILIZATION AREAS

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Fly ash blocks



Fal-G blocks



Mosaic tiles



Interlocking pavers

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BUILDING COMPONENTS



In roofing at Chennai

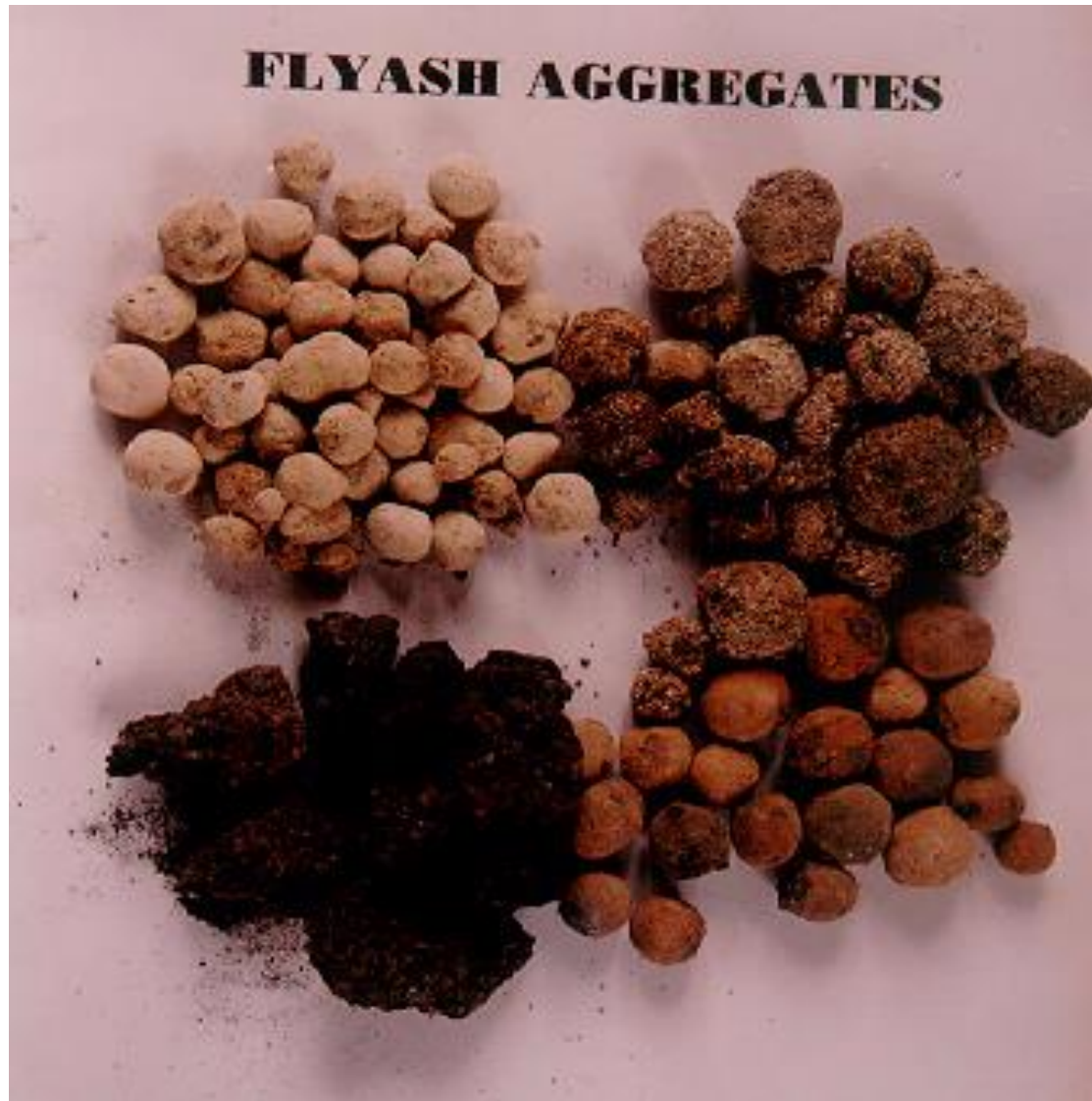
FLYASH IN BUILDINGS



At HITEC City, Chennai

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Value
Added
Products



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Wood Substitute

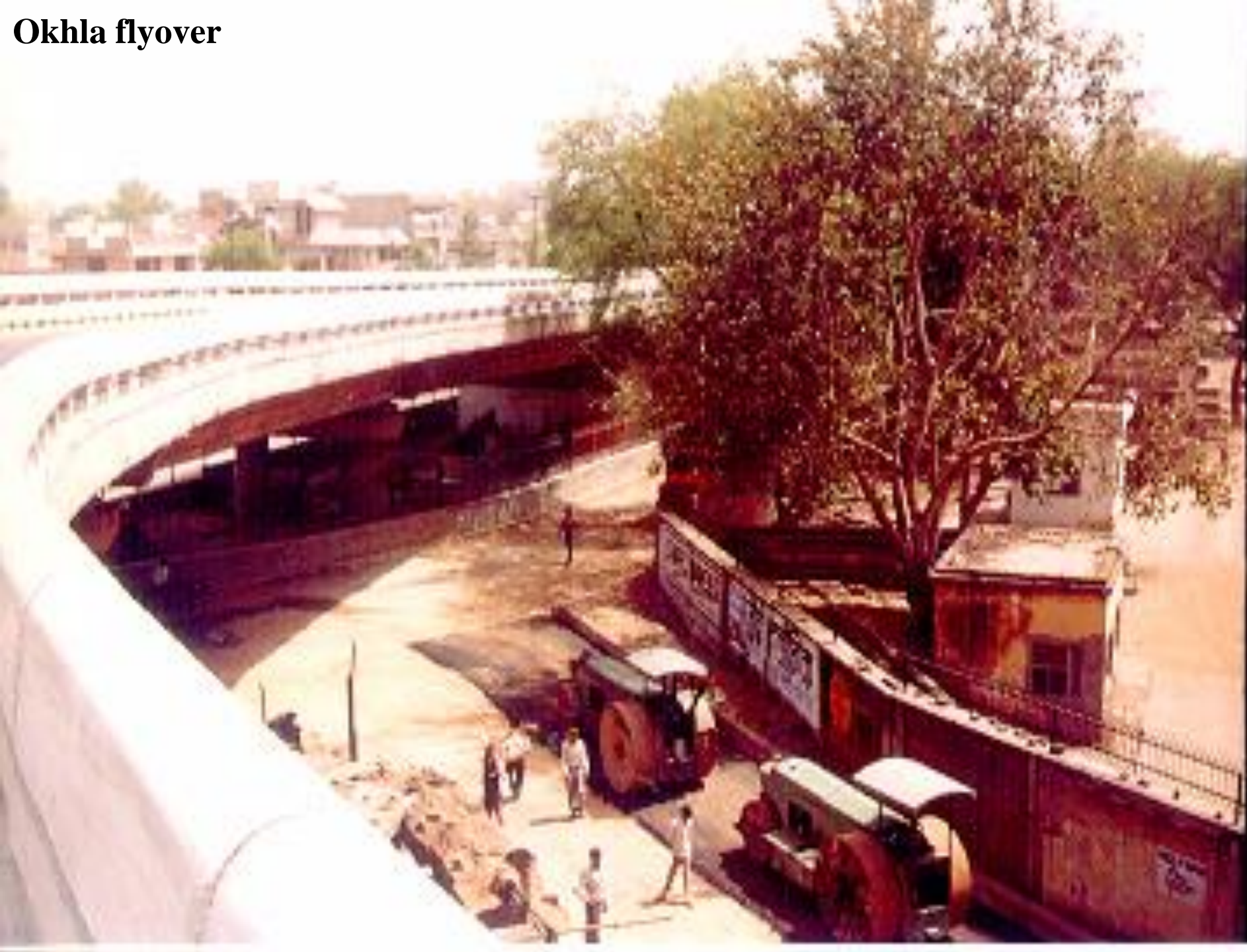


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Fly Ash Based Partitioning Material

Okhla flyover



APPROACH ROAD EMBANKMENT, NIZAMUDDIN



APPROACH ROAD EMBANKMENT IN FLOOD ZONE, NIZAMUDDIN



Punjabi Bagh flyover



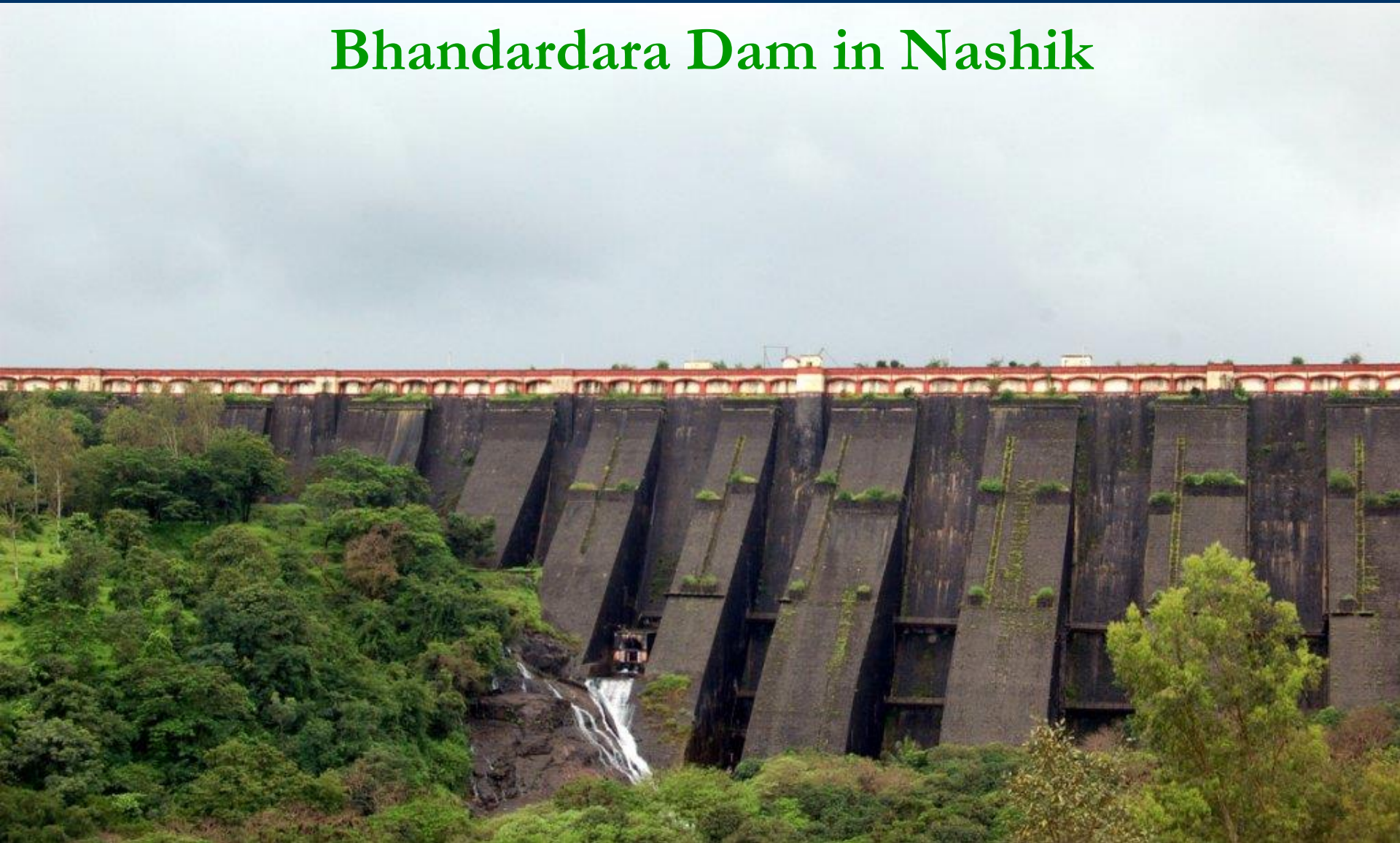
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Utilization of FA in Forestry Plantation, Jajpur (Orissa)



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Bhandardara Dam in Nashik



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BACKFILLING WITH FLY ASH



LEVELING OF FLY ASH BACKFILLED AREA

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VEGETATION OVER THE MINE FILL AREA OF CCL



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A sample prepared of hollow block prepared using metallic mould



A sample prepared of hollow block prepared using metallic mould

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A view of pouring of material in experimental duct

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Chairman Monitoring Committee, observing the demonstration of the experiments conducted at CIMFR, Dhanbad for construction of seal from remote

Handling and Transportation

- Dry fly ash availability
 - Handling and transportation
 - Segregated collection of dry fly ash
 - Bagging of dry fly ash
 - Capability building



Dadri thermal power station project

- dense phase conveying of flyash slurry and
- separate handling of flyash and bottom ash

Safe Management Ash Pond

Use of abandoned ash pond



Human habitat on NFL Panipat ash pond



Forestry at Badarpur thermal power plant ash pond

Contd...

Safe Management of Pond

- Dyke design, construction & maintenance



Dyke constructed with flyash at Korba thermal power station, Madhya Pradesh

- Densification of ash ponds for
 - Seismic stability
 - Increasing the load bearing capacity



Vibroflotation column technology at Vijaywada



Blasting technique at Mettur thermal power plant

SIGNING OF PROTOCOL



Dr. T. Ramasami, Secretary, Department of Science and Technology, and V. V. Nagovitsin, Chairman of the Inter-regional Association of the Economic Cooperation of the Constituent Entities of the Russian Federation signed the Protocol on Fly Ash in presence of Dr. Manmohan Singh, Prime Minister of India and Mr. Dmitry Medvedev, The President of Russia at The Kremlin on 16th December, 2011 after the bilateral summit level talks between the two sides.

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■ MoU Signing Ceremony with Russia

contd...

The Protocol of Intentions between the Department of Science and Technology, Government of India and the Interregional Association "Siberian Accord" Siberian Federal District, Russian Federation on fly ash utilization and safe management is for implementation of the mechanism similar to "Fly Ash Mission - India" in the Siberian Federal District, to facilitate development and application of technologies for utilization and safe management of fly ash, including import of technologies from India.

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UNDER FLY ASH MISSION

- Image of fly ash is transformed
- Number of technologies developed, scaled up and transferred to industry for gainful utilization of fly ash as a resource material and as part-substitution of minerals and other materials
- Properties of fly ash relevant to various applications are use specific.
- Standards, specifications and guidelines prepared & issued
- Legislation as well as facilitation and technology transfer centre in place

Centre for Fly Ash Research & Management

C-FARM is an expert institute for technology development and application for gainful utilization and safe as well as economical management of fly ash

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C-FARM: A TECHNOLOGY TRANSFER AGENCY

Technology scale up/commercialization MoUs signed by:

1. National Metallurgical Laboratory, (NML) CSIR, Jamshedpur
2. Institute of Minerals & Materials Technology, (IMMT) CSIR, Bhubaneswar
3. Central Pulp & Paper Research Institute, Saharanpur
4. Viswa Bharati University, Sriniketan, W. B.
5. Envirobuilt Pvt. Ltd., Nashik
6. Ashking Pvt. Ltd., Nashik

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Consultant/Adviser to:

- Government of Odisha
- Andhra Pradesh Power Generation Co.
- Odisha Power Generation Co.
- NALCO (Aluminum Company)
- GMR (Infrastructure Company)
- Adani Power
- Bhushan Steel Ltd.
- Dept. of Forest, Odisha, etc.

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PROJECTS ON AGRICULTURE COAL ASH USE:

Sl. No	Level of R&D	No. of Sites
1.	Pot experiments	9
2.	Laboratory scale experiments	9
3.	Technology field experiments at research farms	33
4.	Technology field experiments at farmer's field	49
5.	Technology field experiments at degraded/waste lands	8
6.	Technology field experiments at fly ash filled areas/ ash ponds	21
7.	Large scale field demonstration in farmer's field for confidence building	646
Total		775

Field Crops & Vegetables grown with Fly Ash with different Soil Types at various project sites (under the aegis of FAM, DST, New Delhi)

S.N.	Soil	Fly ash doses range	Crops & No. of Sites	Location	Executed by
1	Alluvial Soil	0-200 t/ha	Rice, wheat (2)	Farakka	CFRI, Dhanbad
2	Alluvial Soil	0-100 t/ha	Mustard, jute (1)	Farakka	-do-
3	Laterite Soil	0-200 t/ha	Rice, wheat (4)	Bakreshwar	-do-
4	Laterite Soil	0-100 t/ha	Mustard, Potato, Lentil (1)	Bakreshwar	-do-
5	Black Soil	0-50 t/ha	Sugarcane	Chidambaram	Annamalai University
6	Laterite Soil	0-150 t/ha	Groundnut	Neyveli	-do-
7	Laterite Soil	0-100 t/ha	Sugarcane	Neyveli	-do-

Field Crops & Vegetables grown with Fly Ash with different Soil Types at various project sites (under the aegis of FAM, DST, New Delhi) (Contd.)

S.N	Soil	Fly ash doses range	Crops & No. of Sites	Location	Executed by
8	Black Soil	0-150 t/ha	Rice-Green Gram (1)	Sathamangalam	Annamalai University
9	Black Soil	0-120 t/ha	Cotton-Rice (1)	Vellampudugai	-do-
10	Lateritic Soil	0-10 t/ha	Rice-Groundnut (3)	Kharagpur	IIT-Kharagpur
11	Lateritic Soil	0-20 t/ha	Rice,Groundnut-Mustard (1)	Kharagpur	-do-
12	Lateritic Soil	0-30 t/ha	Mustard-Rice (1)	Kharagpur	-do-
13	Lateritic Soil	0-10 t/ha	Rice (2) –Mustard, Groundnut, Potato (1)	Balarampur, Gholghoria, Burarai	-do-
14	Lateritic Soil (Red)	0-80 t/ha	Sunflower-Groundnut (2)	Raichur	CoA, Raichur

Field Crops & Vegetables grown with Fly Ash with different Soil Types at various project sites (under the aegis of FAM, DST, New Delhi) (Contd.)

S. N.	Soil	Fly ash doses range	Crops & No. of Sites	Location	Executed by
15	Black Soil	0-80 t/ha	Sunflower-Maize (2)	Raichur	CoA, Raichur
16	Alluvial Soil	0-650 t/ha	Tomato (1), Cabbage (1), Potato (1), wheat (2), Pea (1) – Maize (6), Wheat-Maize (2)	Dhodhar, Nilgiri, Rihand Nagar	RRL, Bhopal
17	Alluvial Soil	0-650 t/ha	Sunflower (1), tomato (1), Potato (1), Wheat (1), Berseem (1), Red Gram (1), Maize (1), Rice (1)	Nilgiri, Rihand Nagar	RRL, Bhopal
18	Alluvial Soil	0-40/0-80 t/ha	Rice-Wheat (1), Cotton-Wheat (1), Sunflower-Maize (1) Wheat-Rice (1)	Ropar, Bhatinda	PAU Ludhaina

Field Crops & Vegetables grown with Fly Ash with different Soil Types at various project sites (under the aegis of FAM, DST, New Delhi) (Contd.)

S. N.	Soil	Fly ash doses range	Crops & No. of Sites	Location	Executed by
19	Alluvial Soil	0-12 t/ha	Wheat	Ropar (Astalpur)	PAU Ludhaina
20	Alluvial Soil	100% ash body with 7.5 cm soil cover	Arhar-Wheat (1)	Bhatinda	PAU Ludhaina
21	Black Soil	0-640 t/ha (Residual Effect)	Wheat-Maize, Soyabean-Maize, Lemon Grass (1)	Sarni	RRL, Bhopal
22	Alluvial Soil	0-640 t/ha	Maize-Onion, Rice-Sunflower (1)	Angul	RRL, Bhopal

Field Crops & Vegetables grown with Fly Ash with different Soil Types at various project sites (under the aegis of FAM, DST, New Delhi) (Contd.)

S. N.	Soil	Fly ash doses range	Crops & No. of Sites	Location	Executed by
23	Black Cotton Soil	50 t/ha	Cotton (10) Sorghum (9)	Paras	PDKV, Akola
24	Black Cotton Soil	50 t/ha	Sugarcane (19) Soybean (2)	Nashik	PDKV, Akola
25	Black Soil	0-640 t/ha (Residual Effect)	Wheat-Maize, Soyabean-Maize, Lemon Grass (1)	Sarni	RRL, Bhopal
26	Alluvial Soil	0-640 t/ha	Maize-Onion, Rice-Sunflower (1)	Angul	RRL, Bhopal

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Indian Fly Ash

- A fine material occurred after combustion of coal/lignite
- Having low bulk density
- Sandy silt to sandy loam texture
- Major constituents SiO_2 , Fe_2O_3 , Al_2O_3
- Contains Macro nutrients : Ca, Mg, K, P, S
Micro nutrients : Cu, Zn, Mn, Fe, Mo, B
Heavy metals : As, Se, Pb, Cr, Ni, Cd
Radio nuclides : ^{226}Ra , ^{228}Ac , ^{40}K
- Very close resemblance with natural soils

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Physical Properties of Common Fly Ash and Natural Soil

Parameters	Fly ash	Natural Soil
pH	6.0 - 10.0	4.5 – 14.0
Specific gravity	1.45 - 2.25	2.55 – 2.75
Bulk density (g/cc)	0.85 - 1.2	1.30 – 1.80
Grain size distribution	silt to Silty loam	Varies with soil type
Porosity (%)	45 – 55	20 – 60
Water holding capacity (%)	25 – 40	10 – 45
Electrical conductivity (dS/m)	0.15 – 1.10	variable

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Chemical properties of common fly ash and natural soil (%)

Parameters	Fly ash	Natural Soil
SiO ₂	35 - 65	40 – 65
Al ₂ O ₃	25 - 45	10 – 40
TiO ₂	0.4 -1.8	0.20 – 2.00
Fe ₂ O ₃	0.5 - 6.0	1.00 – 4.00
MnO	0.1 - 0.5	0.02 – 0.10
MgO	0.01 - 0.5	0.20 – 3.00
CaO	0.2 - 8.0	0.50 – 7.00
K ₂ O	0.04 - 0.9	0.40 – 0.20
Na ₂ O	0.07 - 0.43	0.20 – 3.00
L.O.I.	0.2 – 8.0	5 – 16
Organic carbon	0.02- 0.20	0.35 - 0.85

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Total and Available Major, Secondary and Micro Nutrients in Fly Ash and Soil

Nutrient	Total (per cent)		Available (ppm)	
	Fly Ash	Soil	Fly Ash	Soil
N	0.003-0.02	0.02-0.06	5.00-30.00	30.0-150.00
P	0.05-0.80	0.30-0.50	2.00-04.00	5.00-8.00
K	0.80-1.20	0.80-1.60	60.00-150.00	150.00-500.00
Ca	1.20-8.00	0.50-3.00	30.00-140.00	50.00-200.00
Mg	0.01-0.50	0.40-0.80	50.00-60.00	50.00-100.00
S	0.04-0.09	0.06-0.50	30.00-60.00	40.00-100.00

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Total and Available Major, Secondary and Micro Nutrients in Fly Ash and Soil (Contd..)

Nutrient	Total (per cent)		Available (ppm)	
	Fly Ash	Soil	Fly Ash	Soil
Cu	*40.00-80.0	*30.00-60.0	0.50-1.60	0.60-2.00
Zn	*50.00-150.0	*40.00-80.0	0.4-1.80	0.50-3.00
Mn	*500.00-750.0	*100.00-350.0	0.9-1.50	1.00-1.90
Fe	1.50-3.20	0.50-6.50	10.00-25.00	20.00-50.00
B	*17.00-38.0	*10.00-40.00	0.5-1.80	0.10-1.20
Mo	*2.20-6.70	*2.10-04.80	0.10-0.60	0.05-0.80

*ppm

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Total and Available Trace/Heavy Metals in Fly Ash and Soil

Trace/heavy Metals	Total (per cent)		Available (ppm)	
	Fly Ash	Soil	Fly Ash	Soil
Se	0.60-2.60	1.20-2.90	0.10-0.40	0.30-0.80
Cr	50.00-150.00	5.00-40.00	0.30-0.60	BDL-0.50
Pb	10.00-70.00	5.00-30.00	BDL-0.60	BDL-0.40
Co	10.00-50.00	8.00-35.00	0.05-0.15	0.04-0.20
Ni	50.00-150.00	60.00-200.00	0.15-0.25	0.25-0.40
Cd	5.00-10.00	3.00-6.00	0.03-0.07	BDL-0.06
As	1.00-4.00	0.10-1.50	BDL-0.03	BDL-0.01
Hg	BDL	BDL	BDL	BDL

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Why its use in Agro-forestry

- Improves soil texture and reduces bulk density.
- Improves permeability and water holding capacity
- Improves tillage and reduces crust formation.
- Enhances root proliferation.
- Conserves plant nutrients and water.
- Reduces pest incidence.
- Provides macro (K, P, Ca, Mg, S) and micro (Fe, Zn, Cu, Mn, Mo, B) nutrients
- Part substitution of gypsum (up to about 75% with fly ash as a substitute for reclamation of in sodic – saline soils
- Enhance plant productivity and crop yield

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Increased seed yield of sunflower with flyash at 60 t/ha, at Raichur, Karnataka

Mustard in fly ash improved soil, Kharagpur, W. Bengal



Cultivation of cabbage on coal ash amended soil at Dodhar, Rihandnagar (U.P.)







Saline soil reclamation using fly ash

Forestry at BTPS ash pond



Results on the Effect of Fly Ash/ Pond Ash on the Increase in Yield of few crops grown in varied soils

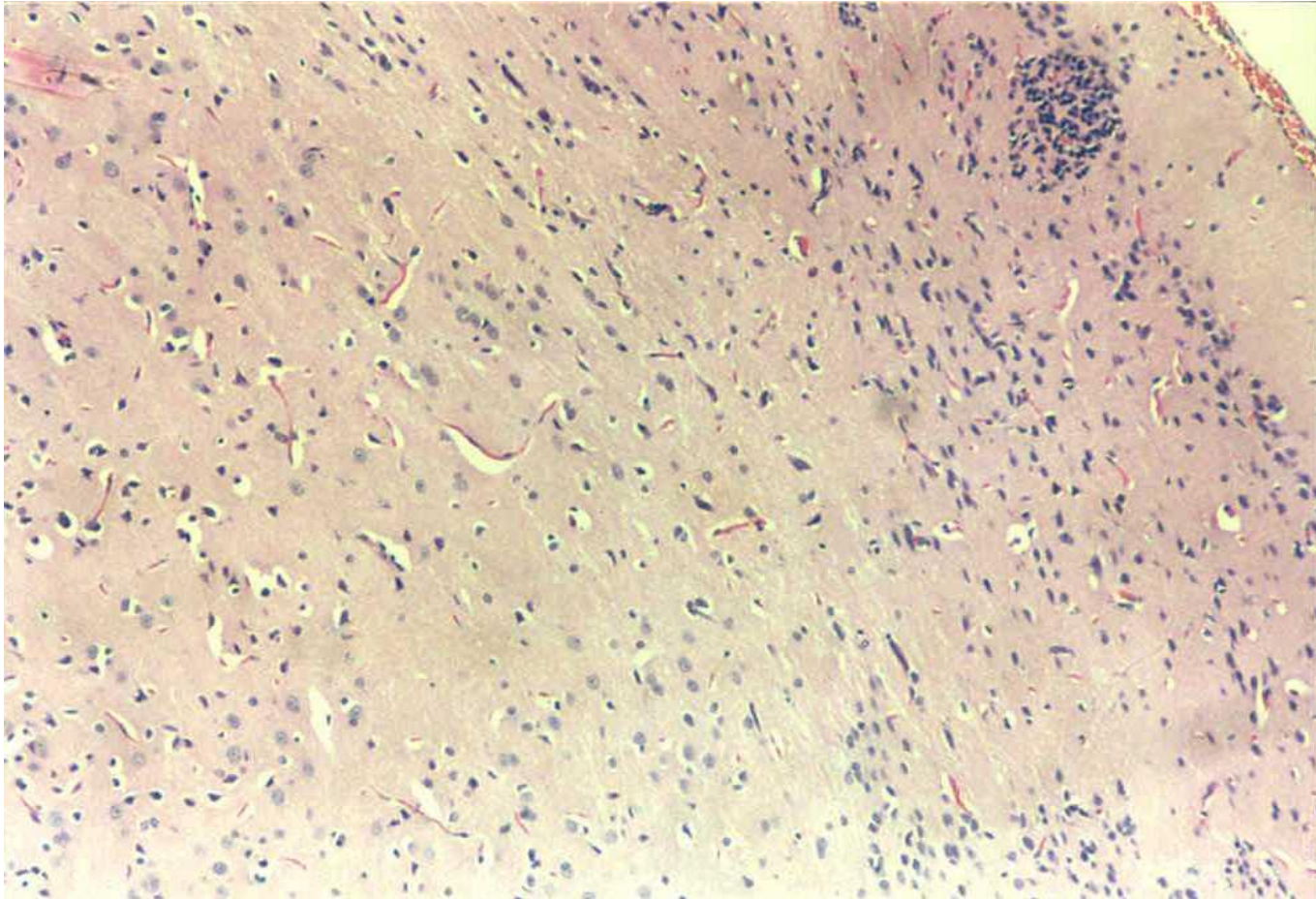
Crop	% Increase Over Control	Soil Type	FA/PA Dose t/ha
Paddy	10-15	Alluvial	200 t/ha
Wheat	15-20	Laterite	200 t/ha
Maize	10-15	Black	30 t/ha+FYM @ 20 t/ha
Lentil	15-20	Laterite	100 t/ha
Green Gram	20-25	Black	150 t/ha + FYM @12.5 t/ha
Groundnut	25-30	Black	30 t/ha + FYM @20 t/ha
Sunflower	20-25	Red	60 t/ha + FYM @20 t/ha
Mustard	15-20	Laterite	10t/ha
Tomato	35-40	Landfill	650 t/ha +FYM
Cabbage	30-35	Landfill	650 t/ha +FYM
FA: Fly Ash PA: Pond Ash LANDFILL SITE			

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Nutritional Quality of Crop Produce grown on Fly Ash amended soil at NIN, Hyderabad

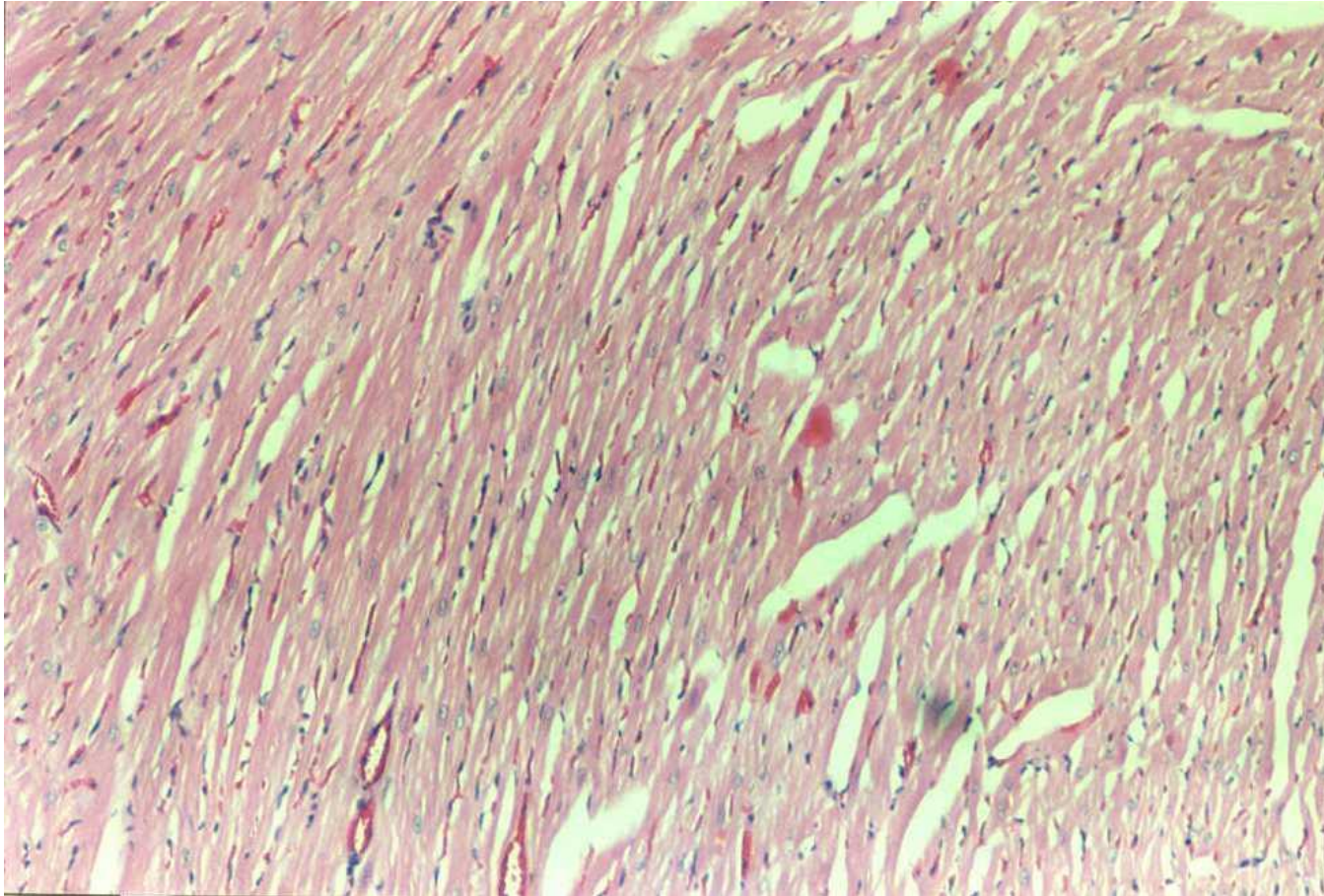
- ☐ No change in proximate composition and trace mineral content
- ☐ Carbohydrate/ Fat/ Protein / Fe / Ca contents generally increased
- ☐ No increase in heavy metal content
- ☐ Biological parameters similar during growth study on experimental animals
- ☐ Histopathology of tissues did not exhibit any abnormality
- ☐ Crop produce is safe for human consumption

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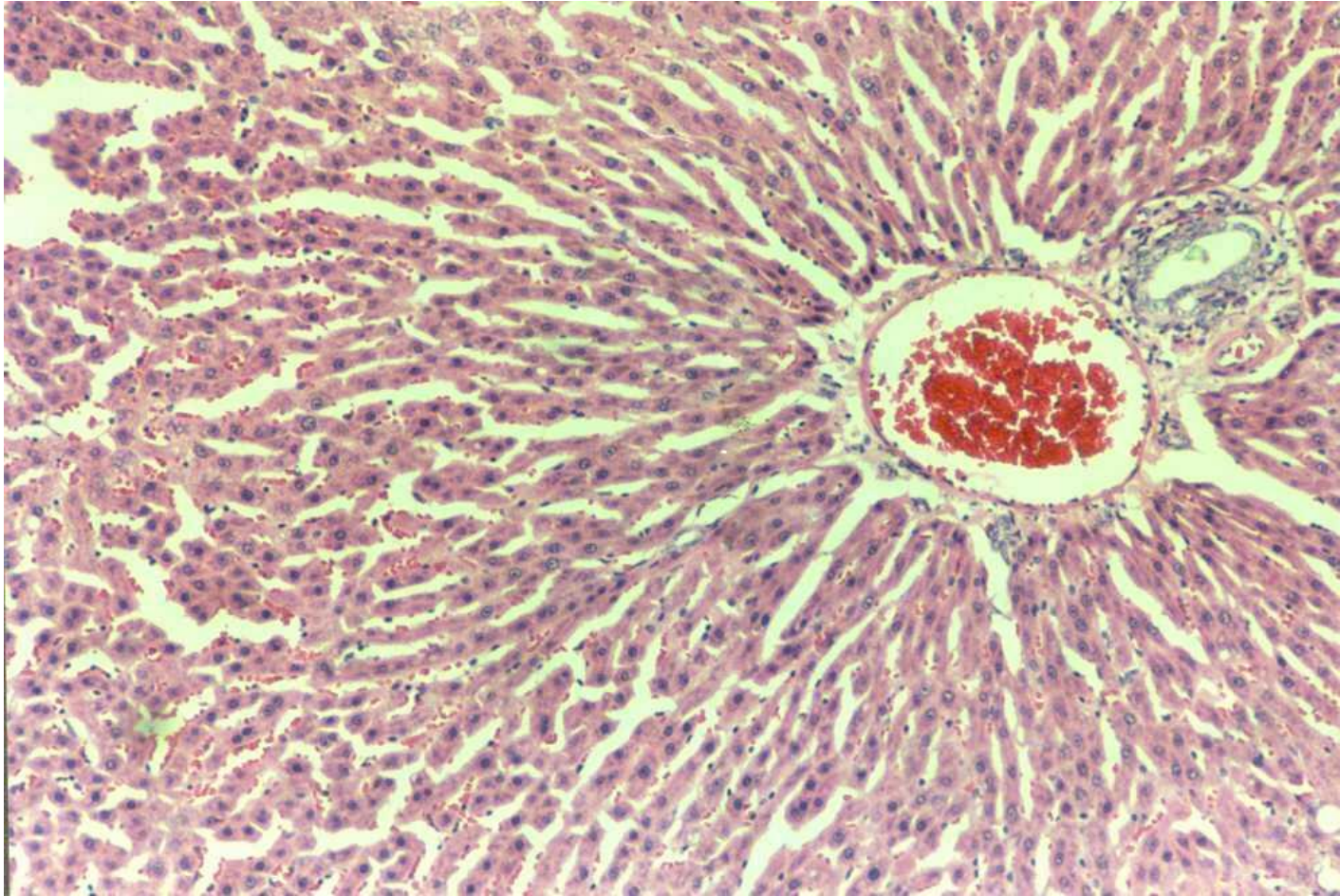
**BRAIN - SHOWING NEURONS
AND BLOOD VESSELS - H & E X 100 - NORMAL**

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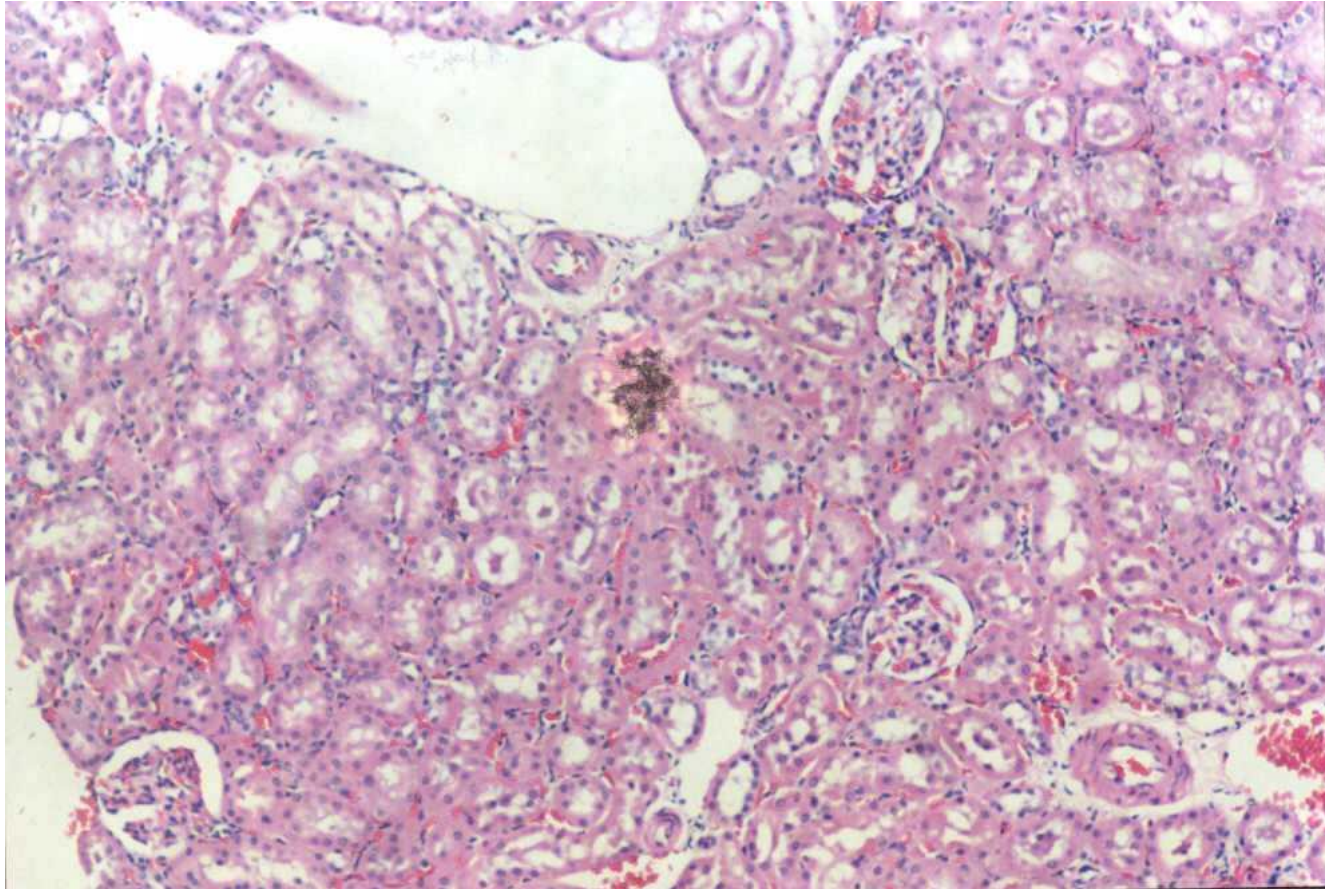
**HEART - SHOWING MUSLCLE
FIBRES ARRANGED LONGITUDINALLY - H & E X 100 - NORMAL**

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**LIVER - SHOWING HEPATOCYTES AND PORTAL TRIAD - H & E X 100 -
NORMAL**

AGRICULTURE COAL ASH USE



**KIDNEY - SHOWING GLOMERULI AND TUBULES - H & E X 100 -
NORMAL**

Impact of radioactivity content in fly ash, soil and crop produce

Sample	Radio activity (Bq/kg)		
	^{40}K	^{226}Ra	^{228}Ac
ESP fly ash	280-432.5	43.6-115.4	55-129
Pond ash	280-353	69-92	77-108
Soil	160-326	30-58.8	37-80
Grain	9-95	0.29-0.75	0.60-1.60
Straw	8.4-10.9	0.39-0.72	0.78-1.00
Vegetables	0.6-85	0.1-0.5	0.4-0.8
Oil seeds	60-110	0.3-0.8	0.6-1.0
Normal range in soil	4000*	1000*	1000*

*Source: Atomic Energy Regulatory Board, Radiological Safety Division, Dept. of Atomic Energy, Govt. of India letter no AERD/RSD/28/2002/6007 on dated 26.07. 2002

Impact of heavy metal content in fly ash, soil and crop produce

Sample	Trace & Heavy metals (ppm)			
	B	Mo	As	Se
ESP fly ash	17.1-28.0	2.5-6.7	1.0-4.0	1.6-2.6
Pond ash	18.3-23.1	2.6-5.3	1.4-3.6	1.2-2.3
Soil	13-17	0-4.8	1.9-2.9	2.4-4.0
Grain	0.2-1.6	0-1.2	0-0.45	0.10-1.0
Straw	0.29-0.42	0-0.67	0-.40	0.18-0.55
Vegetables	0.72-1.3	0.2-0.06	0.10-0.50	0-0.14
Oil seeds	0.1-1.3	0.2-0.6	0.3-0.4	0.10-1.06
Normal range in soil	2-100*	0.1-40*	5-100*	0.1-10*

***Source: P.C. Srivastava and U.C. Gupta (1996): trace element in crop production, oxford and IBH publishing Co. Pvt. Ltd., New Delhi.**

AGRICULTURE COAL ASH USE

PHYSICO CHEMICAL PROPERTIES OF SOILS AT THE START AND AT THE COMPLETION OF THE PROJECT

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	Start(s) Completion(c)	pH	EC dS/m	BD gm/Cm ²	WHC %	TOC %
1	SUTI-II	Alluvial sandy loam	PA 200	s	7.99	1.04	1.52	42.88	-
				c	8.06	0.12	1.42	48.55	-
2	BKTPP-I	Acidic Red sandy loam	PA 200	s	5.01	0.05	1.63	30.92	-
				c	5.39	0.04	1.52	44.73	-
3	IIT(Kharaghpur)	Acid Laterite sandy clay loam	DFA 10	s	5.32	0.02	1.67	34.20	-
				c	5.88	0.03	1.52	37.90	-
3	Balrampur	Acid Laterite sandy clay loam	PA 10	s	4.99	0.02	1.52	35.30	-
				c	5.55	0.03	1.49	39.50	-
4	Yakubpur	Alluvial clay loam	PA 30	s	9.40	1.97	1.16	49.11	-
				c	9.50	1.87	1.14	51.79	-
5	Dodher	Alluvial sandy loam	PA 1170	s	6.40	0.12	1.30	27.40	-
				c	7.40	0.21	1.25	40.00	-
6	RRS Bhatinda	Alluvial sandy loam	PA 80	s	7.66	0.55	0.92	-	-
				c	8.85	0.28	1.33	-	-
7	Sukhdana	Alluvial clay	PA 300	s	7.80	0.457	1.10	64.60	0.57
				c	8.40	0.251	1.31	55.00	-

AGRICULTURE COAL ASH USE

Project No	Site	Soil type	FA Dose t/ha	N %	P %	K %	Ca %	Mg %	S %	TDA mg/kg/24 hr
1	SUTI-II	Alluvial sandy loam	PA 200	0.109	0.068	0.975	0.003	0.002	0.352	68.73
				0.114	0.075	0.908	0.003	0.002	0.032	78.3
2	BKTPP-I	Acidic Red sandy loam	PA 200	0.051	0.013	0.768	-	-	0.057	Nil
				0.016	0.001	0.01	-	-	0.005	12(PA 100)
3	IIT(Kharaghpur)	Acid Laterite sandy clay loam	DFA 10	-	-	-	-	-	-	-
				-	-	-	-	-	-	-
3	Balrampur	Acid Laterite sandy clay loam	PA 10	0.047	0.52	0.17	-	0.049	-	-
				0.062	0.06	0.188	-	0.055	-	-
4	Yakubpur	Alluvial clay loam	PA 30	4.7ppm	11.2ppm	390.0ppm	-	-	1.5	2.58
				57.8ppm	15.67ppm	530ppm	-	-	26.6ppm	6.1
5	Dodher	Alluvial sandy loam	PA 1170	0.25	0.06	1.7	-	-	0.015	NA
				0.059	0.076	6.7	-	-	0.373	2.4
6	RRS Bhatinda	Alluvial sandy loam	PA 80	-	399ppm	2102ppm	7105	2708	89.5	-
				-	485ppm	2193ppm	10755ppm	3204ppm	135ppm	-
7	Sukhdana	Alluvial clay	PA 300	-	-	-	380	72	NA	-
				150ppm	40ppm	170ppm	2435ppm	403ppm	12ppm	-

AGRICULTURE COAL ASH USE

Project. No	Soil type & site	FA Dose t/ha	Start(s) Completion(c)	pH	EC dS/m	BD gm/Cm ²	WHC %	TOC %
8	Red soil (Rain fed) RRS, Raichur	PA 60	s	8.50	0.10	1.62	41.90	-
			c	8.56	0.143	1.60	45.40	-
	Black soil (Rain fed) RRS, Raichur		s	8.60	0.14	1.3	64.20	-
			c	8.60	0.235	1.29	67.40	-
	Red soil (Irrigated) RRS, Raichur		s	8.50	0.10	1.62	41.90	-
			c	8.56	0.143	1.59	45.20	-
	Black soil (Irrigated) RRS, Raichur		s	8.60	0.14	1.30	64.20	-
			c	8.60	0.235	1.28	67.38	-
9	Clay loam Santhamangalam, TN	DLFA 10	s	6.90	0.50	1.00	27.40	-
			c	7.30	1.00	1.10	27.20	-
	Heavy clay Vallampadugu, TN	DLFA 50	s	6.40	0.50	1.10	24.13	-
			c	7.29	0.78	1.19	24.02	-
	Sandy loam TANCOF, Neyveli	DLFA 20	s	74.00	0.32	1.20	25.47	-
			c	8.27	0.83	1.30	25.21	-

AGRICULTURE COAL ASH USE

Project. No	Soil type	FA Dose t/ha	N %	P %	K %	Ca %	Mg %	S %	TDA mg/kg/24 hr
8	Red soil (Rain fed) RRS, Raichur	PA 60	286.0kg/ha	33.9kg/ha	292.0kg/h a	13.5kg/ha	1.4kg/ha	13.9kg/h a	-
			295.10	34.5	337.5	14.4	2.2	15.1	-
	Black soil (Rain fed) RRS, Raichur		376.10	19.2	770.3	35.7	12.1	48	-
	379.00		20.5	794.7	43.1	13.5	45.3	-	
	Red soil (Irrigated) RRS, Raichur		286.00	33.9	292	13.5	1.4	13.9	1120
	323.50		37.6	376.6	17.7	2.8	15.5	1210.1	
	Black soil (Irrigated) RRS, Raichur		376.10	19.2	770.3	35.7	12.1	48	6940 mg/kg/ day
	408.10		24.3	805.5	42.7	16.9	46.6	5075	
9	Clay loam Santhamangalam, TN	DLFA 10	237 kg/ha	24.6 kg/ha	294 kg/ha	10.4 kg/ha	9.3 kg/ha	43.6 kg/ha	0.02
			226 kg/ha	24.6 kg/ha	306.6 kg/ha	11.214	9.7 kg/ha	69.6 kg/ha	0.052
	Heavy clay Vallampadugu, TN	DLFA 50	370 kg/ha	96 ppm	1.06	1.74	0.69	0.7	0.037
			390 kg/ha	99 ppm	1.13	1.87	0.79	0.76	0.081
	Sandy loam TANCOF, Neyveli	DLFA 20	440 kg/ha	88 ppm	0.96	1.4	0.81	0.66	0.077
			455 kg/ha	96 ppm	1.02	1.51	0.89	0.71	0.093

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	Start(s) Completion (c)	pH	EC dS/m	BD gm/Cm ²	WHC %	TOC %
15	Hissar	Sandy Sandyloam loam	PA 400	s	8.10	0.19	-	-	0.36
				c	8.13	0.15	-	-	0.23
16	Mettur	Inceptisols alfosols	PA 20	s	-	-	-	-	-
				c	-	-	-	-	-
	Arachalur	Inceptisols/ alfosols	PA 20	s	-	-	-	-	-
				c	-	-	-	-	-
	PudhukooraiPET	Lateritic	PA 20	s	-	-	-	-	-
				c	-	-	-	-	-
	Kuppanatham	Lateritic	PA 20	s	-	-	-	-	-
				c	-	-	-	-	-
17	Anpara	Alluvial s andy loam	PA 100	s	7.69	0.287	-	-	0.619
				c	7.34	0.279	-	-	0.62
	Obra	Alluvial sandy loam	PA 100	s	6.70	0.099	-	-	0.26
				c	6.40	0.093	-	-	0.28
	Harduaganj	Wasteland	PA 200	s	8.77	0.235	-	-	0.39
				c	8.65	0.229	-	-	0.39

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	N %	P %	K %	Ca %	Mg %	S %
15	Hissar	Sandy Sandyloam loam	PA 400	152.4 kg/ha	36.4 kg/ha	266.1 kg/ha	-	-	-
				159.6 kg/ha	36.8 kg/ha	277.5 kg/ha	-	-	-
16	Mettur	Inceptisols alfosols	PA 20	175 kg/ha	16 kg/ha	165 kg/ha	-	-	-
				178 kg/ha	17.4 kg/ha	168 kg/ha	-	-	-
	Arachalur	Inceptisols/ alfosols	PA 20	171 kg/ha	17.5 kg/ha	158 kg/ha	-	-	-
				178 kg/ha	18.2 kg/ha	163 kg/ha	-	-	-
	PudhukooraiPET	Lateritic	PA 20	251 kg/ha	17 kg/ha	310 kg/ha	-	-	-
				258 kg/ha	18.2 kg/ha	310 kg/ha	-	-	-
	Kuppanatham	Lateritic	PA 20	248 kg/ha	18.8 kg/ha	270 kg/ha	-	-	-
				250 kg/ha	20.2 kg/ha	272 kg/ha	-	-	-
17	Anpara	Alluvial s andy loam	PA 100	141 ppm	6.58 ppm	65.4 ppm	22.8 ppm	17 ppm	35.1 ppm
				151.5 ppm	6.27 ppm	77.21 ppm	34.32 ppm	24.52 ppm	18.98 ppm
	Obra	Alluvial sandy loam	PA 100	60.1 ppm	2.26 ppm	63.5 ppm	21.95 ppm	13.89 ppm	31.22 ppm
				63.83 ppm	2.59 ppm	55.97 ppm	23.87 ppm	14.71 ppm	37.23 ppm
	Harduaganj	Wasteland	PA 200	86 ppm	3.65 ppm	95 ppm	25.55 ppm	16.9 ppm	34.15 ppm
				90.05 ppm	3.68 ppm	92.95 ppm	27.7 ppm	17.25 ppm	34.9 ppm

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	Start(s) Completion(c)	pH	EC dS/m	BD gm/Cm ²	WHC %	TOC %
18	Koradi TPS (Groundnut)	Clayey	PA 15	s	8.00	0.43	-	-	0.51
				c	8.10	0.43	-	-	0.51
	Koradi TPS (Cotton)	Clayey	PA 10	s	8.30	0.41	-	-	0.48
				c	8.20	0.42	-	-	0.5
	Koradi TPS (Sorghum)	Clayey	PA 10	s	8.20	0.41	-	-	0.43
				c	8.20	0.43	-	-	0.53
20	Koradi	Red soil (after 4th crop)	PA 50	s	7.20	0.023	1.39	41.60	0.29
				c	7.30	0.026	1.37	42.43	0.31
	Koradi	Black soil (after 4th crop)	PA 50	s	8.22	0.04	1.36	44.82	0.51
				c	8.17	0.047	1.32	45.04	0.52

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	N %	P %	K %	Ca %	Mg %	S %
18	Koradi TPS (Groundnut)	Clayey	PA 15	255.9 kg / ha	48.34 kg/ha	319.3kg/ha	-	-	-
				254.5 kg/ha	49.49 kg/ha	318.7 kg/ha	-	-	-
	Koradi TPS (Cotton)	Clayey	PA 10	242.1 kg/ha	47.81kg/ha	387.1 kg/ha	-	-	-
				259.7 kg/ha	44.32 kg/ha	422.5 kg/ha	-	-	-
	Koradi TPS (Sorghum)	Clayey	PA 10	220.5 kg/ha	32.82 kg/ha	398.7 kg/ha	-	-	-
				266.6 kg/ha	44.61kg/ha	445.7 kg/ha	-	-	-
20	Koradi	Red soil (after 4th crop)	PA 50	0.027A	0.014A	0.45A	0.69	0.33	0.015
				0.031A	0.02A	0.48A	0.74	0.38	0.019
	Koradi	Black soil (after 4th crop)	PA 50	0.03	0.02	0.58	0.85	0.4	0.02
				0.033	0.025	0.63	0.88	0.43	0.023

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	Start(s) Completion(c)	pH	EC dS/m	BD gm/Cm ²	WHC %	TOC %
21	Jhansi	Black soil	100	s	7.00	0.08	1.28	-	-
				c	6.90	0.08	1.22	-	-
		Red soil	100	s	7.30	0.14	1.36	-	-
				c	6.90	0.09	1.28	-	-
22	Neyveli	Lateritic	200	s	5.40	0.605	1.58	27.40	1.33
				c	6.60	0.87	1.50	30.30	1.52
		Mine spoil	200	s	6.60	0.407	1.70	20.80	0.32
				c	7.20	0.797	1.60	24.60	0.53
24	Santiniketan	Red and lateritic (after 6th crop)	Vermi composed PA 1000	s	-	-	-	-	-
				c	-	-	-	-	-
25	Jhamadhobha	Low lying	Ash filled	s	8.09	0.003	0.98	70.86	0.33
				c	7.86	0.04	1.05	62.90	0.367
26	Ramagundam (oxidation pond)	Red laterite sandy loam	PA 200	s	8.50	0.09	1.41	23.68	0.37
				c	8.34	0.09	1.34	27.00	0.41

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	N %	P %	K %	Ca %	Mg %	S %	TDA mg/kg/24 hr
21	Jhansi	Black soil	100	-	-	-	-	-	-	-
				-	-	-	-	-	-	-
		Red soil	100	-	-	-	-	-	-	-
				-	-	-	-	-	-	-
22	Neyveli	Lateritic	200	102 ppm	4.3 ppm	144.5 ppm	63.5 ppm	48.9 ppm	41.2 ppm	0.27X24
				125 ppm	5.6 ppm	145.8 ppm	74.5 ppm	49.2 ppm	50.3 ppm	0.44X24
		Mine spoil	200	88 ppm	3.1 ppm	22.1 ppm	40.2 ppm	28.3 ppm	37.7 ppm	0.061X24
				120 ppm	4 ppm	31.7 ppm	53.1 ppm	35.3 ppm	55.1 ppm	0.0117X24
24	Santiniketan	Red and lateritic (after 6th crop)	Vermi composed PA 1000	430.5 ppm	14.7ppm	69.5 ppm	-	-	-	-
				488.2 ppm	18.5 ppm	37.2 ppm	-	-	-	-
25	Jhamadhobha	Low lying	Ash filled	BDL	16.12 ppm	62.0 ppm	26.2 ppm	14.64 ppm	44.3 ppm	NIL
				0.045	18.51 ppm	64.9 ppm	24.14 ppm	11.29 ppm	42.1 ppm	0.376
26	Ramagundam (oxidation pond)	Red laterite sandy loam	PA 200	800.90%	10.4 ppm	75.6 ppm	19.3 ppm	15.7 ppm	13.4 ppm	-
				141.0 ppm	11.3 ppm	71.6 ppm	18.5 ppm	18.1 ppm	11.5 ppm	-

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	Start (s) Completion (c)	pH	EC dS/m	BD gm/Cm ²	WHC %	TOC %
27	Chandrapur (Iohara)	Waste degraded land	PA 1200	s	8.70	0.17	1.56	39.70	0.76
				c	8.59	0.251	1.27	45.51	0.8
	Bhusawal (V.M.Rane's field)	Ash affected land	PA 500	s	8.02	0.246	1.48	35.73	0.19
				c	8.21	0.297	1.30	41.50	0.39
	Chandrapur Prof. Bulki's field	Medium black cotton	PA 10	s	8.50	0.35	1.58	55.20	0.48
				c	8.40	0.37	1.45	52.80	0.48
	Chandrapur	NA	Abandoned Ash pond	s	7.28	-	-	-	0.63
				c	6.93	-	-	-	0.75
32	Bakreshwar	Red lateritic sandy loam	PA 100	s	5.06	0.04	1.28	24.60	0.34
				c	5.50	0.07	1.18	30.90	0.45
33	Tildanga, Farakka	Alluvial sandy loam	DFA 25	s	8.21	0.14	-	-	0.49
				c	8.29	0.15	-	-	0.56

AGRICULTURE COAL ASH USE

Project. No	Site	Soil type	FA Dose t/ha	N %	P %	K %	Ca %	Mg %	S %	TDA mg/kg/24 hr
27	Chandrapur (lohara)(Waste degraded land	PA 1200	0.058	19.3 kg/h	380.2 kg/h	-	-	-	1.69
				0.073	21.12 kg/h	384.7 kg/h	-	-	-	1.85
	Bhusawal (V.M.Rane's field)	Ash affected land	PA 500	0.02	14.9 kg/h	234.6 kg/h	-	-	-	1.94
				69 kg/h	15.7 kg/h	241.8 kg/h	-	-	-	2.2
	Chandrapur Prof. Bulki's field	Medium black cotton	PA 10	212.4 kg/ha	38.26 kg/h	282.4 kg/h	56.74 kg/h	31.38 kg/h	55.93 kg/h	1.64
				226.3 kg/ha	42.08 kg/ha	304.43 kg/ha	55.13 kg/ha	34.92 kg/ha	59.29 kg/ha	1.7
	Chandrapur	NA	Abandoned Ash pond	10.00 ppm	8.5 ppm	99.34 ppm	-	-	-	NIL
				19.35 ppm	11.97 ppm	127 ppm	-	-	-	0.36
32	Bakreshwar	Red lateritic sandy loam	PA 100	0.008	20.00 ppm	52.00 ppm	-	-	-	NIL
				93 ppm	20.5 ppm	75 ppm	-	-	-	2.4
33	Tildanga, Farakka	Alluvial sandy loam	DFA 25	95 ppm	23.1 ppm	115 ppm	-	-	-	NIL
				115 ppm	26.2 ppm	39 ppm	-	-	-	3.4

AGRICULTURE COAL ASH USE

TRACE AND HEAVY METAL CONTENT IN THE SOIL

AGRICULTURE COAL ASH USE

S. No	Location	fly ash dose t/ha	Zn	Cu	Mo	Fe	Mn	Project No
1	Suti II	PA 200	-	-	-	-	-	1
2	BKTPP		-	-	-	-	-	2
3	IIT Kharagpur	FA 10	-	-	-	-	-	3
4		PA 10	-	-	-	-	-	
5	Yakubpur	PA 30	66.00	17.83	10.01	5576.67	276.50	4
6	Dodhar	PA 1170	77.00	41.00	2.00		671.00	5
7	Nilgiri	PA 615	-	-	-	-	-	
8	RRS Bhatinda	PA 80	50.50	7.60	8.30	8672.00	168.70	6
9	Sukhdana	PA 300	0.45	1.40	-	13.00	8.96	7
10	Raichur	PA 80/yr	-	-	-	-	-	8
11			-	-	-	-	-	
12			-	-	-	-	-	
13			-	-	-	-	-	

AGRICULTURE COAL ASH USE

S. No	Location	fly ash dose t/ha	Pb	Ni	Se	Cr	Cd	As	Co	B	Hg	Project No
1	Suti II	PA 200	18.10	45.10	2.00	23.70	10.10	1.00	58.60	-	BDL	1
2	BKTPP		23.61	216.72	2.60	179.56	7.29	0.49	35.14	-	BDL	2
3	IIT Kharagpur	FA 10	8.70	10.83	-	-	0.401	-	3.16	-	-	3
4		PA 10	9.50	8.06	-	-	0.471	-	3.78	-	-	
5	Yakubpur	PA 30	16.17	17.30	1.70	40.67	1.93	2.60	22.50	-	-	4
6	Dodhar	PA 1170	13.00	43.00	1.80	65.00	BDL	2.50	-	-	-	5
7	Nilgiri	PA 615	29.75	55.50	1.70	69.00	BDL	-	57.25	-	-	
8	RRS Bhatinda	PA 80	-	-	-	-	-	-	-	40.20	-	6
9	Sukhdana	PA 300	1.59	0.43	-	0.19	-	-	-	-	-	7
10	Raichur	PA 80/yr	14.60	-	1.40	-	-	1.60	-	-	-	8
11			15.50	-	1.40	-	-	1.50	-	-	-	
12			15.00	-	1.30	-	-	1.50	-	-	-	
13			16.90	-	1.40	-	-	2.00	-	-	-	

AGRICULTURE COAL ASH USE

S.No	Location	fly ash dose t/ha	Zn	Cu	Mo	Fe	Mn
14	Sathamangalam	Dry LFA 50	44.80	24.80	1.80	1098.70	128.40
15	AU expt. Form		50.10	28.90	1.80	1152.40	139.50
16	Vallam padugai		54.90	26.80	2.10	1198.20	147.20
19	Ramagundam (after crop I)	PA 200	2.33	1.07	-	15.60	3.69
20	Ramagundam (after crop III)		2.40	1.14	-	15.61	3.72
23	Susri*	Ash pond effluent from Bhusawal	2.03	2.72	-	4.44	6.61
24	Pimpalgaon Shivar*		2.06	4.31	-	5.88	8.12
25	Pimpalgaon Khurd (1)*		1.36	3.64	-	5.82	5.77
26	Pimpalgaon Khurd (2)*		1.68	3.52	-	5.81	11.43
27	Varamgaon*		1.33	2.74	-	4.41	8.95
28	Sakari*		0.99	2.81	-	7.19	8.92

AGRICULTURE COAL ASH USE

S. No	Location	fly ash dose t/ha	Pb	Ni	Se	Cr	Cd	As	Co	B	Hg	Project No
14	Sathamangalam	Dry LFA 50	1.24	0.48	1.50	0.15	1.50	-	0.19	8.30	-	9
15	AU expt. Form		0.99	0.45	1.70	0.14	1.60	-	0.19	9.80	-	
16	Vallam padugai		1.27	0.49	1.90	0.15	1.60	-	0.18	13.10	-	
19	Ramagundam (after crop I)	PA 200	0.17	0.41	-	ND	0.03	BDL	BDL	-	BDL	26
20	Ramagundam (after crop III)		0.18	0.42	-	BDL	0.029	BDL	BDL	-	BDL	
23	Susri*	Ash pond effluent from Bhusawal	2.16	0.51	-	BDL	BDL	BDL	0.04	-	BDL	
24	Pimpalgaon Shivar*		2.81	0.59	-	BDL	BDL	BDL	0.06	-	BDL	
25	Pimpalgaon Khurd (1)*		2.71	0.51	-	BDL	BDL	BDL	0.05	-	BDL	
26	Pimpalgaon Khurd (2)*		2.97	0.59	-	BDL	BDL	BDL	0.05	-	BDL	
27	Varamgaon*		2.48	0.66	-	BDL	BDL	BDL	0.04	-	BDL	
28	Sakari*		2.97	0.69	-	BDL	BDL	BDL	0.06	-	BDL	
	Normal range in soils		10-200	0-500	0.1-10	0-400	0.01-1.1	5-100	0.05-300	NA	0.01-4.6	

AGRICULTURE COAL ASH USE

SUMMARY OF EXPERIMENTS AND FIELD DEMONSTRATIONS FOR USE OF FLY ASH FOR RECLAMATION OF PROBLAMATIC/DEGRADED SOIL

AGRICULTURE COAL ASH USE

State & Project duration	Location	Soil Type/ Texture	Plant species	Best results with	Results	Project No
Phulpur Uttar Pradesh 1997-2000	Dailapur	Alluvial Clay Loam (Sodic soil)	Paddy-Wheat(Iyear)-Paddy-Wheat-Green Manure(Dhaincha)(II & III year), (All sites except Tardih)	Pond Ash (30t) with 50% gypsum	3rd crop(Paddy) yield 1.73q/ha, (+214%) 2nd crop (Wheat) yield 29q/ha (+42%) 4th crop (Wheat)yield 32q/ha (+150%) 1st crop(Paddy) yield 26q/ha(+550%) 3rd crop(Paddy) yield 30.4q/ha (+87.6%) 2nd crop (Wheat), yield 33.6q/ha (+60%). 1st crop (Paddy) 32.6q/ha (+252.43)	4
	Yakubpur			Pond Ash (60t + FYM)		
	Puresudi			Pond Ash (30t) with 50% gypsum		
	Parasinpur 1 Parasinpur 2 Tardih			Pond Ash (30t) with 50% gypsum		
	Mubarakpur		Paddy, wheat	Pond Ash(60t) with FYM		
Jaipur Rajasthan 1997-2004	Bharutian Kalan, Chaksu	Highly degraded wasteland (Saline)	Eucalyptus and Zizyphus Vettiver, Stylosanthes and Melilotus sp.	Infectious propagules (500IP), FYM (4.5kg or nil)) and Fly ash(2.5kg)/plant. Manure 2t/ha for eucalyptus, 1t/ha in trial 2 and 5kg/plant in trial 4, for grasses 20t/ha of fly ash	Gola variety of Zizyphus 41.6kg/plant Vettiver 775gm/sq.m Stylosanthes 650gm/sq.m Melilotus parviflora 550gm/sq.m	10
Delhi 1997-1999	IIT Delhi campus near Nalanda guest house (site 1) Swimming Pool (Site2), Vaishali apartments(Site 3)	Alluvial (degraded) Sandy Loam	Ceiba pentandra, Bahunia purpurea, Melia azadirach, Casia siamea, Pongamia glabra, Erthrina indica, Thevetia elifera, Cassia glauca.	Mycorrhizal consortium at 600 propagules/pit, FYM to fly ash ratio 3 to 1.	Specie/Survival/ashpond/control % / m / m Ceiba pentandra, 92/1.60/1.23 Bahunia purpurea, 100/1.43/1.23 Casia siamea, 75/2.33/1.98 Erthrina indica, 100/1.60/1.25 Other plants growth was less. m-height reached in metres at Site 3 Control: Without Mycorrhiza.	12

AGRICULTURE COAL ASH USE

State	Location	Soil Type/ Texture	Plant species	Best results with	Results	Project No																						
Orissa 1997-2004	Daulatabad, Chowdwar	Laterite with limesludge deposition	Eucalyptus hybrid.	160 to 240t/ha of Fly Ash with soil conditioner and microbial inoculants.	<table><tr><th>Item</th><th>Without FA</th><th>With FA</th></tr><tr><td>GBH(cm)</td><td>16.2</td><td>15.6</td></tr><tr><td>Height (cm)</td><td>611</td><td>620</td></tr><tr><td>Stem wt.(kg)</td><td>16.5</td><td>18.2</td></tr><tr><td>Biomass(kg/plant)</td><td>24.3</td><td>26.7</td></tr><tr><td>Total wood(kg)</td><td>946</td><td>1442</td></tr></table>	Item	Without FA	With FA	GBH(cm)	16.2	15.6	Height (cm)	611	620	Stem wt.(kg)	16.5	18.2	Biomass(kg/plant)	24.3	26.7	Total wood(kg)	946	1442	13				
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Durgaprasad	Degraded soil with reddish brown lateritie. Sandy clay Loam to Sandy Loam	Eucalyptus hybrid Eucalyptus clones, Acacia auriculiformis, Casuarina equisetifolia Eucalyptus Acacia Acacia mangium	Fly ash 12% to be mixed in pits Fly ash (12% to 18%) + chemical fertilisers	<table><tr><th colspan="3">Survival % in 6th year</th></tr><tr><td>Acacia</td><td>45</td><td></td></tr><tr><td>Eucalyptus</td><td>82</td><td></td></tr><tr><td>Eucalyptus clones</td><td>14</td><td></td></tr><tr><th>Item</th><th>Height</th><th>collar dia</th></tr><tr><td>Acacia</td><td>0.84(1.78%)</td><td>1.23(2.05%)</td></tr><tr><td>Eucalyptus</td><td>4.93(5.12%)</td><td>0.92(1.73%)</td></tr><tr><td>Casuarina</td><td>1.20(2.45%)</td><td>1.75(4.01%)</td></tr></table> Figures in brackets indicate variance over control	Survival % in 6th year			Acacia	45		Eucalyptus	82		Eucalyptus clones	14		Item	Height	collar dia	Acacia	0.84(1.78%)	1.23(2.05%)	Eucalyptus	4.93(5.12%)	0.92(1.73%)	Casuarina	1.20(2.45%)	1.75(4.01%)
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Neyveli, Tamilnadu 1996-2000	Mine spoil	Silty Loam	Paddy-Green gram-Paddy- Green Manure-Paddy- Paddy -Green gram	LFA(Dry) 20t/ha +Pressed Mud 10t/ha +NPK. Repeat application of fly ash in 3rd and 5th crop at 20t/ha	3r crop (Paddy),27.2q/ha (+41.7%). 1st crop (Groundnut) yield 42.3q/ha, (+64%). 3rd crop(Maize) yield 38.3q/ha (+85%). 5th crop (Groundnut) 42q/ha (+75.7%) and 6th crop(maize)31.2q/ha (+76.4%)	22																						
	Overburden dump	Lateritic sandy Loam	Ground nut- Sunhemp - Maize- Sunhemp - Ground nut -Sun hemp - Maize. (Sunhemp grown for green manure	LFA (Dry)200t alone NPK with Pressed mud 10t/ha & LFA (Dry)200t. Repeat application before 3rd and 5th crops.	1st crop (Groundnut) yield 43q/ha, (+66.7%). 3rd crop(Maize) yield 39q/ha (+88.4%). 5th crop (Groundnut) 42.4q/ha (+77.4%) and 6th crop(Maize)31.8q/ha (+79.7%) + Percent increase over control																							

AGRICULTURE COAL ASH USE

						Project No																								
State	Location	Soil Type/ Texture	Plant species	Best results with	Results																									
Maharashtra 1996-1999	Lohara teak nursery Chandrapur	Waste/ degraded land	Teak (Tectona grandis)Saplings	Fly Ash at 1200t/ha	<table><thead><tr><th>Age</th><th>height cm</th><th>Dia mm</th></tr></thead><tbody><tr><td>4months</td><td>23.7/37.4</td><td>7.4/10.7</td></tr><tr><td>23months</td><td>145.1</td><td>13.4</td></tr><tr><td>Timber</td><td>control</td><td>Fly ash</td></tr><tr><td>Grade A</td><td>401</td><td>567</td></tr><tr><td>Grade B</td><td>58</td><td>54</td></tr><tr><td>Grade C</td><td>24</td><td>48</td></tr><tr><td>Total</td><td>483</td><td>669</td></tr></tbody></table>	Age	height cm	Dia mm	4months	23.7/37.4	7.4/10.7	23months	145.1	13.4	Timber	control	Fly ash	Grade A	401	567	Grade B	58	54	Grade C	24	48	Total	483	669	27
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AGRICULTURE COAL ASH USE

SUMMARY OF EXPERIMENTS AND FIELD DEMONSTRATIONS FOR USE OF FLY ASH FOR RECLAMATION OF AREAS CONTAINING ASH

AGRICULTURE COAL ASH USE

State & Project Duration	Location	Species planted	Best yield with	Achievement			Project ref
West Bengal 1996-1999	Ash filled low lying area (4000 sq.metre) in Farakka STPS	Dalbergia Sisoo	1:4 mixture of bottom ash up to a maximum depth of 3 metres, in pits of 15cm diameter, 15 cm depth and at 2m x 2m spacing	Time Zero 36months	Height (m) 0.75 4.05/4.21	Girth (cm) 6/6.2 22.2/23.2	1
Uttar Pradesh 1993-1999	40000 t Pond ash filled in 2ha area in Nilgiri	Sunflower/Sugarcane/Tomato/Cabbage/Okra/Redgram/Potato/Wheat/Maize/Paddy.	35cm top soil was spread and FYM and CF was applied	Crop Wheat Potato Maize	Yield (q/ha) 28 107 21.4	Increase over control (%) 12 9.2 12	5
Ropar, Punjab 1997-2001	Fly ash dumping site at GGS, Thermal Power Plant	Wheat,Sunflower, Winter Maize, Maize fodder and Raya	7.5 cm soil cover with FYM at 20t/ha	Crop Wheat Sunflower Maize fodder Raya	Yield q/ha 253 61 25 83	Increase over control (%) 61.8 2.6 62.5 3.3	6

AGRICULTURE COAL ASH USE

State & Project Duration	Location	Species planted	Best yield with	Achievement	Project ref
Delhi 1997-2000	Badarpur fly ash pond site	Horticulture species, (Targetes erecta, Cymbopogan martini, Polyanthus tuberosa, Dianthus caryophyllus and Helianthus annuus). Eucalyptus tereticornis, Melia azadirach, Populus deltoids and , Dalbergia Sissoo	Farm yard manure (Double dose) and Mycorrhiza (Double Dose for horticulture species and single dose for tree species)	Height in metres Tree Zero time One year Eucalyptus 0.688 6.16 Melia 1.076 6.44 Dalbergia 0.894 3.80 Dianthes 55.35 flowers/plant Polyanthes 51.45/flori/spile Palmarosa 4.25kg sq.cm. Green biomass Microbiological property Micro Organism Increase over control % DD FYM DD FYM+ VAM N-fixing 40 27 P-solubilising 39 63 Total culturable 63 32	11

AGRICULTURE COAL ASH USE

State & Project Duration	Location	Species planted	Best yield with	Achievement	Project ref
Tamilnadu 1998-2004 (includes studies on Entomology & agricultural microbiology)	Ash pond site at Neyveli	Field experiment Sorghum, Sun Flower Casuarina, Eucalyptus and cashew (Tree species) Cucumber, Clusterbeans and Bhendi (Vegetables) Jasmine and Neerium (Flowers)	FYM 25t/ha + humic acid 50kg/ha = 200% NPK Coir pith 25t/ha, FYM at 25t/ha, LFA 100 Humic acid 50kg/plant, 200% of NPK Red earth 75t/ha Biofertilisers FYM:Coir pith :: 2.5:0.5 Red earth 100 t/ha+FYM 37.5t/ha+LFA 50t/ha +Phosphobacteria 4kg/ha	18.54q/ha 4.96q/ha Cashew 3kg/tree (after 4th year) Casuarina 12000 poles, (after 5th year) Eucalyptus 3500 poles (after 5th year) Cucumber 11.6, Cluster beans 15.8, Brinjal 5.4, and Bindi 7.5 kg/year Jasmine 8t and Neerium 12t/ha	23

AGRICULTURE COAL ASH USE

State & Project Duration	Location	Species planted	Best yield with	Achievement	Project ref
Jharkhand 2004-2008	Low lying area filled with fly ash in Jamadoba	Timber, Medicinal fruit bearing, Oil yielding, Ornamental, Seasonal vegetables.	Earth with cow-dung manure (2:1), Coco peat g/pit, Vermicompost 250g/pit biofertilisers and recommended dose of NPK	Item Forest species Fruit yielding & Ornamental Survival Rate (%) 63 to 97 30 to 50	25
Maharashtra 1996-1999	Abandoned ash pond at Chandrapur (One acre)	942 plants consisting of 17 different species which were one year old	Sewage sludge, biofertilisers, Rhizobium and Phosphobacterium cultures, humic acid mixed with pond ash	Hetti, Bougenvillae, Gillersidia, Eucalyptus and Subabul showed better growth	27
Chhattisgarh 1999-2000	Ash pond site (3.5 acres) at Korba	Casurina equisetifolia, Melia azadirach, Albizzi procera, Gmelina aroborea, Perennial and Seasonal Plants (Mentha arvensis, Vetiverzizanoisdes, Tagete erecta, Polianthes tuberosa and Helianthes anus	Double the dose of Farm yard Manure with mycorrhiza	Height in centimetres After 15 months Casurina equisetifolia, 262.731, Melia azadirach 367.35 Albizzi procera 171.04 Gmelina aroborea 333.52 After 16 months poplar 592	30
West Bengal 1993-1996	Ash ponds at Bandel and Kolaghat, and ash-land fills at Titdanagar	40 different vegetables and Miscellaneous crops	40cm soil turfing	17 crops performed better	31

AGRICULTURE COAL ASH USE

Laboratory and field studies
for

Use of fly ash in forest nursery & plantation

AGRICULTURE COAL ASH USE



Teak Nursery raising at Barabati Site, Sukinda, Cuttak

AGRICULTURE COAL ASH USE



Eucalyptus tereticornis at 6-24% fly ash dose (L to R), Aug., 2004
Site-II : Village Durgaprasad, Distt. Dhenkanal, Odisha

AGRICULTURE COAL ASH USE



Eucalyptus hybrid grown with fly ash, Aug., 2004
Site-I: Village Choudwar, Distt. Cuttack, Odisha

AGRICULTURE COAL ASH USE



Eucalyptus tereticornis at 6-24% fly ash dose (L to R), Aug., 2004
Site-II : Village Durgaprasad, Distt. Dhenkanal, Odisha

AGRICULTURE COAL ASH USE



*Overview of Plantation with fly ash at Tamka, Cuttack
(July, 2009)*



*Forestry plantation with 50% Fly ash at Tamka, Cuttack
(June, 2013)*

AGRICULTURE COAL ASH USE

Positive Indicators

- Improves soil texture and reduces bulk density.
- Improves permeability and water holding capacity
- Improves Improvisation and reduces crust formation.
- Enhances root proliferation.
- Conserves plant nutrients and water.
- Reduces pest incidence.
- Provides macro (K, P, Ca, Mg, S) and micro (Fe, Zn, Cu, Mn, Mo, B) nutrients
- Part substitution of gypsum (up to about 75% with fly ash as a substitute for reclamation of in sodic – saline soils
- Enhance plant productivity and crop yield
- Rich farmers & orchard owners are transporting fly ash up to 500 km
- Fly ash is approved as organic – farming amendment in western India

AGRICULTURE COAL ASH USE

Impediments

- Apprehensions
- Mind Set
- Resistance to Change
- Lack of Policy Directives

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***Thank you
for
your time & attention***