EERC

ENVIRONMENTAL ECONOMICS RESEARCH COMMITTEE

Theme: Industrial Pollution and Policy
EERC Working Paper Series: IPP-9

Internalisation of Wastes in Industrial Plants: A Study of the Techno Economic Scope of Two Plants

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Prepared for

ENVIRONMENTAL ECONOMICS RESEARCH COMMITTEE

Under

The World Bank Aided

"India: Environmental Management Capacity Building

Technical Assistance Project"

Ministry of Environment and Forests

Indira Gandhi Institute of Development Research

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Contents

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Preface

The Final Report on the project "Internalization of Wastes in Industrial Plants, A Study of the Techno-Economic Scope in Two Plants" that we are going the submit to the Core Unit, "Indira Gandhi Institute of Development Research", is a project under "India : Environmental Management Capacity Building Technical Assistance Project".

This Report is only a part of a bigger project, namely, EMCaB of the Ministry of Environment and Forests, Government of India, aided by the World Bank. The final Report that we are going to submit, thus, has been supported at multi levels, in terms of time allowed for the study, and budget sanctioned for the study. We covered in this study only two plants. We, however, hope that the findings, the suggestions, and the recommendations of this study will have macro implications for the national economy.

The collection of information had been really a difficult task to fulfill the objectives and purpose of the study. The collection of data would not have been possible without the untiring efforts of the project team meant for this purpose. The members of the project team took all the pains to tabulate and present data collected from the field in accordance with the objectives of the study. The errors in interpretation of data, and policy recommendations that followed, rest with me.

We are thankful to a number of authorities and experts on the subject that we chose to study in this Project. At the stage of presentation of Proposal in July 15, 2000, I got suggestions for improvement from Dr. O.P. Mathur and Dr. Usha Raghupathi, the experts meant especially for this proposed study at that period. I am especially grateful to Prof. Kirit Parikh of IGIDR, Mumbai, who had been expert of my Project since it got the green signal for take off. I express my gratitude to Dr. (Mrs.) Jyoti Parikh who had been kind enough to encourage me in pursuing this study and allowing me time to complete it in the shape as it is now. I feel it is necessary to mention the names of experts who offered positive suggestions for improvement of the Report, while it was presented in July, 2000 at IGIDR, Mumbai, and in June, 2001 at Jammu University, Jammu, and in March 2002, at IGIDR, Mumbai. Among others, they are Prof. P. Appasamy, Prof. R. Mukherjee, Prof. U. Shankar, Prof. S. Ayengar and Sri K.K. Narang.

In addition to the long list of persons and institutions mentioned in the page on "Acknowledgment" in this Report, it will be my duty to mention the names of two consultants appointed for the quality improvement of the Report. They are Prof. Alok Gupta of Allahabad University and Prof. B.K. Datta of Calcutta University.

We are especially thankful to the target people as respondents to our questionnaire, like the persons in brick plants, cement plants, the personnel in the selected plants, namely, NTPC, Dadri and IFFCO, Phulpur, and the people settled in the adjoining areas of the selected two plants, and also external experts. The recommendations that we have offered in this Report relied heavily on the facts and ideas brought to light by these target people and plants.

We are thankful to TIFAC, DST, Delhi, particularly for the kind of information that it revealed to us. For collection of secondary data, we also relied on the Library of the Indian Statistical Institute, Calcutta, in addition to the Library of my own Institute. The Institute provided all the infrastructural and manpower facilities for getting the Report complete.

May we be excused if we forget to mention the valuable services of persons and institutions in conducting this study.

On behalf of the Project Team, I submit the Final Report of the study to the Core Unit, the Indira Gandhi Institute of Development Research, Mumbai, for acceptance.

October 2002

G.B. Pant Social Science Institute, Allahabad – Bhaskar Majumder

Acknowledgement

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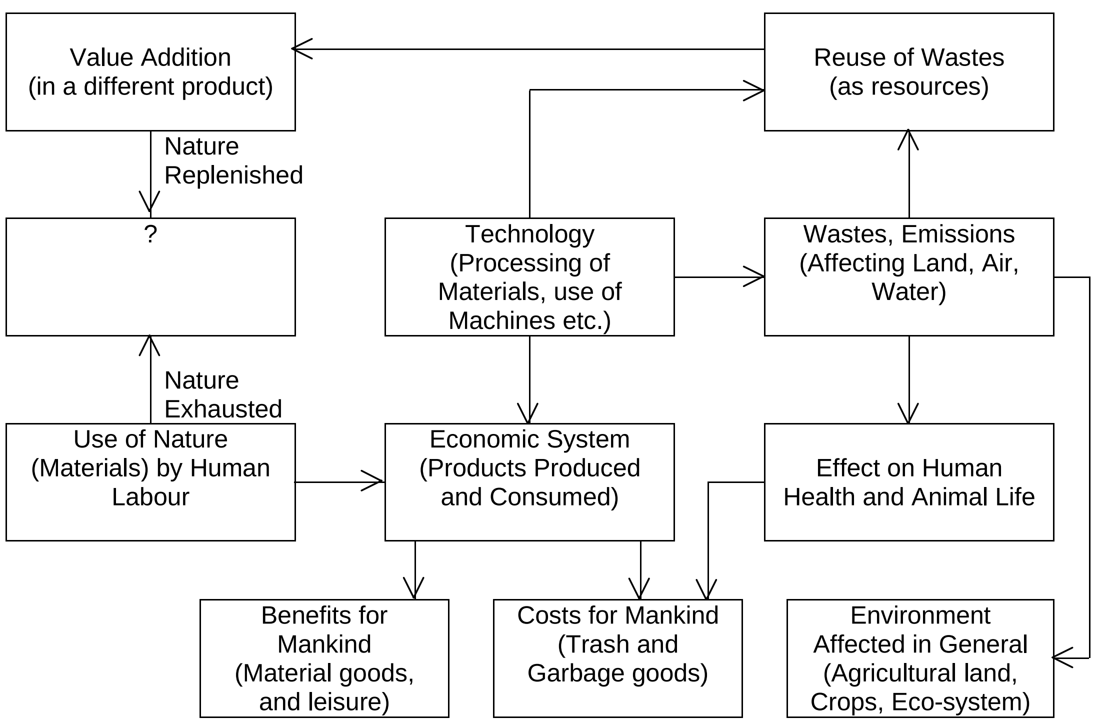
Executive Summary

I. Background of the Study: Internalization of Industrial Wastes

Conventionally, an economy is a system that links inputs and outputs. Environment is the physical domain that offers the economy the scope to develop. Either because of the type of inputs used or because of the technology applied for production of output, physical wastes are generated by the industry.

We assume that the industry itself takes the role to internalize wastes either within the plant where it is generated, or works in an inter-industry frame to internalize wastes. The internalization of wastes in industries is shown in **Flow Chart 1.3 (Chapter 1, p. 4)**.

Flow Chart 1.3
Management and Use of Wastes



The type of waste in our study refers to the wastes generated at the level of the plant, given the optimality in use of resources (machine-man-material, time, energy etc.). We concentrate on fly ash as a solid waste. The fly ash is generated in any coal using plant. The fly ash that the plant piles up imposes environmental costs on the society. The government can come forward to impose tax per unit (volume on weight basis) of fly ash so stored by the plant. This may compel the ash generating plant to either reuse and recycle the stored ash or transport it at its own cost to other users of fly ash. This leads to internalization of environmental cost of fly ash. Our analysis rests essentially on reuse of wastes. This re-use can convert a liability into an asset.

II. Objectives of the Study

We will study two industrial plants located in two districts, Allahabad and Ghaziabad, of Uttar Pradesh, India. The plants are selected such that coal happens to be the basic input for production of their respective final products. Use (burning) of coal leads to generation of fly ash. We will examine the techno-economic possibilities of converting 'fly ash' into economic 'goods', through internalization of fly ash within the industrial plants. The objectives of our study will be to examine

- How the generation of fly ash by the chosen industrial plants can be reduced per unit of final output;
- How 'fly ash' generated in one industrial plant is transformed into final product within the same or in another industrial plant;
- How are the adjoining areas, like those for human settlements, crop fields etc. affected by generation of fly ash in the industrial plant;
- What type of alternative products and technologies can be thought of to ensure long-term internalization of fly ash.

III. Coverage of the Study

One of the two plants that we select is the Phulpur Unit of the Indian Farmers Fertilizers Cooperative Ltd. (IFFCO), in the district of Allahabad, Uttar Pradesh. The second plant is the Dadri unit of the National Thermal Power Corporation (NTPC) in the district of Ghaziabad, Uttar Pradesh.

The Phulpur Unit of IFFCO is a fertilizer plant that uses coal as a basic physical input and produces fertilizer as the final output. In addition to coal, the Unit uses naphtha, fuel oil, water, and electricity as other physical inputs (**Chapter 4, Table 4.1, p. 20**). In the production process, fly ash is generated. We will examine if, and how far, this Unit internalizes ‘fly ash’.

The Dadri Unit of the NTPC generates electricity with an installed capacity of 840 MW. In the Thermal unit of the Dadri power plant, fly ash is generated as a byproduct (**Chapter 5, Table 5.1, and 5.2, p. 47, 48**). We will examine the scope of ash utilization by the Dadri Unit.

In both the cases, we will examine the nature and cost of disposal of fly ash, and the net benefits from utilization of fly ash. We will also examine the cost-benefit implications of utilization of fly ash.

IV. Methodology of the Study

We will study the methods the selected plants have been using to control and reuse fly ash. In addition to collecting data from the Reports and Records of these Units, we will collect primary data from the R&D personnel of the selected plants.

We will examine the actual and techno-economic possibilities of utilization of fly ash in products of use. For this, we will select plants that produce bricks and cement based on information on utilization of fly ash in India from secondary sources (**Chapter 3, Box 3.2, p. 16)**. India uses at present only 3.0 per cent of total fly ash generated. Of this, as high as 93.0 per cent is used in production of bricks and Portland Pozzolana cement.

Box 3.2
Utilization of Fly Ash in India
(Product-specific utilization as a percentage of total utilization of fly ash)

Areas of Use	% Utilization of Fly Ash
Fly Ash Bricks	70.2
Portland Pozzolana Cement	23.0
Asbestos Products	6.41
Others*	0.57

Note: * *Include Underground Fills, Hydraulic structures, Ash Ponds and Dykes, Agriculture and Soil Amendment*.

In selection of manufacturing units, we will follow the Notification dated 14 Sept., 1999, of the Ministry of Environment and Forests, GOI.

We will use structured schedules for collection of information from the brick and cement plants, located adjacent to the selected IFFCO and NTPC plants, in accordance with the Notification of the MOE&F, GOI, 1999. We will use structured schedules for interviewing people affected in the areas adjoining the selected industrial plants that generate and dispose of fly ash. We will use questionnaire to get ideas from experts on utilization of fly ash.

V. Data Analysis:

Fly Ash: Generation, Management, Utilization, and Reduction of Ash Content in Coal Used in Selected Plants

V.1 Major Observations: IFFCO, Phulpur, and NTPC, Dadri

IFFCO, Phulpur

IFFCO, Phulpur, has installed necessary equipments for controlling the quality of liquid effluents and of gaseous emissions. Liquid effluents are treated before being discharged into the main effluent nallah outside the plant premises. The quality of the effluent lies within the standard laid down by the Pollution Control Board, U.P.

The dumping of fly ash by IFFCO, Phulpur, in the form of Ash Pond may not exhaust the area required outside the plant as the ash is being supplied regularly to cement manufacturers. The plant has shifted since April 2000 from wet ash disposal in the ash pond formed in the adjoining area to supplying dry ash. The rate of utilization of fly ash exceeds the rate of generation so that on a span of less than ten years from year 2000, the plant can plan to utilize all fly ash generated. This utilization covers both internal and external uses.

NTPC, Dadri

Coal for NTPC, Dadri, comes from North Karanpura Coalfields in Bihar (now in Jharkhand). Before 1998, the ash content in coal used by Dadri was 40.0 per cent that came down to around 35.0 per cent after 1998. However, the source of coal has remained unchanged. The NTPC, Dadri has formed an Ash Mound inside the plant premises for storage of fly ash. In addition, it supplies fly ash that it generates to cement and asbestos industries.

The NTPC, Dadri, supplies dry ash. Since the beginning of commercial production in August 1992 till the end of March 2001, around 22.0 per cent of fly ash generated by the unit has been utilized. Almost 16.0 per cent of this have gone for filling low-lying areas and embankments. The rest 6.0 per cent has gone for manufacturing bricks, blocks, cement, and asbestos. Around 78.0 per cent of the accumulated ash generated, thus, are dumped in Ash Mound (**Chapter 6, Table 6.1, p. 84)**.

The reason why IFFCO, Phulpur, can utilize cent per cent fly ash generated is zero transportation cost when it supplies fly ash to cement manufactures. The reason why NTPC, Dadri, does not attempt to utilize fly ash above 20.0 per cent on average is that it has already incurred huge fixed cost for carrying fly ash from the boiler to the ash mound.

V.2 Conventional Clay Brick Plants (located within 50-km. radius from IFFCO, Phulpur, and NTPC, Dadri): Reasons for Non-Utilization of Fly Ash

- ➢ The R&D laboratory of IFFCO, Phulpur, has developed a project for utilization of fly ash in brick manufacturing. These bricks are both internally and externally used.
- ➢ NTPC, Dadri, produces fly ash bricks on a regular basis primarily for internal use.
- ➢ We did not find any record of the number of conventional clay brick plants within a radius of 50 km. from IFFCO, Phulpur, and NTPC, Dadri.

We selected a total of ten clay brick plants within the 50-km. radius from IFFCO, Phulpur, and NTPC, Dadri, to capture the major problems and possibilities of utilization of fly ash.

V2.1 Non-Utilization of Fly Ash in Conventional Clay Bricks: General Reasons

- ♦ Land for conventional clay brick plant is easily available (purchase or lease-in) in the Districts, Allahabad and Ghaziabad.

- The price of land is within reach (purchase or lease-in) of the brick plant owners in both the Districts.
- The technique of production of conventional clay bricks is known.
- Conventional clay brick plant owners do not know the technology of mixing fly ash in clay bricks.
- The transportation cost of fly ash from ash generating plant is high relative to the cost of land leased in.
- There are no problems of marketing of conventional clay bricks.
- Reliability of conventional clay bricks in the market is high.
- The clay bricks ensure stable benefits for conventional brick plant owners.

V.3 Fly Ash-Sand-Lime-Gypsum Brick Plants Located within 50-km. Radius from IFFCO, Phulpur, and NTPC, Dadri: Observations Regarding Actual and Possible Use of Fly Ash

We did not find any fly ash-sand-lime-gypsum brick plants within the radius of 50-km. from IFFCO, Phulpur. In addition, we did not find any record of the number of fly ash-sand-lime-gypsum brick plants within a radius of 50 km. from NTPC, Dadri. We could locate as high as seven functioning fly ash-sand-lime-gypsum brick plants located within 50-km. radius from NTPC, Dadri, that use fly ash generated by the latter. There is no supply constraint so far as availability of raw materials for manufacturing fly ash bricks in these plants are concerned. All the seven fly ash brick plants reported that they got technology for manufacturing fly ash-sand-lime-gypsum bricks from NTPC, Dadri. NTPC, Dadri is ready to provide technological support to any potential entrepreneur willing to set up a fly ash brick plant.

Since market price of fly ash-sand-lime-gypsum brick is higher than cost of production per unit, hence the producers of such bricks can market these bricks, even with positive transportation cost of fly ash **(Chapter 5, Table 5.22, p. 67)**. There is also positive price-differential between clay bricks and fly ash bricks (**Chapter 5, Table 5.24, p. 69**). Manufacturing and marketing fly ash bricks, thus, require steps for relative cost reductions.

V.4 Cement Plants, which receive Fly Ash from IFFCO, Phulpur, and NTPC, Dadri: Utilization of Fly Ash

Cement Plants as Users of Fly Ash from IFFCO, Phulpur

The permissible percentage of fly ash that can be used in Portland Pozzolana Cement (PPC), as reported by the users of fly ash varies from a minimum at 25.0 to a maximum at 35.0. Based on the survey of a number of cement plants, we observed that there is no dearth of demand for fly ash from the cement manufacturers. It is difficult to locate all the cement plants as buyers of fly ash generated in IFFCO, Phulpur, because of operation of intermediaries (truck operators). Neither the IFFCO, Phulpur, nor the cement manufacturers incur any transportation cost for carrying fly ash from IFFCO to cement plants**.**

Cement Plants as Users of Fly Ash from NTPC, Dadri

The cement manufacturers are the main external users of fly ash supplied by NTPC, Dadri. We could locate the Diamond Cement, Jhansi, UP, that takes only 15.0 per cent of its required fly ash per day from NTPC, Dadri. The technical ratio in which fly ash is mixed is given as Fly Ash: Clinker: Gypsum as 38:55:07 for producing Portland Pozzolana Cement. NTPC, Dadri, has remote chance of increasing supply of fly ash to Diamond Cement, unless the transport cost is borne by NTPC, Dadri.

V.5 Effect of Spread of Fly Ash in the Areas Adjoining IFFCO, Phulpur, and NTPC, Dadri

In the Areas Adjoining IFFCO, Phulpur

IFFCO, Phulpur, is reported to take care of areas within a radius of 3 km. from its own location (plant boundary). We surveyed seven villages and 65 households settled within 2000 meter from the Plant, following pilot survey. The exact number of the households settled within the radius of three km. from IFFCO, Phulpur is not known. We selected the households in a dispersed manner within each village. Almost all the households from all the villages reported to have been experiencing adverse effect of spread of fly ash disposed by IFFCO on agricultural land. They also reported about the air and water-borne diseases because of spread of fly ash.

The Directorate of Environment, UP, and the Pollution Control Board, Government of UP, do not keep any record of the quality of air and water in the areas inhabited by people adjoining IFFCO, Phulpur. We did not find any registered medical practitioner who could confirm the health-related problems conveyed by the people in the adjoining area.

In the Areas Adjoining NTPC, Dadri

We selected seven villages following pilot survey and sixty-five households in the areas adjoining NTPC, Dadri. The selection of households followed what we did in case of surveying areas adjoining IFFCO, Phulpur, in the district of Allahabad. The households reported adverse effects of spread of fly ash on agricultural land. They also complained about air-borne diseases because of spread of fly ash. We did not find any registered medical practitioner staying in the adjoining areas that we surveyed. The Directorate of Environment, UP, and the Pollution Control Board, Government of UP, do not keep any record of the quality of air and water in the areas inhabited by people adjoining NTPC, Dadri.

V.6 Reduction of Ash Content in Coal Combustion: Possibilities in IFFCO, Phulpur, and NTPC, Dadri

In India, 70.0 per cent of extraction of coal comes from open cast mines at present and the underground mines contribute the balance. Both the quality of coal and the method of combustion determine the effluents produced during combustion of coal. The heat value of the fuel is determined by

UHV = 8900 – 138(A+M),

where,

UHV = Useful Heat Value,

A = Ash Content in percentage

M = Moisture Content in percentage.

Coal available from different sources is graded in terms of the UHV. Using this technique, available coal in India has been classified into seven grades, A to G. For superior grades (A, B, C), the (A+M) percentage is less than 30.0 while for inferior grades (E, F, G), it is more than 30.0. In between lies the intermediate grade, D. The inferior grade coal constitutes around 70.0 per cent of total usable coal available in India.

Use of clean coal also leads to higher useful heat value (UHV) because it generates lower ash content by percentage and total quantity per unit of generation of electricity. NTPC, Dadri, reported using clean (washed) coal since 1998 for reduction in ash content. The source of coal has remained unchanged. The coal used by IFFCO, Phulpur, has an ash content of 40.0 per cent at the minimum and 48.0 per cent at the maximum. IFFCO, Phulpur, has no plan to change the source of coal that it receives and its R&D (laboratory) does not have any plan to go for clean (washed) coal to reduce ash content.

VI. Results

Based on our study of two selected plants, IFFCO, Phulpur, and NTPC, Dadri, we offer the following results. The policy recommendations follow from the results:

VI.1 Cost (Fixed and Recurring) for Disposal of Fly Ash by IFFCO, Phulpur, and NTPC, Dadri

The fixed cost for dry ash disposal (on setting pipelines etc.) for IFFCO, Phulpur, was around Rs. 2.5 crores. The recurring cost of dry ash disposal is virtually nil except that certain utilities like Instrument Air and Electric Power is provided to dry ash system. If accounted, the recurring cost will not exceed Rs. 0.15 per tonne of ash. The land area that remains covered as on Dec. 31, 2001 with ash filled during the earlier period is around five acres outside the plant area.

The distance of the ash mound from the ash generating point at NTPC, Dadri, is four-km. For carrying ash from the boiler to the ash mound, fixed cost incurred was Rs. 137 crore. The recurring cost (ash handling cost per MT) is Rs. 30. Quantity of dumping of ash per day is 3556 MT for the Dadri Unit for which average handling/dumping cost per day comes to be a little more than Rs. one lakh (**Chapter 5,Table 5.4, p. 50**).

VI.2 Land Cost for Land Leased-in: The Case of Brick Plants Adjoining IFFCO, Phulpur, and NTPC, Dadri

Most of the brick plant owners within 50-km radius of IFFCO, Phulpur, and NTPC, Dadri, use lease-in land for digging purposes. Of the total land being used by the brick plants adjoining IFFCO, Phulpur, around 80.0 per cent are on lease. Of the total land being used by the brick plants adjoining NTPC, Dadri, around 60.0 per cent are on lease.

Average land price per acre at the market for brick plant owners who leased-in land within 50-km radius of IFFCO, Phulpur, is Rs. 89,000. The average land price comes to be Rs. 1,41,000 for the brick plants located within 50-km radius of NTPC, Dadri.

The availability of abundant and low cost topsoil helps in using clay as and when required. Absence of initiatives and incentives from the Government helps in continuing production of clay bricks without mixing fly ash by any percentage.

VI.3 Land Saving (Area, Volume, and Value) by Replacing Clay by Fly Ash

Soil cutting area (sq. metre) in any year for all the brick plants in the District of Allahabad is 316.84 acres of which agricultural land constitutes 73.48 per cent. Assuming soil cutting destroys topsoil, the total value of land that is destroyed comes to be around Rs. three crore for the whole district covering all clay brick plants (on the basis of average land price existing at present). Given the quantum of soil cutting per year, we calculate the quantity of fly ash that can replace 30.0 per cent (maximum) clay. Thus, we calculate maximum agricultural land that can be saved by using fly ash (maximum 30.0 per cent) as replacement of clay (weight-to-weight basis). As we see, out of a total of 232 acre of agricultural land, as high as 25.0 per cent can be saved (**Chapter 4, Table 4.12, p. 32**).

Soil cutting area (sq. metre) in any year for all the brick plants in the District of Ghaziabad is 1155.6 acres, of which agricultural land constitutes 100.0 per cent. The total value of land that is destroyed by soil cutting comes to be more than Rs. sixteen crore for the whole district covering all clay brick plants (on the basis of average land price existing in 2001). Given the quantum of soil cutting per year, we calculate the quantity of fly ash that can replace 30.0 per cent (maximum) clay. Thus, we calculate maximum agricultural land that can be saved by using fly ash (maximum 30.0 per cent) as replacement of clay (weight to weight basis). As we see, out of a total of 1155.6 acre of agricultural land, as high as 25.0 per cent can be saved (**Chapter 5, Table 5.15, p. 60**).

VI.4 Cost-Benefit Projections for Conventional Clay Bricks and Fly Ash Mixed Clay Bricks

We now concentrate on cost-benefit projections for conventional clay bricks and fly ash mixed clay bricks. We cover the districts, Allahabad and Ghaziabad, for encompassing IFFCO, Phulpur, and NTPC, Dadri. For both the districts, bricks are more or less similar by quality (size and weight). For the district of Allahabad, the total number of conventional clay brick plants at the time of survey was 356, while for the district of Ghaziabad it was 360. We selected ten such brick plants located within the 50-km. radius of each of the ash generating plants, IFFCO, Phulpur, and NTPC, Dadri. There is no record of the number of conventional clay brick plants within the specified radius. Thus, we relied on district level data to arrive at some projections.

For the district Allahabad, average digging depth for clay bricks is much higher. Average land price for the district Ghaziabad is much higher relative to that of Allahabad. The average distance of the clay brick plants from the ash generating plant is same for both the districts. This is because of selection of clay brick plants within the radius of 50 km. in accordance with the Notification of the GOI, 1999. The average transportation cost for carrying fly ash (per 16 MT) is much higher for Ghaziabad. Both the average cost of production per 1000 bricks and average market price for Ghaziabad are higher relative to those of Allahabad (**Chapter 4, Table 4.11 Part-A, p. 31, and Chapter 5, Table 5.14, Part-A, p. 58**). There is variation in quantity of soil that is exhausted (used) between the districts for brick manufacturing because of variations in digging depth. The quantity of soil used (in cubic metre) is more in case of district Allahabad relative to Ghaziabad. Naturally, the number of clay bricks that can be manufactured per acre (sq. metre) of land is much higher for district Allahabad relative to Ghaziabad. On the assumption of 25.0 per cent clay replaced by fly ash (on weight-to-weight basis), the quantity (volume) of fly ash that can be used, thus, is higher for Allahabad relative to Ghaziabad. For this ratio-specific utilization of fly ash (75:25), the transport cost of fly ash from the ash generating plant is lower for the district Allahabad.

The cost of production of fly ash mixed clay bricks per 1000 is marginally more when 25.0 per cent of clay is replaced by fly ash, for both the districts. Per 1000 bricks, the cost-difference is Rs.27 for Allahabad, and Rs. 42 for Ghaziabad. As percentage of cost of production of clay bricks in the respective districts, these are 3.33 and 4.47 (**Chapter 4, able 4.11 Part-B, p. 31, and Chapter 5, Table 5.14, Part-B, p. 58, Chapter 7, p. 95)**.

VI.5 Net Benefits (Total Benefits – Total Cost) for Utilization of Fly Ash in Conventional Clay Brick Plants and Fly Ash-Sand-Lime-Gypsum Brick Plants

While production of conventional clay bricks increasingly exhausts agricultural land as we observed, production of fly ash bricks saves agricultural land (by both area and volume). However, both cost of production per unit and market price per unit are higher in case of fly ash-sand-lime-gypsum bricks. While net surplus (Revenue – Cost) is positive for both types of brick plants, it is much higher for clay bricks per plant based on annual production level **(Chapter 5, Table 5.23, p. 78)**. Since plant size is much higher (by capacity production) for clay bricks, hence clay brick plants record on average higher net benefits. Calculated over 1000 pieces of bricks, fly ash-sand-lime-gypsum brick plant shows more net benefits. Thus, there are reasons to promote fly ash brick plants.

On the assumption of 25.0 per cent clay replaced by fly ash (on weight-to-weight basis), the quantity (volume) of fly ash that can be used is higher for district Allahabad relative to district Ghaziabad. The transport cost of fly ash from ash generating plant is lower for the district Allahabad.

VII. Policy Recommendations

The purpose of this study is to prevent and minimize generation of waste, and maximize reuse and recycling. The study also aims to production of reusable goods from waste and saving scarce resources assisted by the participation of government authorities and other stakeholders. The study concentrates on fly ash as a waste generated in coal-using industrial plants. Saving topsoil by utilization of fly ash in possible value-added goods requires a number of measures. These measures include:

Measures Recommended for Ash Generating Plants

- ⇒ planned disposal and dumping of ash by the ash management/utilization cell of the ash generating plant,
- ⇒ identification and selection of the site for dumping fly ash in advance so that human settlements are not displaced, nor is there any adverse effect on agricultural land,
- ⇒ transparency in disclosure of fly ash generated per plant per year and hence accountability of fly ash generator,
- ⇒ public announcement regarding the quality of ash being generated, the receivers of fly ash who utilize the ash generated by the plant, the quantity of accumulated ash up to date,
- ⇒ shouldering of transportation cost of fly ash from the ash generating unit to the ash utilization unit.

Measures Recommended for Government

- ⇒ announcement through Notification or G.O. what the ash generating plants will have to do regarding dumping and disposal of fly ash, before these ash generating units are given license to setup these plants,
- ⇒ identifying the location of ash generating plants at a safe distance from existing human settlements and plantation areas,
- ⇒ soil testing of the brick plants to examine its possible mixing with fly ash generated by the coal-based plants within 50-km radius, testing to be done free of cost for the brick plants (may be by MOE&F, GOI),
- ⇒ circulating Notification including amendments, if any, regarding utilization of fly ash among micro level public bodies and public administration,
- ⇒ maintaining a record of quality of soil, air, and water within a reasonable area adjoining ash generating plants (may be by the Pollution Control Board, GOI,

and also by the State Pollution Control Board and Directorate of Environment),

⇒ imposing tax per unit (volume on weight basis) of fly ash stored by the ash generating plant,

⇒ reducing rate of tax per unit or total tax exemption on fly ash mixed clay bricks, so that it has an encouraging effect on production of fly ash mixed clay bricks,

⇒ reducing/exempting tax on fly ash users for productive purposes,

⇒ documenting quality of fly ash products and its dissemination by Government/ appropriate authority,

⇒ eco-labeling fly ash bricks, e.g, fixing logo on the environmentally safe fly ash bricks,

⇒ maintaining a record of the number of conventional clay brick plants within the radius of 50-km from major fly ash generating plants, (may by MOE&F, GOI),

⇒ being a buyer of clay-mixed fly ash bricks, and fly ash-sand-lime-gypsum bricks,

⇒ fixing the price per unit of fly ash bricks, both clay-mixed fly ash bricks and fly ash-sand-lime-gypsum bricks on the basis of input cost,

⇒ announcing the price of fly ash bricks fixed per unit for both the buyers and producers of such bricks.

⇒ filling mine and land, keeping in mind transportation cost of fly ash from the point of generation to the site (land and mine),

⇒ importing coal with lower ash content on a selective basis, in the context of exhausting superior grade coal in India.

Measures Recommended in General

⇒ supplying technology to the potential users of fly ash for manufacturing value-added goods,

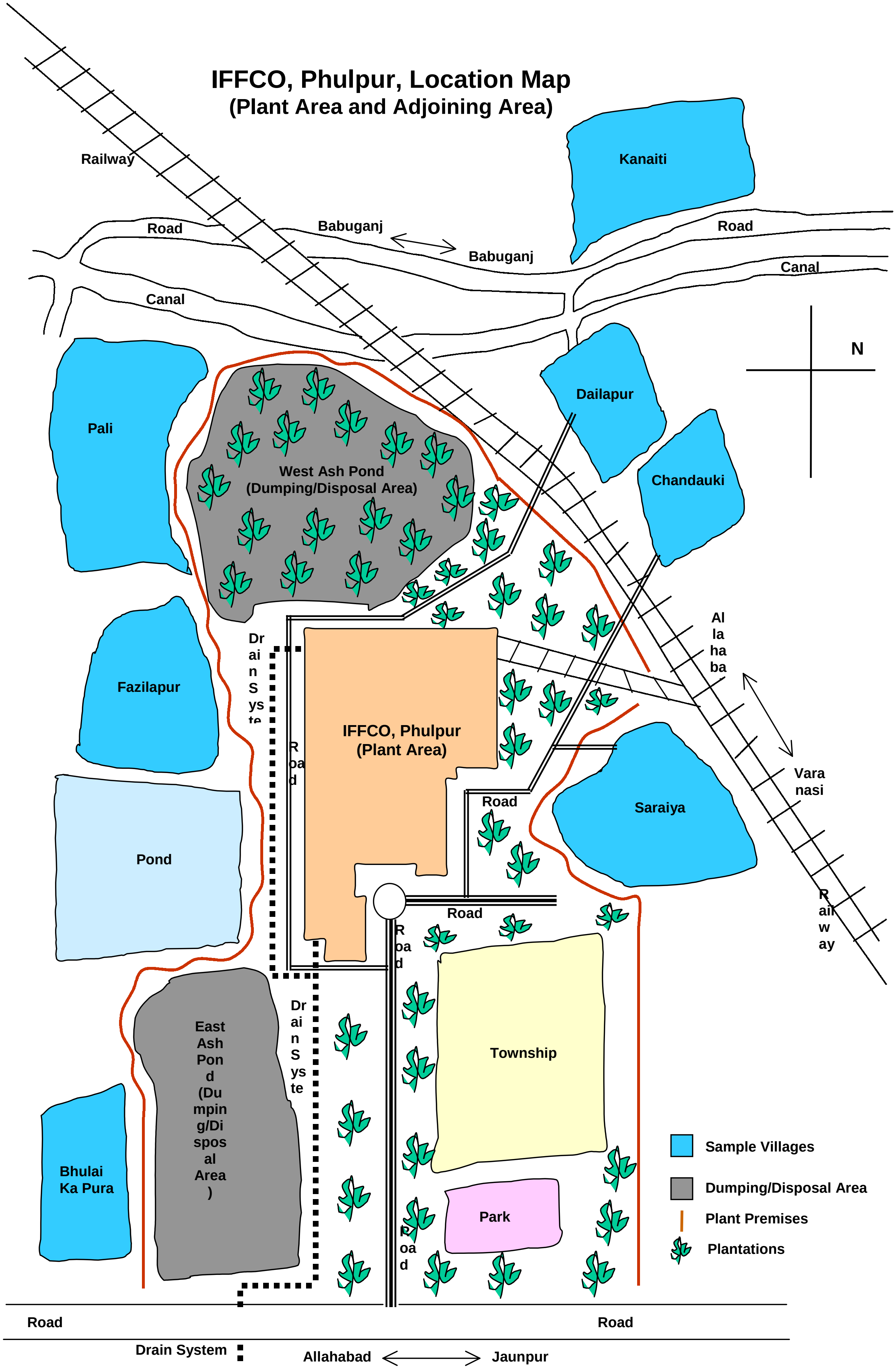
⇒ providing cost-free training to the managers and workers in general engaged in utilizing fly ash in value-added goods,

⇒ providing information on alternative products and technologies through public media for utilization of fly ash,

⇒ circulating/publicizing the results of soil testing to the actual and potential users of fly ash.

The suggestions that we have offered center on brick plants. We found no problems for the cement plants so far as utilization of fly ash in clinker and gypsum for manufacturing cement is concerned. The alternative products where fly ash can be utilized for value-addition of products have been discussed in **Chapter 2 (Box 2.4, p. 10)**.

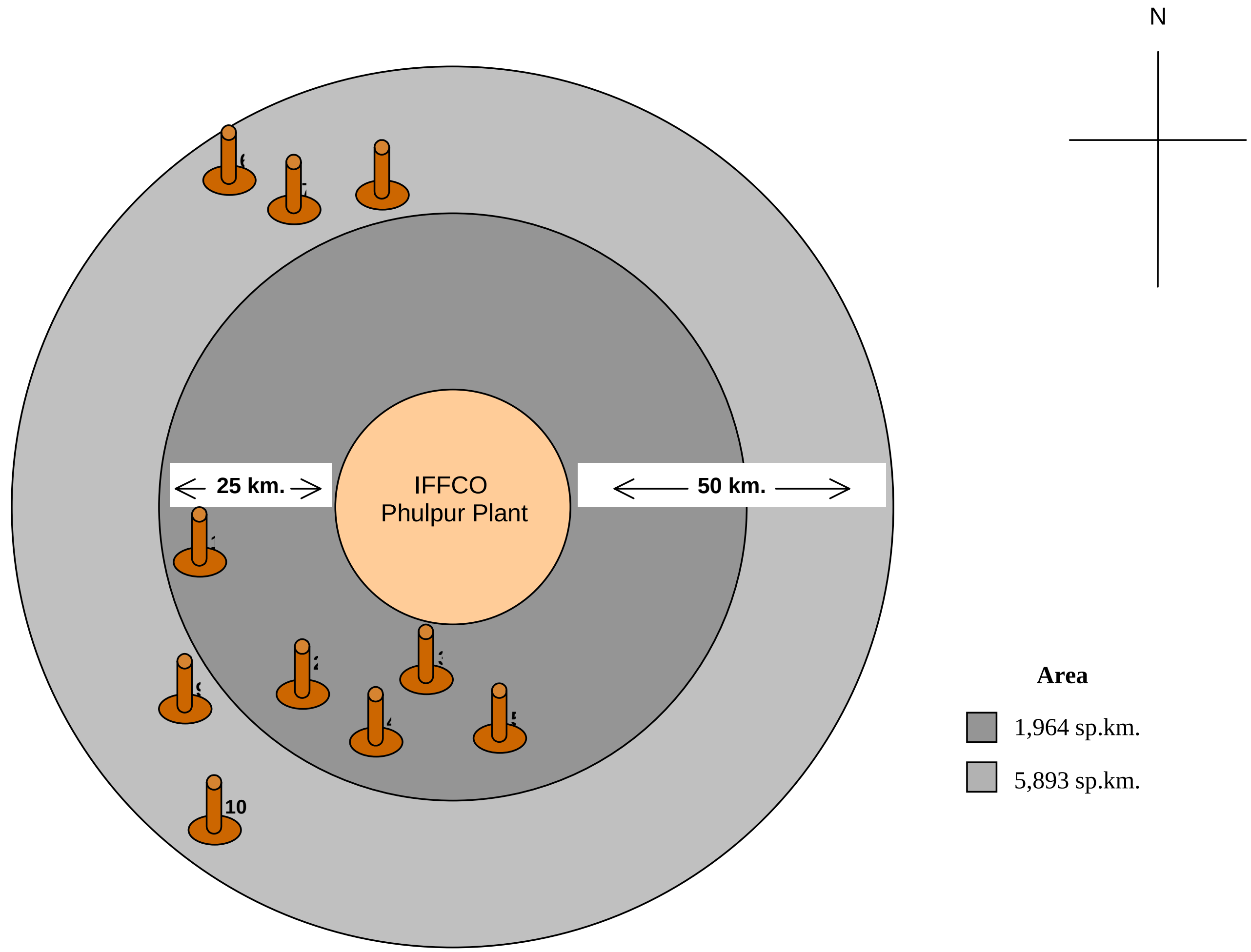
IFFCO, Phulpur, Location Map
(Plant Area and Adjoining Area)



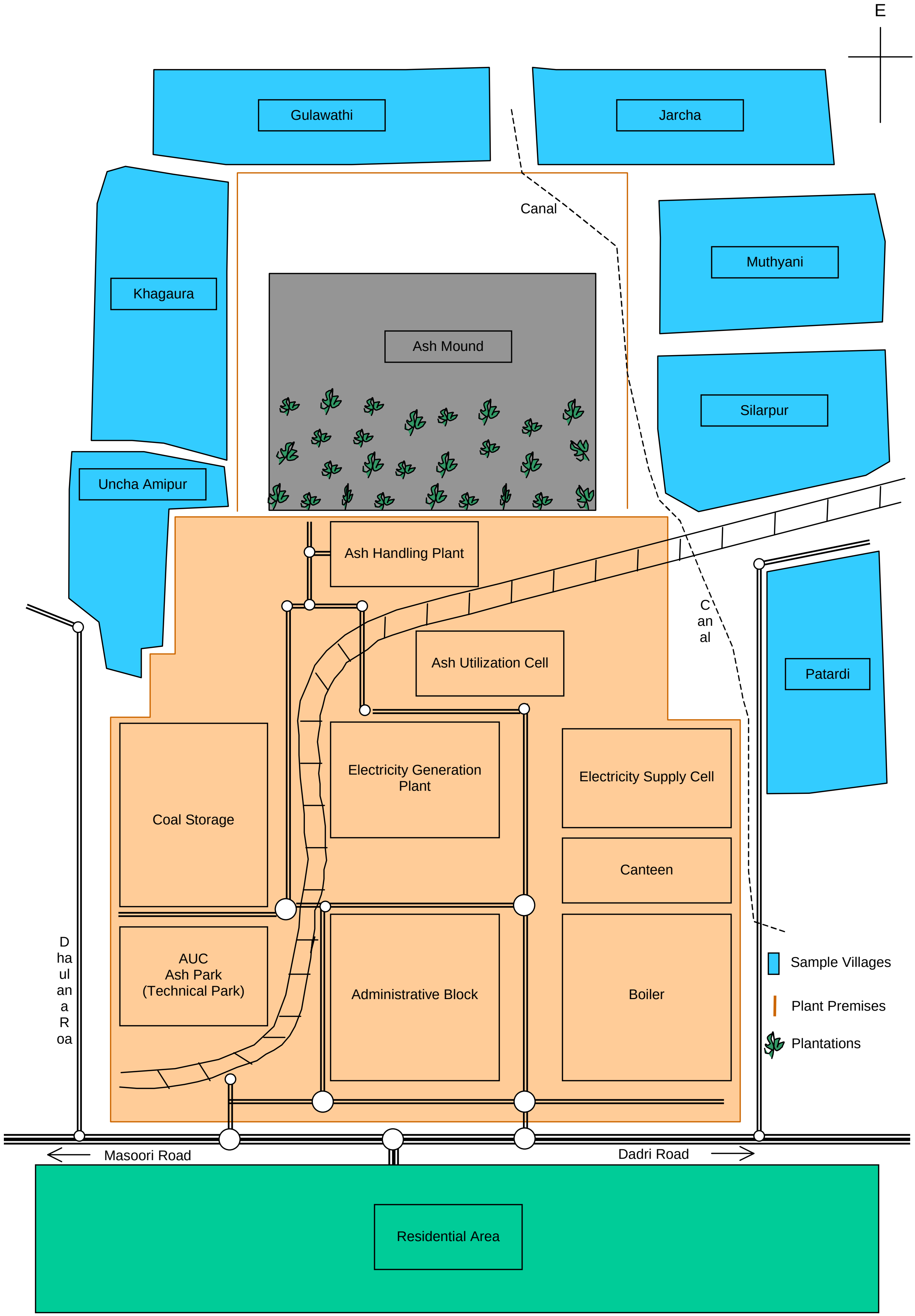
Location of Conventional Clay Brick Plans

Selected Plants

1. NHS Brick Factory
2. Milendra Brick Factory
3. Ahuja Brick Factory
4. Sakti Brick Factory
5. KMM Brick Factory
6. Raj Brick Industry
7. Ram Bihari Brick Industry
8. Mishra Brick Factory
9. Jaiswal Brick Industry
10. D.K. Jaiswal Brick Factory



Note: The study team could not get the number of conventional brick plants located within a radius of 50 km. From IFFCO, Phulpur.

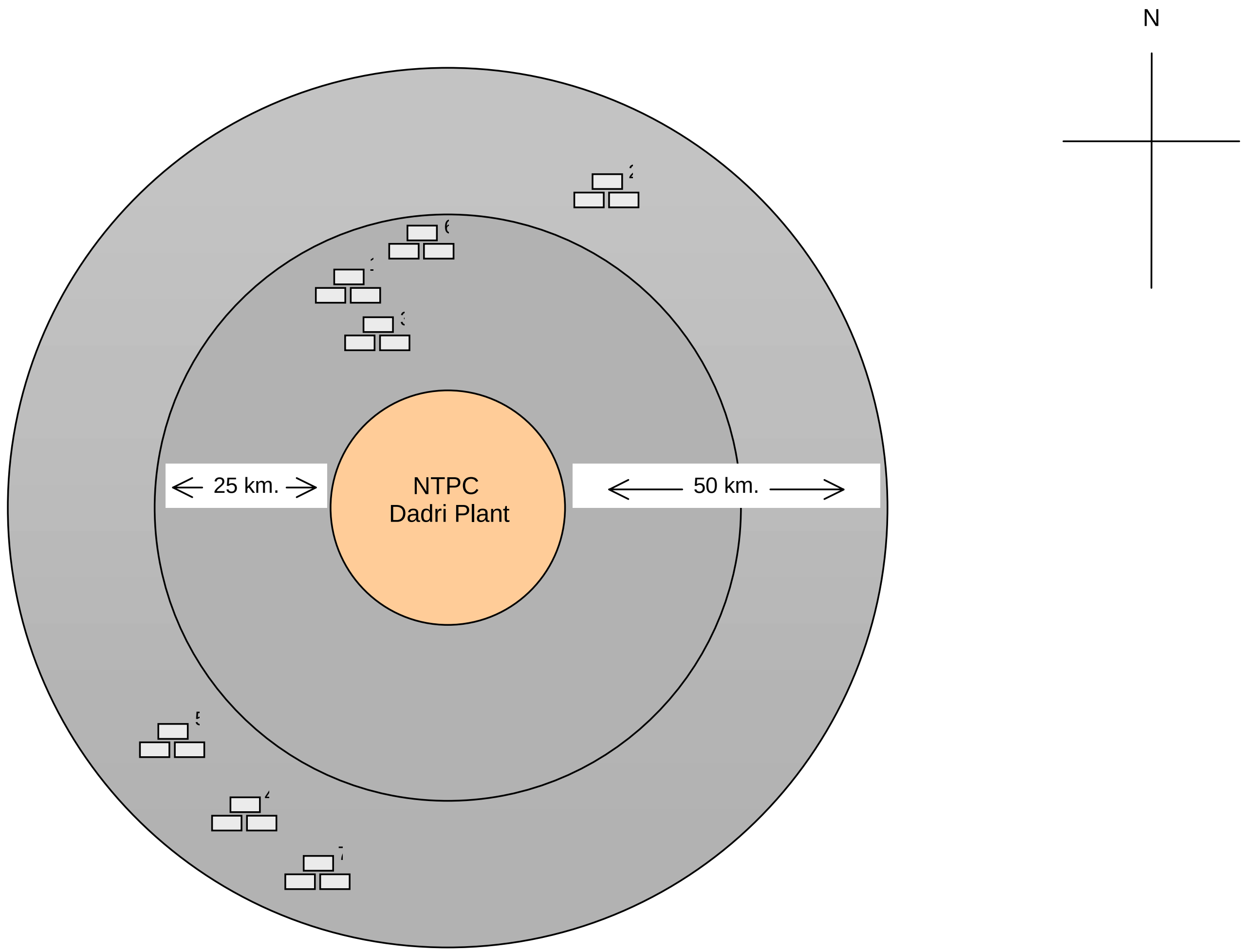


NTPC, Dadri, Location Map
(Plant Area and Adjoining Area)

Location of (Fly Ash, Sand, Lime etc.) Brick Plans

Selected Plants

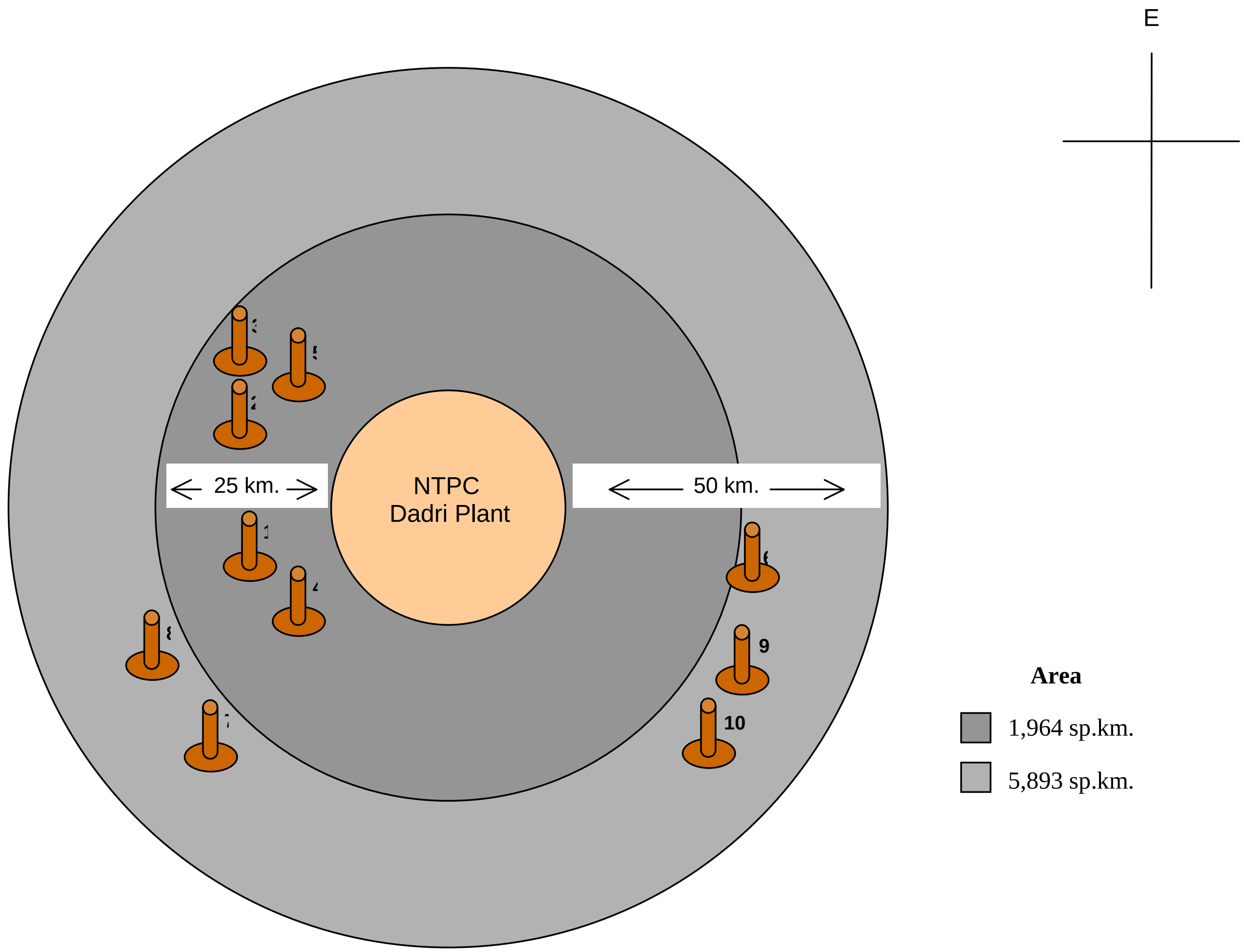
1. Sarswati Brick Factory
2. Om Brick Factory
3. Ganga Brick Factory
4. Neelam Brick Factory
5. Eco Vision Industries
6. Drona Brick Manufacture
7. Anand Brick Factory



Location of Conventional Clay Brick Plans

Selected Plants

1. Jagpal Brick Factory
2. Indian Brick Industries
3. Janta Brick Field
4. Raj Brick Factory
5. Surya Brick Factory
6. Rajesh Brick Plant
7. R. K. Brick Factory
8. Geet Brick Factory
9. Silngh Brick Factory
10. Beer Brick Field



Note: The study team could not get the number of conventional brick plants located within a radius of 50 km. from NTPC, Dadri.

Chapter 1 : Industrialization: Some Environment-Related Issues

1.1 The Environment-Related Problems of Industrialization

The relevance of nature or natural resources to man lies in its transformation by man. This transformation is what we call production whereby commodities come into being. This commodity production accompanies with it continuous development in technologies, the latter changing the nature of the product itself. The change is from lower order low-technology product to higher order high-technology product. This brings about industrialization.

Of late, it is being argued that this transformation of natural resources is accompanied by serious environmental degradation (The World Resources Institute, 1998, p. 51). Economic activities involve transformation of resources from natural forms and locations to where these are used as final products. The economy as a 'guest' develops at the cost of the 'host', viz., the earth's ecosystem. The development of the economy conventionally relies on (i) a dynamic shift from agriculture to industry, and (ii) the growth of industries. Both these dimensions, namely, the structural transformation and the growth in industries, takes man far from nature in its original form and fractures nature. It seems to be a fact that when the transformation of nature by man, instead of showing a symbiotic relationship between man and nature, shows a man-centric effort to conquer nature and ultimately overpower it, the economy is itself stressed. The transformation of natural resources generates wastes at different stages. The 'environment is used as a repository of waste products' (Mehta, Mundle, Sankar, 1997, p. 53). Because of growth in industries, industrial wastes are growing in quantity and becoming more difficult to dispose of or degrade (The World Resources Institute, 1998, p. 51). Historically the foundation of industrial economies was use of nature as direct sources of materials and energy. For the same reason, the economic prosperity or wealth of nations has been identified as the volume of produced goods and their consumption. The problem is that 'industrial economies eventually excrete as waste most of the raw materials they devour. This refuse presents a massive disposal problem' (Young, 1991, p. 40). The industries emit massive air, water, and solid pollutants, contributing to smog, build up of heavy metals, organic water pollution, hazardous solid waste, and many other sources of damage to communities and ecosystems (World Bank, 2000a, p. 10). The scale and variety of industrial waste with industrialization have been 'incompatible with continued reliance on landfills, the traditional method of disposal' (Young, 1991, p. 44). This is because the top surface of land is scarce while there is a limit to digging the topsoil to accommodate wastes. Even if the wastes are put inside the depth of soil up to the permissible limit, it will have a tendency to leak, releasing wastes into ground water.

Use of natural resources for industrial purposes has not only endangered the need to maintain the long-run capacity of the earth, but has also endangered the short-run capacity of agriculture. What is meant by this capacity? 'The carrying capacity of an eco-system is the maximum stress it is capable of absorbing without it changing to a vastly different state. Eco-systems are endemically subject to natural shocks and surprises... The self-reorganizing ability of eco-systems determines its capacity to respond to the perturbations they are continually subjected to' (Dasgupta and Maler, 1997, p. 4). The carrying capacity degrades by 'environmental deterioration including soil erosion, aquifer depletion, rangeland deterioration, air pollution' etc (Brown and Mitchell, 1998, p. 168). We would like to examine the possibility of sustainable industrialization that does not lead to continuous erosion of the long-run capacity of the earth, and that helps maintain the carrying capacity of the eco-system. Thus, we will examine the possibility of how these wastes can be reused in an intra-plant and inter-industry frame, and planned dumping of these wastes, if there remains any residue after planned internalization of wastes.

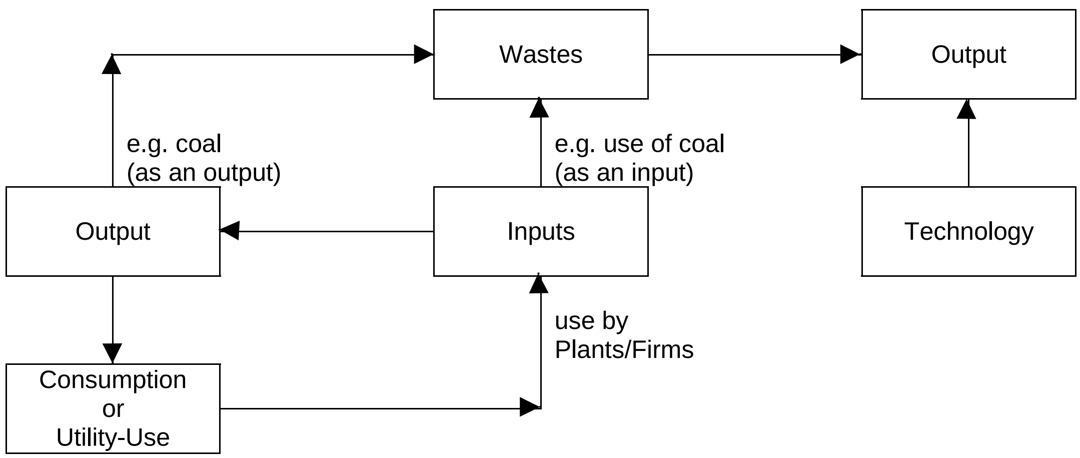
1.2 Industrial Wastes as Seen by Industries in Countries

During the pre-independence period, the concern for environmental problems in India was least because of both small size of population and absence of industrialization (Sankar, 1998, p.3). The concern for waste management through re-use and recycling drew attention with accelerating industrialization. **A waste is considered as a discarded material, which has no immediate value to the consumer who is abandoning it (Cointreau, 1982, p. 4).** Fuel burning residuals is one of the many wastes that come from operation of industrial plants. In the developing countries, generally the responsibility of tackling industrial wastes lies with the municipalities. This is unlike in the developed countries like the US where 'industrial refuse is not treated as part of municipal refuse' (Cointreau, 1982, p. 7). While the former attitude may lead to resource removal, the latter leads to resource recovery if properly planned by the industry itself, which generates fuel-burning wastes in the course of production. **Generation of industrial wastes is seen 'as a side effect of production and consumption in the economy -- this side effect (or externality) is a form of social cost that is not borne by the agent who is its source.** The theoretical analysis leads to a straightforward prescription to correct the misallocation of resources that results from these side effects on the environment: a unit tax on the polluting activity that is equal to the marginal social damage of the pollution. Such a Pigouvian tax has the potential to "internalize" the external cost and can lead to socially efficient levels of environmental protection (Oates, 1996, p. 198). In some studies it is assumed that waste management is the responsibility of the public administration by removal of waste as early as possible and by destruction of waste (Mesoli, 1980). Later, the focus shifted to utilization of wastes like other non-waste resources utilized for productive purposes. In a less industrialized economy, a government can not credibly threaten to shut down the plant if the firm does not comply with the environmental standards. Instead, the firm will threaten to shut down the plant if it does not obtain a lenient license. The threat by the firm controlling the plant is likely to be effective because the economic benefits of the plant are concentrated at a local level, and the benefits of governmental actions or the environmental benefits are spread across a large geographic area (Digkstra, 1999, p. 93-94). Thus, the government has to listen to the views of polluters, in our context, the firms before taking any direct action. The Government, or Pollution Control Board on its behalf, can rely on guiding the plants through suggestions for adoption of appropriate technologies. This approach stresses on resource recovery (Bever, 1976; Heidenstem, 1977). In some studies, minimizing the costs of collection and disposal of wastes through operation of vehicles and route of transport within the municipal budget has been focused while considering solid waste management (Oates, 1996, p. 207; Gerlagh, 1999). There are alternative ways of looking at waste management. One is with respect to industrial purposes where waste management rests on techno-economic considerations, while another is with respect to environmental degradation and preserving nature by non-use or replenishment (Beukering et al, 1999). In our study, we will consider reuse of an industrial waste that covers the second aspect also.

1.3 Society-Economy-Environment Linkages: The Background of the Study

Conventionally, an economy is seen as a system that links inputs and outputs. More generally, the inputs are also products, so that the economy comes to be a system of production of commodities by means of commodities. Environment is the physical domain that offers the economy the scope to develop itself (Sengupta, 1999). In other words, the environment supplies basic inputs to the economy, while the economy gives back some transformed inputs (by protection and preservation of resources) and generates wastes (**Flow Chart 1.1**).

Flow Chart 1.1
Product to Product Flow



The linkages between society-economy-environment can be shown through **Flow Chart 1. 2** where we take the following assumptions:

I. There is a given vector of products and a given vector of associated technologies;

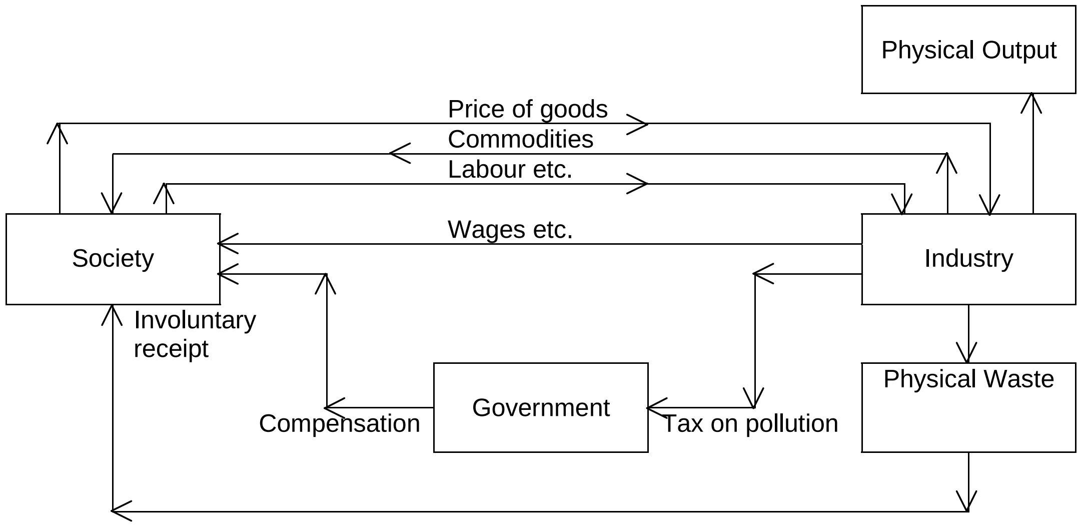
II. There is no restriction on generation of wastes. Individuals in the society are isolated maximizers of their present benefits;

III. The government represents a welfare state and hence imposes taxation on wastes on the assumption that wastes are 'bad' (leading to health hazards);

IV. The government is a maximizer of tax yield and individuals in society claim a share of this tax yield.

The **Flow Chart 1.2** will then look like the following:

Flow Chart 1. 2
Society-Economy-Environment Linkages



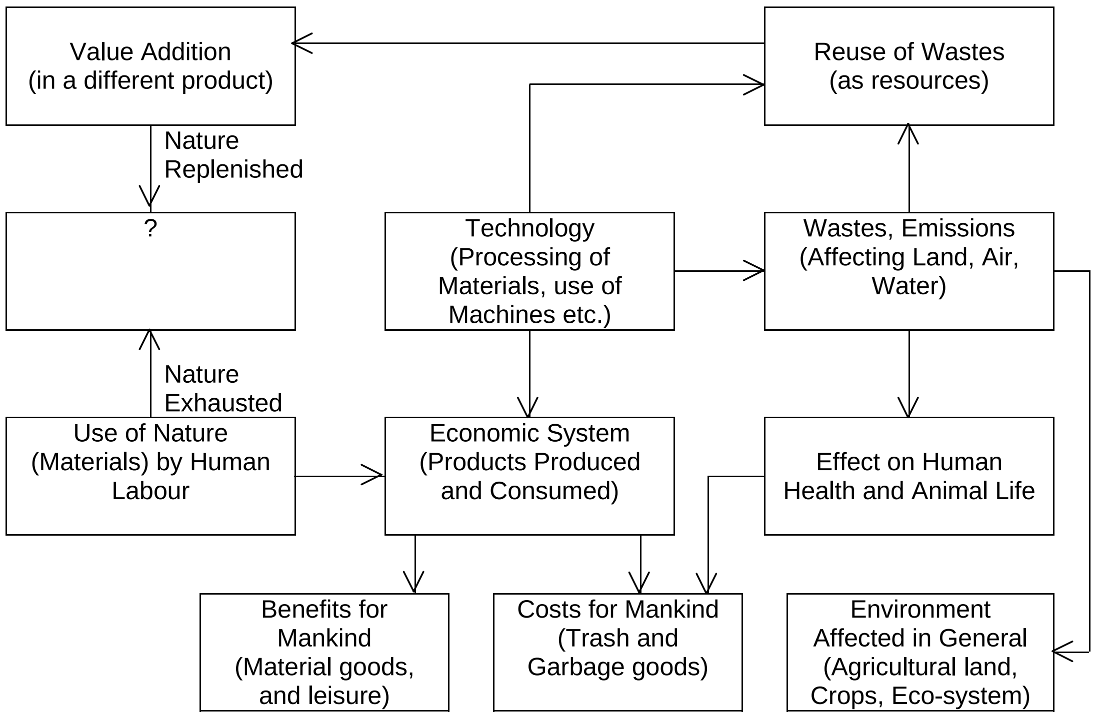
Individuals constitute a society and go to the industry as isolated productive agents to produce physical output. These individuals voluntarily participate in the process of exchange: controllers of technology running the industry sell commodities while sellers of labour power buy those commodities. Either because of the type of inputs used or because of the nature of technology applied for production of this output, physical wastes are generated by the industry. Individuals in society are affected adversely by these wastes.

The government in such an economy is assumed to represent a welfare state and hence imposes taxation on industry. The individuals claim a share of the tax yield in the form of 'compensation'. Thus, the tax yield may be distributed among the individuals in society. The society is compensated by the industry for generating wastes, the government is the link between the society and the industry.

1.4 Internalization of Industrial Wastes in the Economic System

We can relax assumption (iii) without disturbing the essential features of a welfare state. We assume that the state does not impose taxation on the industry generating wastes. The industry itself takes the role to internalize wastes either within the plant where it is generated, or works in an inter-industry frame to internalize wastes. The internalization of wastes in industries may be shown in **Flow Chart 1.3.**

Flow Chart 1.3
Management and Use of Wastes



The use of natural resources by man gives birth to an economic system. In conversion of nature into products, technology also produces wastes, emissions etc. The economic system, via offering goods for consumption (benefits) also affects human living conditions by producing wastes and trash or garbage goods. Technology may play a positive role by showing the path of reusing wastes. This reuse leads to value addition in some products, other than where wastes are generated. While in the initial use of nature, nature was being exhausted, in reuse of wastes (offshoot of use of nature) nature was replenished.

The purpose of this study is to prevent and minimize generation of waste, and maximize reuse and recycling. The study also aims to production of reusable goods from waste and saving scarce resources assisted by the participation of government authorities and other stakeholders. The study concentrates on fly ash as a waste generated in coal-using industrial plants.

Chapter 2 : Generation of Industrial Wastes: Disposal and Dumping of Fly Ash

2.1 Wastes: Definition and Type

A plant as a production unit uses some products considered as inputs. Whether or not the inputs are blended in an optimal ratio (ratio determined technologically in the sense of maximizing output per period per unit of composite input), there remains some residue. This residue is seen generally as an excess of inputs used over what is required for optimality (Gupta and Kashikar, 1997, p. 462). This definition of waste as an excess of inputs used over what (optimum) is required is relevant for combination of inputs like machine-power and man-hour, energy and time spent, etc. The inputs are required for producing final output of a product in a particular plant, given the state of technology chosen by the plant.

The type of waste in our study refers to the wastes generated at the level of the plant, given the optimality in use of resources (machine-man-material, time, energy etc.), We concentrate on solid wastes. The fly ash is generated in a Thermal Power Plant or any coal using plant. Generation of this type of waste, as a component of solid waste, is not to be understood as reflections of technological limitations, underproduction, or non-application of scale economies in production, lack of planning or improper planning at the plant level, managerial inefficiency etc. These wastes are a natural outcome of the inputs used. We assume that there is no perfect substitute of these inputs being used at present or in the foreseeable medium-term period. The context is thus production of electricity in a Thermal Power Plant or use of coal as energy input in a fertilizer plant, and the problem is generation of inescapable wastes (for example, fly ash). Generally, these solid wastes from industries are disposed off by discharging the wastes on the heaps that occupy land (GOI, DST, TIFAC, 1990, Nov. p.1). **We assume that the task is not to consider elimination of wastes, but to plan for its re-use. This re-use can convert a liability into an asset**.

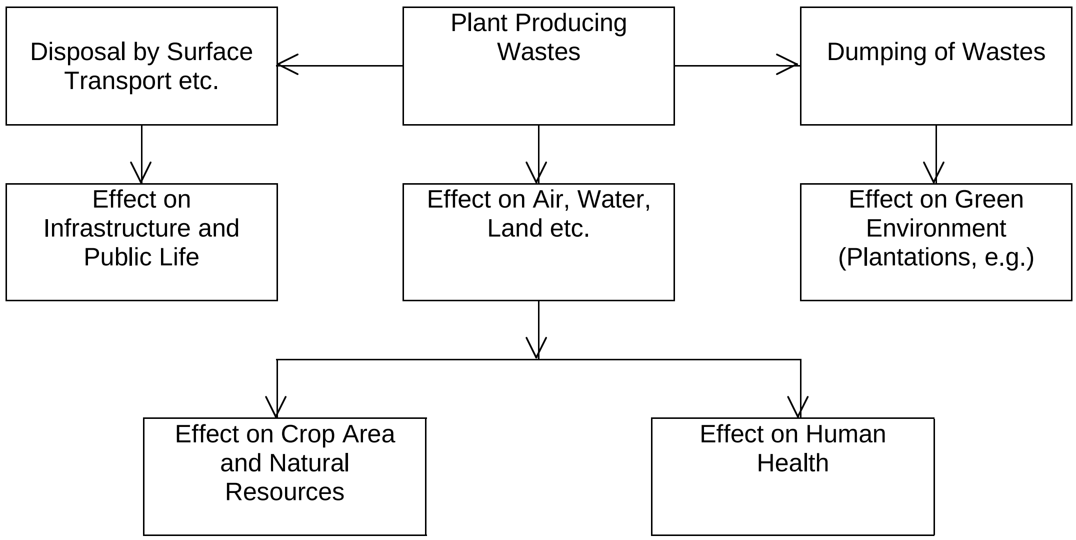
2.1.1 Industrial Wastes: Types

A waste in a plant becomes hazardous depending on both the product and the inputs used. The intensity of hazard depends also on the location of the plant, the mode of transport for carrying the product/inputs etc. If these factors, namely location and transport, are planned (in the sense of elimination of risk/failure at both the levels, inside the plant and outside for human settlements), then also the effect of industrial waste is felt, e.g, on water, air, land etc. (Mattew and Unnikrishnan, 1997, p. 603). This effect is felt by disposal and dumping of wastes. This may be shown by the **Flow Chart 2.1.**

2.2 Fly Ash: Definition and Types

Fly ash is 'the finely divided residue resulting from the combustion of ground or powered coal which is transported from the firebox through the boiler by flue gases'. Fly ash is the mineral matter in coal that is left behind after combustion of coal. This is known in UK as pulverized fuel ash (pfa). Pulverized fuel combustion is in operation for the last half a century. Most of the large boilers in industrial plants use this technique. 'Formation of ash is the outcome of the combustion of coal in the boiler at temperatures in the range of 1300ºC — 1450ºC in presence of nearly 20 % excess air. In pulverized coal fired boilers, not only is residence time of particles in the furnace of the order of only a couple of seconds, but the mineral matter of coal thus released is finely dispersed on account of the fineness of the pulverized coal itself. ... Moving upwards with high velocity, some of the fine particles of ash get agglomerated into coarser yet fine particles, which become highly destructive during their passage through the connective zone of the boiler' (GOI, DST, TIFAC, 1995, August, p. 21-22). The effluents produced during coal combustion are determined both by the composition of the fuel and by the method of combustion. The elements that make up the fuel and the oxidant in which it is burnt, are ultimately discharged to the environment with consequent environmental effects (Chadwick, Highton, and Lindman, 1987, p. 81). In case of pulverized fuel (coal) combustion 'the oxidant stream is greater than the force of gravity on the particles, and coal powder (< 200 μm in diameter) or pulverized fuel is blown into the furnace which has a number of burners. The pulverized fuel is combusted in suspension. **A small fraction of the ash falls to the bottom of the furnace (bottom ash) where it can be removed**. However, the major part is carried away as particulate in the flue gas (pulverized fuel ash or PFA)' (Chadwick, Highton, and Lindman, 1987, p. 83). Fly ash possesses pozzolanic properties similar to naturally occurring pozzolanic materials, primarily of volcanic or sedimentary origin. About 2000 years ago the Romans mixed volcanic ash, called pulvis puteolanus (later changed to 'pozzolana') with lime to produce mortar and concrete. A pozzolan is a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties (ACI 226.3R-87, p. 9).

Flow Chart 2.1: Disposal and Dumping of Industrial Wastes



There are two types of ash found in a coal-using plant. Generally, this ash is associated with Power Plants, though other plants using coal as energy also generate ash. The types of ash thus generated are bottom ash and fly ash (NTPC, 1999, Oct., p. 31).

Bottom Ash: Bottom ash is found at the bottom of Boiler furnace following burning of coal for generation of energy. This ash has relatively higher carbon content and lower fineness.

Fly (Dry) Ash: This ash is very fine, found in powder form. The size of one particle of this ash varies from about one micron to 300 microns. This ash is collected from different fields of Electro-Static Precipitators (ESP) in dry form. 'The design of ESP depends upon the electrical and physical characteristics of fly ash as well as capacity of the furnace and the stack height. Free escape of fly ash into the atmosphere is prevented as the furnace gases are made to pass through electrostatic precipitators, a pair of electrodes, sometimes in association with mechanical arresters. There is a discharge electrode at high potential, and a grounded collecting electrode. The gas ions in the corona are attracted towards the collecting electrode. The fly ash thus gets deposited. The fly ash is collected in hoppers and disposed off' (GOI, DST, TIFAC, 1995, August, p. 23-24). This ash is characterized by relatively lower carbon content and higher fineness. Fineness of fly ash becomes more in subsequent fields of ESP as compared to initial fields. **The ash in dry form has pozzolanic properties, which helps it to react with free lime to be fit for being a useful construction material.**

2.3 Disposal of Fly Ash

There are three main methods of disposal of fly ash by the ash generating plant. The first one is selecting a nearby area and disposing fly ash in that area (generally on land), the second one is mixing fly ash with water and discharging the slurry into planned ash pond located inside the ash generating plant or outside, the third is discharging fly ash in ravines in close proximity to the ash generating plant. The first choice is not feasible unless it is a deserted area. The soft choice for fly ash disposal is ash pond, because it happens to be the easiest and cheapest method for the ash generating plant. Usually ash is sluiced to a lagoon near the plant with water maintained in the lagoon. The existing small size or declining availability of land near the plant and continuous water discharge may restrict this easy method of disposal of fly ash. The problems of leaching along with ponding of wastes draw attention to selection of a pond site, its size, lining of the pond, possible height of the pond and treatment of the sludge discharged to reduce its porosity and permeability. Also, continual removal of the surface layer of water that develops in the pond from rainwater or other runoff is necessary (Congressional Office of Technology Assessment, n.d., p. 242).

2.4 Dumping of Fly Ash

The problems and limitations associated with disposal of fly ash by ash ponding may encourage the ash generating plants to ash dumping. The dumping takes mainly the nature of landfill. For landfill purposes the ash is collected dry and the sludge is dewatered and/or treated to improve its structural properties. In this form, the wastes are more easily transportable than the wet sludge. This allows the landfill site to be away from the ash generating plant. The site selected for dumping is a matter of concern. Probably it is a less valuable location. However, there is no fixed value of any particular site. The other factor is transportation cost of dried and treated sludge. Because of the problems associated with both disposal and dumping of fly ash, the apparently soft choices are not feasible. The alternative thus lies in utilization of these wastes.

Dumping of fly ash is generally planned in the sense that the dumping authority knows the location, size and shape of the dumping of ash by quantity known at present and estimated for future. This dumping till date has taken two shapes for industries functioning in India, one is Ash Pond, and the other is Ash Mountain.

Ash Pond: The ash generated in coal-using plants is accumulated over time, the rate of generation being higher than the current rate of utilization. The unutilized ash is mixed with water to form slurry and is pumped either to develop low lying areas or pumped to the designated ash dumping areas. The ash mixed with water to form slurry in a specially constructed ash dump area is known as Ash Pond. Ash pond is a mixture of bottom ash and fly ash. While ash is mixed with water to form slurry, the pozzolanic properties of dry ash are reduced.

Ash Mountain: It is a system of collection and storage of dry fly ash. This is Ash Mountain, as different from the slurry mode of ash collection and disposal.

2.5 Cost of Disposal of Fly Ash for the Ash Generating Plant

For disposal of fly ash, the plant needs to incur both capital and recurring costs. The capital costs include expenditure on civil works like setting of pipes, and pumps. Since fly ash is highly abrasive, the installed pipes and pumps are subjected to high depreciation costs. There comes thus recurring expenditure on maintenance of ash pond pipe line. The recurring expenditure comes also on treatment of ash pond effluents and recycling or partial recycling of water. There comes also administrative expenditure on operation of ash-slurry disposal system. These are over and above construction and development of ash ponds.

2.6 Problems of Disposal of Fly Ash

The major problems associated with the disposal of fly ash are presented in **Box 2.1**. These problems are recorded based on survey of areas adjoining IFFCO, Phulpur and NTPC, Dadri in the summer of 2001.

Box 2.1
Problems of Disposal of Fly Ash

- Air-borne fly ash from ash deposits, particularly during summer,
- Absence of suitable area to discharge ash pond water,
- Inadequate sources of water for slurry disposal,
- Scarcity of land by area for dumping of fly ash,
- Unsuitable and inadequate plantations on the ash dumped areas,
- Fly ash disposal-led deterioration of the fertility of the adjoining soil, particularly for agricultural purposes,
- Leakage of undesirable elements from fly ash deposits to local fresh water bodies,
- Leakage of slurry-cum-water to nearby agricultural fields,
- Health and longevity of plantations on the soil affected by fly ash borne air and water,
- Absence of boundary walls for high altitude ash pond and the pressure on boundary walls, if any, that endanger the safety of adjoining human settlements and cropfields,
- Transportation of fly ash for disposal,
- Unsafe location of ash pond.

Source: *Field Visit, 2001*.

2.7 Fly Ash: A Brief View for Indian Industries

Because of industrialization, good quality coal reserves are depleting fast in India. Still then, coal continues to be used as a major source of energy in Indian industries. The superior quality coal that is with lower ash content is being used in steel, railway and other metallurgical industries. Once, coal with a maximum ash content of 35.0 per cent was graded. It means, any sample with higher percentage of ash was not graded as coal. With reducing quality of mined coal and depleting coal reserves, the average ash content of coal used in thermal power plants is around 50.0 per cent now (GOI, Techno-Economic Survey, TIFAC, n.d., Different Issues). The quality and quantity of fly ash depend on the factors, which we summarize in **Box 2.2**.

Box 2.2
Factors Determining Quality and Quantity of Fly Ash

- The percentage of ash in coal and its mineralogical properties,
- Fineness of the grinding of coal,
- Nature of the combustion system, type of burners, air/fuel ratio including effectiveness of air/fuel mixing, prevention of any channeling of air and combustion gases,
- Boiler design.

Source: *GOI, Dept. of Science & Technology, TIFAC, n.d., Techno-Market Survey, High Value Added Products & Applications of Fly Ash, New Delhi*.

2.8 Quality of Fly Ash

The mineralogical properties of fly ash depend positively on the ESP from which it is collected. Since it has hardly any carbon content, the ESP fly ash is grey in colour. When mixed with bottom ash, overall carbon content increases in the range of 3.0 per cent to 5.0 per cent. The presence of carbon adversely affects the pozzolanic activity. Since fly ash contains hardly any unburnt carbon, hence it should not be mixed with bottom ash (GOI, DST, 1995, August, p. 33). The most important quality parameters that determine the possible uses of fly ash are (i) residual carbon content, (ii) granulation and fineness, (iii) chemical and alkaline composition (GOI, DST, TIFAC, 1990, Nov. p. 108).

2.9 Fly Ash as a Problem for the Society and Economy of India

There are about 70 thermal power plants in India, which produced around 40 million tonnes of fly ash per annum in 1993, and around 50 million tonnes the next year.

Between 1990 and 1995 coal consumption in Thermal Power Plants increased by 81.81 per cent while ash generation increased by 97.36 per cent, that confirms higher ash content in coal. Most coal in India is bituminous with mineral matter content of 30.0 to 40.0 per cent. Ash content in coal, however, is projected to stabilize at 36.0 per cent for the first two decades of 21st century (**Table 2.1**). With respect to gradual production of inferior grade coal, from within Indian coalmines, only application of superior technology, like coal cleaning, can explain this long-term stabilization of ash content. The assumption is non-import of coal from abroad. It is observed that a 1000 MW thermal power plant generates about one million tonne of fly ash per annum for generation of electricity. **Only 3.0 per cent of fly ash is utilized in India at present for productive purposes, as opposed to 25.0 to 80.0**

per cent utilization in industrialized countries. Unless commercially used, accumulated fly ash will create disaster for the living conditions of people in the country. Because of its physical characteristics and volume, fly ash is supposed to pose serious problems for the human society. The problems are briefly presented in **Box 2.3**.

Box 2.3
Problems of Non-Use of Fly Ash

- Fly ash is extremely difficult to tackle in a dry state because of its extreme fineness,
- Fly ash is readily air-borne and hence it pollutes air,
- Fly ash mixed with water causes soil and water pollution by leaching,
- Inhalation of fly ash causes silicosis, fibrosis of lungs, bronchitis, pneumonitis etc.,
- By being air borne, fly ash corrodes structural surfaces of residential buildings of the people living near the ash generating plants,
- Ultimate settlement of fly ash on cultivable land in the adjoining area degrades soil fertility.

Source: *GOI, Dept. of Science & Technology, TIFAC, 1995, Techno-Market Survey on Fly Ash Bricks. August, p. 2*.

Table 2.1
Actual and Estimated Consumption of Coal and Generation of Fly Ash in Thermal Power Plants in India, 1990-2020

Year	Installed Thermal Power Capacity	Coal Consumption (Million Tonnes)	Ash Generation (Million Tonnes)	Ash Generation as % of Coal Consumption	Multiple over last five years	
					Coal Consumption	Ash Generation
1989-90	45,000	110	38	34.54	-	-
1995	54,000	200	75	37.50	1.81	1.97
2000*	70,000	250	90	36.00	1.25	1.20
2010*	98,000	300	110	36.66	1.20	1.22
2020*	1,37,000	380	140	36.84	1.26	1.27

Note: * *Estimated.*
Source: *Saxena, 1999, P. 133.*

2.10 Economic Uses of Fly Ash by Value Addition: Possibilities

We accept the fact that reuse of the materials seen as wastes by both industries and public authorities incur a cost which is more than what is accepted as a rational input choice. The reason is that the inputs considered as usable by the industries have already taken a shape, either at a very nominal cost (if not zero cost) like coal extracted from the mines and used in power plants, while the wastes lack this quality of being readily available at an usable form. The example for the latter may be ash as a derivation from use of coal in power plants. The problems may be seen into two parts, one being discovering substitutes of coal as an energy in the industrial sector or finding superior grade coal to produce lesser fly ash per unit of generation of electricity, the other being utilizing coal as it is and trying to reuse the fly ash generated from coal-burning. Discovering substitutes of coal is a long-term task. We concentrate on reuse and internalization of fly ash generated from utilization of coal.

We make a distinction between reuse and internalization of wastes in the industrial sector. Reuse implies that wastes generated in industries are possible materials of use anywhere, while internalization implies utilization of the industrial wastes in an inter-industrial frame. In application, however, this distinction is often blurred. The example may be the reuse of fly ash in surface transport. The inter-industrial use of fly ash is also often unplanned, both with respect to quantity of the waste used in a separate plant and timing of setting up of the second plant that absorbs a part of the fly ash generated in the first plant.

The Geotechnical Properties of fly ash allow it to be used in construction of roads and embankments, structural fills etc. The Pozzolanic Properties of fly ash allow it to be used in manufacture of cement, concrete and its products, building materials etc. The physical and chemical properties of fly ash are similar to those of soil, implying that essential plant nutrients are present in fly ash also. These physio-chemical properties of fly ash allow it to be used in agriculture/soil amendment (NTPC Guide, Oct., 1999, p. 41).

By economic uses of fly ash, we mean use of technologies and production of commodities that add to the value to the final user of the products. The fly ash products may be for both private and public uses. The value addition may be low, medium, and high. In **Box 2.4** we enlist some of the possibilities for value-addition in fly ash products.

Box 2.4
Products from Utilization of Fly Ash: Some Possibilities

- Extraction of minerals from fly ash
  - Extraction of alumina
  - Extraction of magnetite
  - Extraction of cenospheres
- Manufacturing of cement
  - Fly ash-lime- calcined gypsum (FaL-G) cement
  - Fly ash slag cement
  - Portland pozzolana cement
- Fly ash bricks and blocks
- Road surfacing and pavement construction
- Mine fill and embankments
- Fly ash as soil stabilizer and fertilizer agent
- Fly ash as a base material for building distempers
- Fly ash as domestic cleaning material
- Fly Ash as partial replacement of cement in prefabricated structures.

Source: *GOI, DST, TIFAC, 1995, Techno-Market Survey on Fly-Ash Bricks, August, p. 36-43*.
GOI, DST, TIFAC, 1990, Techno-Market Survey on Technologies for Disposal of Thermal Power Station Fly Ash, Nov. p. 98-99.
GOI, DST, TIFAC, n.d.(2), Techno-Market Survey on Fly Ash Prefabrication, Technology and Market, p. 20, 25, 27.

In terms of productive use, fly ash is seen as a raw material or as a filling material. As a filling material, it may be used for wasteland reclamation and purification of polluted water in pond. As a raw material, it may be used in cement and bricks, substituting for stone and clay. By extension, the fly ash bricks and cement may be used in construction purposes (roads, dams, tunnels, railway sleepers and other infrastructure). Fly ash as filler may substitute sand, soil and gravel for road and pavement construction. These uses are very much confirmed from experiences of uses of fly ash across the developed countries in the world (GOI, DST, TIFAC, 1990, Nov., p. 101-123).

Chapter3 : Internalization of Industrial Wastes: The Case of Fly Ash

Fly ash is a waste generated by coal combustion facilities from particulate control devices, the bottom ash and slag from the boilers, and the sludge from flue-gas desulfurization (FGD) systems. 'The ash is an alkaline material consisting of insoluble inorganic elements (most of which are enriched in concentration compared to their natural abundance), as well as elevated levels of radionuclides' (Congressional Office of Technology Assessment, n.d., p. 240). Fly ash consists of water-soluble species, mainly calcium, magnesium, potassium, sulfate, and chloride. These species cover a maximum of ten per cent of the ash. The presence of these materials may lead to leaching of ash components into surface and ground waters unless the ash is disposed in a planned manner. The materials like calcium sulfate or calcium sulfite consists of small and thin crystals that settle so slowly as to make the sludge difficult to dewater and thus contributing to its physical instability. The disposal methods will show if the undesirable elements in FGD wastes enter surface or ground water. The disposal methods that are in practice are ash ponds, landfill, and utilization for productive purposes (Congressional Office of Technology Assessment, n.d., p. 241).

3.1 Fly Ash: An Industrial Waste or an Intermediate Product?

Generally, the governments in the developing countries see industrial wastes as materials to get rid of. Hence, comes the question of management of these wastes in terms of disposal and dumping. The questions of how to reduce these wastes at the technology-cum- production point and how to reuse the wastes remain unnoticed. The industries as autonomous decision-makers in selection of products and technologies can thus bypass the problems that grow out of disposal and dumping of wastes. It is known that planned final product(s) at the level of any plant also produces garbage and trash. These market-delinked wastes can well be market-linked if the apparent wastes are seen either by its originator or by some sister concern as intermediate products or inputs. The problem can be seen specifically from two sides, one being the technological side of reducing the wastes by selection of substitute products of material-saving technologies for the same product and the other being reuse of the wastes. We center on an inter-industrial frame for internalization of industrial wastes. This internalization rests on the productive uses of wastes.

Many of the problems regarding disposal and dumping of fly ash need addressing a number of suggestions, and programme actions. Rather than trying to respond to all the problems of disposal and dumping of fly ash, we concentrate on reuse of fly ash. In case of possibility of reuse of fly ash, the problems of disposal and dumping remain planned and generally of short-duration in nature. By reuse, the adverse effects of spread of fly ash on environment is also reduced when the emissions from unwanted disposal are avoided, and resources are saved. The reuse leads to value addition when the ash is transformed into some other exchange-based products (Cornelissen, dr. ir, Hans, 1999, p. 24).

3.2 Objectives of the Study

We will study two industrial plants located in two districts of Uttar Pradesh, India. These selected districts are Allahabad and Ghaziabad. The plants are selected such that coal happens to be the basic input for production of their respective final products. Use (burning) of coal leads to fly ash. This coal-converted 'fly ash' may be considered as a natural physical waste. We will examine the techno-economic feasibility of converting 'fly ash' into economic 'goods', through internalization of fly ash within the industrial plants. This may also show the path of resource recovery. Thus, the objectives of our study will be to examine

(i) How the generation of fly ash by the chosen industrial plants can be reduced per unit of final output;

(ii) How 'fly ash' generated in one industrial plant is transformed into final product within the same or in another industrial plant;

(iii) How are the adjoining areas, like those for human settlements, crop fields etc. affected by generation of fly ash in the industrial plant;

(vi) What type of alternative products and technologies can be thought of to ensure long-term internalization of fly ash.

The study will concentrate on both the possibility of reducing the generation of fly ash and find out the ways of using fly ash. Thus, we will study the techno-economic possibilities of internalizing fly ash through reuse. An analysis of the effects of fly ash on the environment will be a part of the study.

3.3 Coverage of the Study

One of the two plants that we select is the Phulpur Unit of the Indian Farmers Fertilizers Cooperative Ltd. (IFFCO), in the district of Allahabad, Uttar Pradesh. The second plant that we select is the Dadri unit of the NTPC (National Thermal Power Corporation) in the district of Ghaziabad, Uttar Pradesh.

The Phulpur Unit of IFFCO is a fertilizer plant that uses coal as a basic physical input and produces fertilizer as the final output. In the production process, fly ash is generated. Our purpose will be to examine management of ‘fly ash’, a waste that can also be seen as a byproduct. The Phulpur Unit of IFFCO is a modern fertilizer complex having a 900 tons per day Ammonia plant and 1500 tons per day Urea plant. In addition to coal, the Unit uses naphtha, fuel oil, water and electricity as other physical inputs. Coal happens to be the main fuel for boilers, and a small quantity of fuel oil is used as support fuel for proper combustion of coal. We will examine if, and how far, this Unit internalizes ‘fly ash’. We will see if it uses fly ash inside its own plant premises in producing products like bricks, or if it controls fly ash by converting it into an ash pond or ash mountain. We will also see if the Unit sells fly ash to some other plants.

The Dadri Unit of the NTPC generates electricity with an installed capacity of 840 MW. It operates using both coal and gas as basic inputs. In the Thermal unit of the Dadri power plant, fly ash is generated as a byproduct. We will examine the scope of ash utilization by the Dadri Unit. We will see if the Unit controls fly ash as ash pond, or as ash mountain, and if it utilizes fly ash inside the plant for producing products like bricks, or if it sells fly ash to some other firms.

In both the cases, we will examine the nature and cost of disposal of fly ash, and the net benefits from utilization of fly ash. In both the cases, we will examine the cost-benefit implications of utilization of fly ash.

3.4 Methodology of the Study

We will study the methods the selected plants have been using to control and reuse fly ash. In addition to collecting data from the Reports and Records of these Units, we will collect primary data through observations and conversation with the R&D personnel of the selected plants.

We will examine the actual and techno-economic possibilities of utilization of fly ash in products of use. For this, we will select a number of economic activities in the manufacturing sector based on information on utilization of fly ash in India from secondary sources (**Box 3.2**). These activities will be manufacturing bricks and cement though we are aware that there are other areas of utilization of fly ash. In selection of manufacturing units we will follow the Notification dated 14 Sept., 1999 of the Ministry of Environment and Forests (MOE&F), Government of India (NTPC Guide, Oct., 1999, p. 7). We will use structured schedules for collection of information from the brick and cement plants, located adjacent to the selected IFFCO and NTPC plants, in accordance with the Notification of the MOE&F, GOI, 1999. We will use structured schedules for interviewing people affected in the areas adjoining the selected industrial plants that generate and dispose of fly ash. We will use questionnaire to get ideas from experts on utilization of fly ash.

3.5 Manufacturing Bricks: The Technological Possibilities of Utilizing Fly Ash

We deal here with the question of brick manufacturing technologies that allow mixing of fly ash. One such possibility of manufacturing fly ash bricks starts with a homogeneous mixing of raw materials, namely, fly ash, sand, and lime. Some technologies also take help of chemicals like gypsum. In a technologically fixed ratio, the raw materials are mixed in the brick plant to manufacture green bricks. The 'steam method or watering method' cure the green bricks. The method of curing may differ, for example, from water curing to steam curing at low pressure or autoclaving at 10-14 kg/cm^2 (NTPC Guide, Oct. 1999, p. 46). The second is mixing of fly ash with clays. However, not all clays and fly ashes are suitable for manufacturing bricks. 'In alluvial clays where clay fraction (particles less than 0.005 mm) is below 15 % and coarser particles (more than 0.02 mm) above 50 %, fly ash can only be pushed to the extent of 20 %. The clay fraction provides plasticity to clay-fly ash-water system and facilitates smooth moulding. It bonds fly ash particles and is responsible for green and dry strength of bricks. Hence, addition of larger proportions of fly ash in clays having poor clay fractions presents problems during moulding and drying. Black cotton clays, on the other hand, are quite plastic even at a lower clay fraction. This is due to montmorillonitic clay mineral present in them. These clays can, therefore, be incorporated with larger amounts of fly ash for brick manufacture' (GOI, DST, TIFAC, 1995, Aug. p. 78-79). For fly ash bricks, it is desirable that the oxide composition should be similar to ordinary brick clays – the silica content should be over 40.0 per cent, aluminium oxide not less than 15.0 per cent, iron oxide not less than 5.0 per cent and sulphide and soluble sulphite content insignificant (GOI, DST, TIFAC, 1995, Aug, p. 79).

3.6 Manufacturing Fly Ash-Sand-Lime Bricks: Availability of Technologies in India

If the general climate is characterized by presence of moisture, then fly ash will react with lime at an ordinary temperature and will develop a compound possessing cementitious properties. 'After reactions between lime and fly ash, calcium silicate hydrates are produced which are responsible for the high strength of the compound'. Bricks made by mixing lime and fly ash thus become 'chemically bonded bricks' (NTPC, Oct. 1999, p. 44).

A number of organizations/institutes in India have developed technologies for manufacturing fly ash-sand-lime bricks. Some of them are the Central Fuel Research Institute (CFRI), Dhanbad, National Council for Cement and Building Materials (NCBM), Ballabhgarh, Central Building Research Institute (CBRI), Roorkee, Ahmedabad Electricity Co. Ltd., Ahmedabad, INSWAREB, Visakhapatnam Fal-G Technology (NTPC Guide, Oct. 1999, p. 46). We present here the fly ash brick technology developed by CFRI, Dhanbad. We cover here the technique of production in brief, the properties of the final product, the economy or market-viability. The technique involves mixing of fly ash, sand, and lime in a technologically fixed proportion with specific quantity of water and a small quantity of accelerator. The raw mix is molded in hydraulic press. The process yields green bricks. The green bricks are dried for a reasonable period and then cured in steam in low pressure. The technique, the properties etc. are shown in **Box 3.1**.

The Central Power Research Institute (CPRI) has developed the technology to manufacture acid resistant bricks using fly ash to the extent of 25.0 to 35.0 per cent. It is also reported that semi-insulating bricks may be produced from fly ash using china clay, saw dust, and molasses or spent lye as binder (GOI, DST, TIFAC, 1990, Nov. p. 97).

3.6.1 Use (Utility) of Fly Ash-Sand-Lime Bricks

As are conventional clay bricks, the fly ash-sand-lime bricks are also suitable for construction of concrete buildings and other masonry works. The fly ash bricks have the potentialities for better use than the use of conventional clay bricks. The reasons for this better use are the following:

(i) Fly ash bricks possess crushing strength more than that of market-tested clay bricks; thus, fly ash bricks are fit for bearing load.

(ii) Fly ash bricks require no plastering for construction of buildings, these bricks being uniform in shape and smooth in finish.

(iii) The weight of each fly ash brick (of equal size as the conventional bricks) is less than each conventional (clay) brick.

(iv) Fly ash bricks are less porous than common clay bricks.

(v) Fly ash bricks satisfy the specifications of Bureau of Indian Standards (BIS) regarding quality of such bricks.

Box 3.1
Technology and Economy of Fly Ash Brick Production, CFRI, Dhanbad, India

Technology of fly ash brick production: Fly Ash-Sand-Lime	
1. Raw Materials	Mixture of Raw Materials
(a) Fly Ash	80.0 %
(b) Sand	9.8 %
(c) Lime	10.0 %
(d) Ordinary Portland Cement	Nil
(e) Gypsum	Nil
(f) Accelerator	0.2 %
2. Hydraulic Press Pressure Requirement	200-240 kg/cm^2
3. Air Curing of Green Bricks	12-24 hours
4. Autoclaving/Steam Curing/Water Curing	
(a) Pressure	2-2.5 kg/cm^2
(b) Temperature	120ºC
(c) Time	3-4 hours
Properties of produced fly ash bricks	
1. Compressive Strength (Wet Comp. Strength)	100-150 kg/cm^2
2. Water absorption	20.0 %
3. Durability	Good
4. Efflorescence	Free from Efflorescence
5. Bulk Density	1570 kg/m^3
6. Shape	Uniform
7. Finish	Smooth
8. Saline Condition	No adverse effect
Economy in production of fly ash bricks	
Capacity per Day	Investment (Rs. Lakhs) For 100 kg/cm^2 strength (approx)
20,000	100
8,000	48
Production Cost per 1000 bricks (Rs)	1000-1400*

Note: * *Cost of production is lime dependent. The variation in cost thus depends on the extent of variation of lime cost*.
Source: *CFRI, Dhanbad, March 2001.*

3.7 Technology for Manufacturing Clay-Fly Ash Bricks

The process of manufacturing clay-fly ash bricks is similar to that of manufacturing normal clay bricks except that fly ash is mixed with clay in a specific proportion before moulding bricks. Fly ash mixed with clay eliminates drying cracks in the bricks produced from black cotton clays. The unburned carbon present in fly ash (or mixed fly and bottom ash) provides additional fuel for burning during firing (GOI, DST, TIFAC, 1990, p. 55). A mixture of fly ash (40-60 per cent) in clay of moderate level of plasticity leads to production of green bricks. The process of production is manual or extrusion. The green bricks are dried in normal open air or in the shed. The period for drying of green bricks generally excludes monsoon. The dried green bricks are fired in traditional brick kilns of continuous type at 1000 +_ 30ºC with a soaking period of 5 to 7 hours. This yields red clay bricks. This technology was invented and developed in Poland. The first such plant was commissioned in Poland in 1985.

3.7.1 Use (Utility) of Clay-Fly Ash Bricks

The major properties of fly ash that makes it useable for production of clay-fly ash bricks are the following:

(i) Fly ash has physical, chemical and mineralogical properties similar to those of clay (soil).

(ii) Unburned carbon in fly ash improves firing and reduces fuel requirement. This leads to saving thermal energy up to 30 per cent during firing process.

(iii) Fly ash mixture in clay has the ability to modify the drying behaviour of sensitive plastic clays.

(iv) The mixture of fly ash in clay not only reduces excavation of precious (scarce) top soil, but also reduces consumption of coal that would have been required in conventional brick making.

(v) The technology requires minor changes in existing arrangement at kiln sites. The production of mixed bricks is also not much susceptible to quality of ash (NTPC Guideline, Oct., 1999, p. 43-44).

3.8 Utilization of Fly Ash: Practices and Possibilities

Almost all the industrialized countries utilize fly ash as much as possible. Fly ash utilization is as high as 80.0 per cent in West Germany, 70.0 per cent in Netherlands, 65.0 per cent in Denmark, France, and Belgium, and 55.0 per cent in UK and Poland. Denmark even imports fly ash and exports its value-added products. Incidentally, there are no coal mines in Denmark. In Denmark, fly ash is used as filler for stabilization of sand and gravel in road building. In case of fly ash being used as filling material under dwellings, the Ministry of Health, Government of Denmark, has recommended that a top layer of sand or gravel of at least 20 cm should be arranged as protection against radioactive radiation from the ash (Jensen, 1999, p. 7). In

Germany, there comes the necessity of stockpiling of fly ash to meet huge construction works during a particular time in a year. 'Some of the fly ash produced in winter time is conditioned with water (15 to 20 %) in a mixing screw at the power plant and temporary stockpiled at approved stockpiled sites. This fly ash is used in earthwork and road construction where large amounts of mineral building materials are required and the current production of a power plant would normally not be sufficient for a major road construction project. Since the value of the material used is low and soil and rock materials are available near the site, in most cases transportation cost is the limiting factor. Therefore fly ash as a building material in earthwork and road construction is only competitive in the vicinity of the power plant. But, in order to get rid of the surplus of the winter production, the power plant operators sometimes are forced to deliver the fly ash at a negative price' (Berg, 1999, p. 12).

India uses at present only 3.0 per cent of total fly ash generated (GOI, DST, TIFAC, 1995, Aug. p. 26). **Of the negligible use of fly ash in India, as high as 93.0 per cent is used in production of bricks and Portland Pozzolana cement** (**Box 3.2**).

Box 3.2
Utilization of Fly Ash in India
(Product-specific utilization as a percentage of total utilization of fly ash)

Areas of Use	% Utilization of Fly Ash
Fly Ash Bricks	70.2
Portland Pozzolana Cement	23.0
Asbestos Products	6.41
Others*	0.57

Note: * *Include Underground Fills, Hydraulic structures, Ash Ponds and Dykes, Agriculture and Soil Amendment*.

Source: *GOI, DST, TIFAC, n.d., Techno-Market Survey, High Value Added Products and Applications of Fly Ash, p. 180.*

Example: Manufacture of Fly Ash-Sand-Lime Bricks

Pulver - Ash Projects Ltd., Tribeni, West Bengal

(Source: Field Visit on March 27, 2001)

The Pulver - Ash Project Ltd., West Bengal, was **commissioned in 1994 to internalize fly ash generated in the Bandel Thermal Power Station**, in an intra-government inter-industrial framework. The only product this plant has been producing is bricks of modular size (190 ml.x90 ml. x 90 ml. or approximately 7.6"x3.56"x3.56"), as opposed to the conventional clay brick of size 10"x5"x3" in West Bengal. The plant was set up with an installed capacity of absorbing 20.0 per cent of fly ash generated per period in Bandel Thermal Power Plant, given the projected utilization of coal in the Power Plant and hence generation of fly ash. **The Ash Plant has been absorbing 10.0 per cent of the fly ash generated in the Power Plant**. While the capacity production of bricks in the ash project was 12.6 crore pieces, the actual production came to be only 3 crore pieces, excess capacity thus being 8.4 crore pieces during 1994-2000. The reason being that while the Ash Plant was set up with a provision for running three shifts, for the last six years it could manage to run only one shift of eight hours.

The ash plant was setup under the cottage and small-scale industries sector. The only heavy machinery that was installed in the beginning for production of bricks was an 800-ton brick press imported from Germany in 1994. The operation of the press machine is automatic. The machine has blocks for production of 18 green bricks that takes 18-20 seconds for pressing of the machine. In a single working day of 8 hours, thus the Ash Plant produces 15,552 pieces of bricks. Out of these, 2 to 5 per cent are rejected as damaged, broken etc. due to mishandling and are generally dumped in one corner of the 8.5 acre plant situated on the bank of the Ganges. The rate of depreciation of the machine (10 to 15 per cent per year) is very high. The Ash Plant does not have any plan to replace the machine.

The process of partial internalization of fly ash between the Thermal Power Plant and Pulver Ash Plant works as the following described in brief:

Two parallel set pipelines, each with a length of 700 ft. and a diameter of 10 inches, are used as channels for unidirectional movement of fly (dry) ash from the Thermal Plant to the Pulver Ash Plant. The regularity or interruption, if any, in this flow of dry ash is controlled administratively-cum-technologically at the levels of both the plants. In the ash plant, two hoppers have been installed to store this dry ash along with two other smaller hoppers installed for storing sand and lime separately. In a technologically fixed ratio, these inputs (fly ash, sand, and lime) are mixed to produce green bricks through the press machine. The mechanized bricks roll through a conveyor (leather) belt, collected by the workers manually, and arranged in trolleys set on the rail track of small length. Two cylindrical chambers are used for curing the bricks by steam. The carrying capacity of each chamber is 12,500 bricks. The cured bricks are sorted out, and they get ready for sale. One can use colour on the body of this fly ash brick, though the bricks are smooth. The colour used on these bricks remains durable.

However, the **Ash Plant remains underutilized** both in terms of machines installed and manpower employed. There was lack of long term vision by non-commissioning of more than one shift when manpower was already employed in 1994 for running three shifts. The paradox is that output of one shift goes to pay the wage bill for manpower of three shifts, thus showing non-profitability of the Ash Plant. At the same time the initial objective of internalization of fly ash generated in Thermal Power Plant through Pulver ash project is lost by non-expansion of the Ash Plant. Price setting for fly ash bricks can not cure the problem of commercial viability at the current scale of production, because this price setting is dependent on price per unit of conventional bricks. For example, the ex-factory price of fly ash brick per 1000 piece at present stands at Rs. 2200.00, which converges to the price of the conventional brick per thousand at the unloading point at the major market (Calcutta). **As reported at the Ash Plant level, the actual unit (average) cost of fly ash brick is much higher than the price fixed per unit**. This unit cost includes depreciation (cost) of the heavy imported press machine installed. It is reported that there is no substitution at home of the machine imported for the said purpose. For the ash bricks, the private individuals are the buyers. The sale and purchase of these bricks are done on a cash basis, seller being the government of West Bengal. **The government as a buyer is generally absent in the fly ash brick market, at least at the level of this plant. Nor is the government (as owner of both Thermal Power Plant and Ash Plant) ready for imposing binding conditions on the private conventional brickfield owners on utilization of fly ash released from Power Plant.**

So far as the generation of fly ash in Bandel Thermal Power Plant is concerned, there remains no choice but to dump most of the ash in the form of an ash pond in an adjoining area. The problem is that there is not much scope for infinite expansion of area of this pond. The Power Plant, thus, disposes of the ash to private operators through inviting public tender. For this disposal, the Power Plant pays subsidy to private operators, that is, free supply of fly ash at the gate plus a percent of the carrying cost. This is contrary to the interest of the Pulver Ash Project, which pays a price to the Power Plant for buying fly (dry) ash. There is thus point in supplying cost-free ash to the Pulver Ash Project also, and by the same process, allow the utilization of installed capacity of the Ash Plant. The argument of capacity utilization stands when the high capacity machine is already imported and installed and manpower is employed for running three shifts a day. The capacity utilization also depends on the price per unit of the product and steady sale.

3.9 Manufacture of Cement Concrete and Mortar: Technological Possibilities of Mixture of Fly Ash

Fly ash is used in manufacturing of cement concrete in the industrialized countries like UK, and US. Technologically, the difference between fly ash and Portland cement becomes apparent under a microscope. Fly ash particles are spherical in shape, allowing these to flow freely and blend in mixtures. This property makes fly ash a desirable admixture for concrete. During the period when fly ash is blend with cement concrete, lime is liberated. The fly ash mixed with cement concrete reacts with the lime and forms additional cementitious material. For concrete work, the ratio at which Portland cement may vary range from 15.0 per cent to 25.0 per cent. 'Indian Standard (IS): 456-1999 code of practice for plain and reinforced concrete allows the use of fly ash as part replacement of Ordinary Portland Cement conforming to IS: 269. It also allows the use of fly ash as admixture and part replacement of fine aggregates. IS: 2250 -1981 code of practice for preparation and use of masonry mortars also specifies the use of fly ash in cement mortar/lime mortar mix' (NTPC Guide, Oct. 1999, p. 63).

3.9.1 Benefits of Mixed Cement Concrete

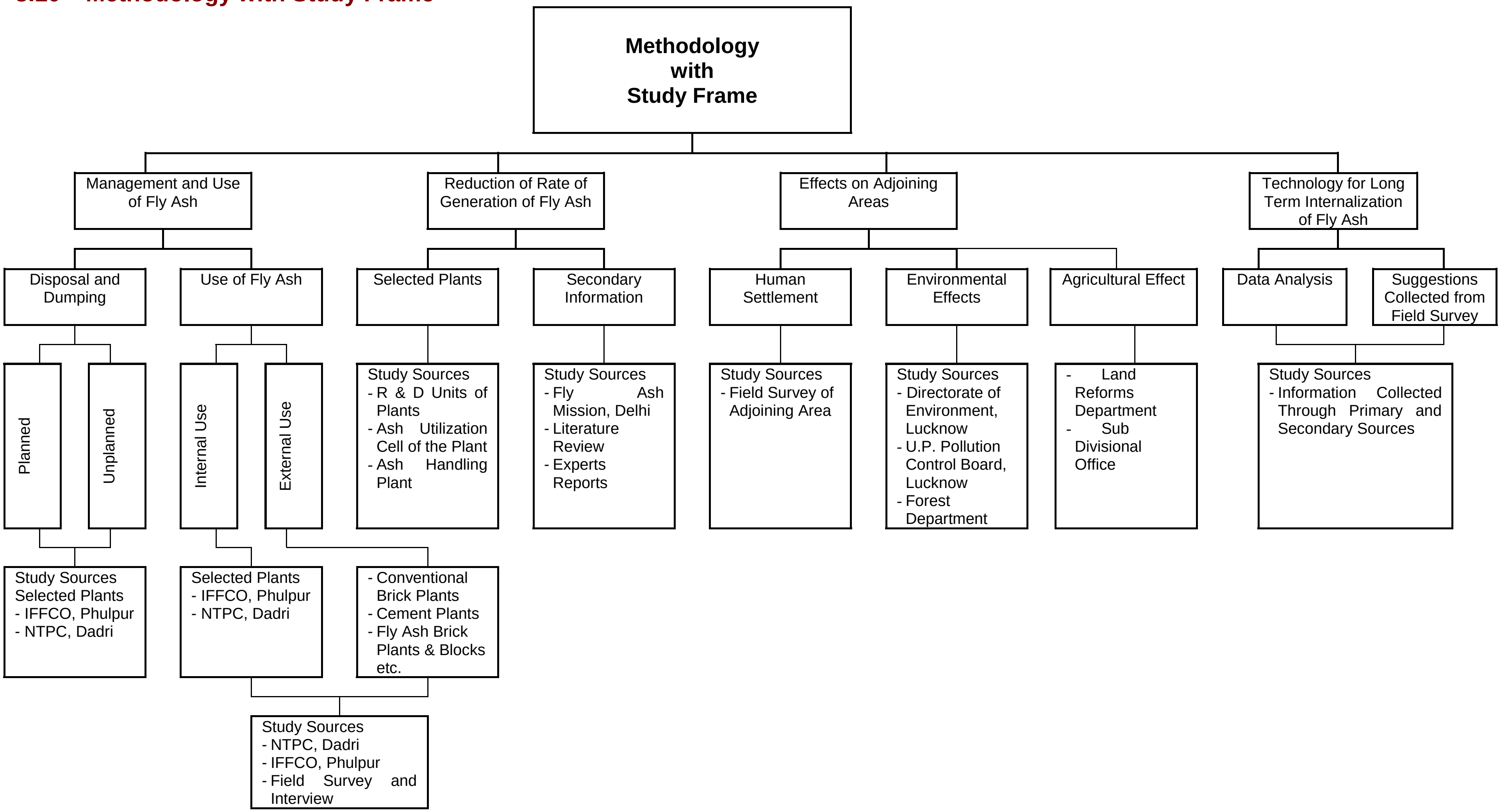
The 'ball-bearing' effect of fly ash particles creates a lubricating action when concrete is in its plastic state. This creates benefits in use of mixed fly ash cement, which are described in **Box 3.3**.

Box 3.3
Relative Benefits of Fly Ash Concrete

- **Workability**: Mixed concrete is easier to place with less effort, responding better to vibration;
- **Improved Finishing**: Mixed concrete makes sharp and clear architectural design more easy to achieve;
- **Higher Strength**: Fly ash continues to combine with free lime, increasing structural strength over time;
- **More Durability**: Dense fly ash concrete helps keep aggressive compounds on the surface, where destructive action is reduced. Fly ash concrete is also more resistant to attack by sulfate, mild acid, soft (lime using) water, and seawater;
- **Reduced Heat of Hydration**: The pozzolanic reaction between fly ash and lime generates less heat that results in reduced thermal cracking when fly ash is used to replace Portland cement;
- **Reduced Slump Loss**: More dependable concrete allows for greater working time, particularly in hot weather;
- **Reduced Segregation**: Improved cohesiveness of fly ash concrete reduces segregation that can lead to rock pockets and blemishes;
- **Reduced Bleeding**: Very few bleed channels in fly ash concrete reduces porosity and chemical attack. Improved paste to aggregate contact results in enhanced bond strengths;
- **Reduced Permeability**: Increased density and long term pozzolanic action of fly ash, which ties up free lime, results in fewer bleed channels and reduces permeability;
- **Reduced Sulfate Attack**: Fly ash ties up free lime that can combine with sulfate to create destructive expansion;
- **Reduced Efflorescence**: Fly ash chemically binds free lime and salts that can create efflorescence and dense concrete holds efflorescence producing compounds on the inside;
- **Reduced Shrinkage**: The lubricating action of fly ash reduces water content and hence reduces shrinkage (It is known that the largest contributor to drying shrinkage is water content);
- **Reduced Alkali Silica Reactivity**: Fly ash combines with alkalis from cement that might otherwise combine with silica from aggregates, causing destructive expansion.

Source: *Ward, John,* ***www.isgresources.com*** *(with permission)***.**

3.10 Methodology with Study Frame



Chapter 4 : Internalization of Fly Ash: A Study of IFFCO, Phulpur Unit, Allahabad, Uttar Pradesh

4.1 Production Networking of IFFCO, Phulpur

Indian Farmers Fertilizer Cooperative Limited (IFFCO) was set up on November 3, 1967. IFFCO is a federation of over 30,444 societies, most of them being village cooperatives, spread over 18 states and 3 Union territories in India. IFFCO at present owns four giant fertilizer units. These units are the Kalol and Kandla units in Gujarat, and Phulpur and Aonla units in Uttar Pradesh.

The fertilizer complex located at Phulpur, Allahabad, was conceived in 1974 and built at a cost of Rs. 205 crores. The total area acquired by the plant is 1068 acres, including the area under the plant that is 321 acres. The rest of the area, that is, 747 acres, covers township, cordet, agricultural farms, green belt, ash ponds, roads, and open space (www.iffco.nic.in). **IFFCO, Phulpur unit has a production capacity of 900 Tonnes Per Day (TPD) ammonia and 1500 TPD urea**. **The Plant started commercial production in March 1981**. The Plant includes steam and power plant, water treatment plant, cooling towers, inert gas generation, instrument and plant air system, naphtha and fuel oil handling system, ammonia storage and handling, urea storage and bagging, coal and ash handling, effluent treatment plants. IFFCO, Phulpur unit is a naphtha-based fertilizer unit. The main inputs of the plant are naphtha, fuel oil, coal, water, and electricity (**Table 4.1**). Indian Oil Corporation through Rail tankers supplies the feed stock, naphtha and fuel oil. **The power plant receives coal from Central Coalfield Ltd. and Coalfields of Rajhara, Patratu, and North Ramgarh (**Chaudhudy et al, 1999). **For this, the mode of transport is railways.** Raw water is pumped from Borewells located around the factory and township. **Electricity is mainly generated in the power plant captivated**, but a part of the electricity required is received from the UP State Electricity Board (UPSEB).

Table 4.1
Inputs and Output of IFFCO, Phulpur, Uttar Pradesh

Plant	Output (TPD)	Name of Inputs Used	Quantity of Inputs Used (MT per day)
IFFCO, Phulpur	Ammonia, 900 Urea, 1500	Naphtha	850
		Fuel Oil	60
		Coal	1000
		Water	24,000
		Electricity*	

Note: * *1 MW (Megawatts), TPD: Tonnes per day*
Source: *IFFCO, Phulpur, Plant Documents, n.d.(Documents collected in 2000).*

4.1.1 Coal Specifications of IFFCO, Phulpur

IFFCO, Phulpur uses grade E/F non-coking coal. Collieries of Central Coalfields Ltd. such as North Ramgarh and central Saunda are the sources of supply of coal. Electricity generated in turbogenerated sets is internally used. Annual coal consumption for the plant ranges from 3.4 to 4.0 lakh MT. Annual ash generation ranges from 1.5 to 1.8 lakh MT. It means the **ash content in coal used varies from 40.0 to 45.0 per cent**. On the basis of Proximate Analysis (chemical and physical properties of coal used in IFFCO, Phulpur), total moisture (TM) in coal used ranges from 3.0 to 4.0 per cent, and volatile moisture (VM) ranges from 18.0 to 20.0 per cent. Air-dried moisture ranges from 1.0 to 1.5 per cent. The plant can not use very high VM coal (>25.0 per cent) which will form slagging and bummer damage in the boiler. The possibility of reducing ash generation in the plant depends on availability and use of low ash- content coal **(Table 4.2)**.

Table 4.2
Use of Coal by IFFCO, Phulpur (By quantity and cost)

Year	Use of Coal (Quantity in Lakh MT)	Cost of Coal (Rs. crs, Approx.)
1998	3.85	44.0
1999	3.40	39.0
2000	4.05	46.6

Source: *IFFCO, Phulpur, Allahabad*.

4.1.2 Steam and Power Plant: Operations

Three coal-fired boilers have been installed to cope with the steam and power requirements of ammonia and urea plants in IFFCO, Phulpur. Each boiler, supplied by the BHEL, generates high-pressure steam at 110 kg/cm^{2}g, 465^0 C with a capacity of 125 tonnes per hour. **The installed boilers have been designed for fully automatic operation incorporating modern control systems. For ensuring thermal efficiency, the maximum heat recovery from the flue gas is**

incorporated. Consequently, the gas is made free from ash particle by means of electrostatic precipitator. **Coal is the main fuel for boilers**, **and a small quantity of fuel oil is used as support fuel for proper combustion of coal.** DM water from water treatment plant and recycled condense from ammonia and urea plants are received in the makeup water tank. After removing dissolved oxygen in steam Deaerator, boiler feed water is heated to 264^0C in economizers and fed to boiler drum. The steam generated in steam drum is superheated to 465^0C in super heaters and is supplied to power generation unit and process plants. A big open coal yard has a coal storage capacity of more than 30 days coal requirements and is equipped with the facility to unload coal at a rate of 500 tonnes per hour. Wagon tippler with marshalling equipment placed at extreme end of coal yard provides the quick automatic unloading of coal from coal wagons. **Unloaded coal is fed to coal crusher through conveyer belts. Crushed coal is sent to coal bunkers. Ultimately, crushed coal is sent to Pulverizing unit of Bowl mill. The pulverized coal is pneumatically transferred to coal burners, located in combustion chamber**. Combustion air, drawn through forced draft fans and preheated, enters combustion chamber, flue gases are drawn by induced draft fans. After heat recovery in the superheated coils, economizers and air preheater, flue gases are made ash free in electrostatic precipitator and exhausted in open atmosphere through a 100-meter high chimney. **Ash collected in electrostatic precipitator is ejected to the ash disposal ponds in slurry form.**

4.2 Fly Ash: Generation and Management

IFFCO, Phulpur claims to maintain a clean environment around the factory. **The Phulpur unit of IFFCO has installed all necessary equipment for controlling the quality of liquid effluents and of gaseous emission. Liquid effluents from the plant are treated before being discharged into the main effluent nallah outside the plant premises**. **The quality of the effluents always lies within the standard laid down by the UP Pollution Control Board** (IFFCO, Phulpur, Plant Document, n.d., p. 10). The required treatment facilities

Photo 4.1: IFFCO, Phulpur Plant, Green Belt

comprise of neutralization system for acidic and alkaline effluents, chromate treatment plant and sludge settling system for cooling tower blowdown water, gravity oil separators for oil recovery, ammonia distillation column for treating the amonical effluents, ash ponds to separate the coal ash from the ash water slurry and lime sludge, oxidation ponds using water hyacinth for domestic sewage and finally guard ponds.

Disposal systems for dry ash and wet ash are independent. Generation of bottom ash in the plant is 30 MT per day per boiler. For the disposal of wet bottom ash, water consumption is 1000 M^3 per boiler per day. The source of this water is recycled effluent/drain water. The accumulated quantity of ash in ash pond is about 15.0 lakh tonnes at present. Acquiring additional land for construction of ash pond in the neighbouring area is not possible due to socio-economic constraints. The plant can hope to reduce the generation of fly ash by reducing the unburned coal and increasing the boiler efficiency. **The plant till date has no technology/technique to reduce the rate of generation of fly ash.** Its R&D (laboratory) have no role in reducing the generation of fly ash (Technical Division, IFFCO, Phulpur, May 2001).

Photo 4.2: Ash disposal pipe from boiler to ash pond.

The area allotted for storage of ash (bottom, dry, and pond) inside the plant is nil, while 70.0 per cent of the area outside the plant has already been covered for storage of ash. The storage capacity of ash pond of the plant is 23 lakh MT of ash. **The dumping of fly ash is going not to exhaust the area that is acquired outside the plant as the ash is being supplied regularly to cement manufacturers. The rate of supply of ash far exceeds the rate of current generation of ash in the plant (Table 4.3 and Fig. 3.1a, 3.1b)**. For 2000-2001, the rate of supply of fly ash was 168.0 per cent of ash generation (www.iffco.nic.in, 04.12.2001).

Table 4.3
Coal: Use and Ash Content,
Fly Ash: Generation and Utilization (IFFCO, Phulpur)

Indicators	1998	1999	2000
Use of Coal (in Lakh MT)	3.85	3.40	4.05
Generation of Fly Ash (in Lakh MT)	1.70	1.50	1.79
Ash Content in Coal (in %)	44.15	44.12	43.95
Utilization of Fly Ash by Quantity (in Lakh MT)	1.15	1.40	2.83*
Utilization of Ash as % of Generation of Ash	67.6	93.3	159.0*
Ash Dumped by Quantity (in Lakh MT)	0.55	0.10	Nil
Ash Dumped as % of Generation of Ash	32.4	6.7	Nil

Note: * *IFFCO, Phulpur, installed dry ash collection system in April 2000, and hence utilization exceeded generation*.
Source: *IFFCO, Phulpur, Allahabad*.

The coal used by IFFCO, Phulpur, has an ash content (Minimum) at 40.0 per cent. On average, it varies from 44.0 to 48.0 per cent. Based on coal consumption at the rate of 1000 MT/Day, the plant generates 400 MT ash per day at the minimum. During the last 20 years (1981-2000), the accumulated ash came to be (400 MT x 330 working days (average in a year) x 20 years) 26,40,000 MT.

For the calendar year 2000, the ash generation rate came to be 540 MT per day on average. The disposal rate is 2.5 times the rate of generation, that is, 1500 MT per day. Based on 330 working days in a year, the plant disposes of 4,95,000 MT fly ash in a year. The plant, thus, needs less than six (6) years to dispose of all accumulated fly ash. However, during these six years, the plant generates (600 MT x 330 working days x 6 years) 11,88,000 MT fly ash. Thus, additionally, the plant needs (at the present rate of disposal) 2.4 years to utilize the ash generated (Information provided by Technical Division, IFFCO, Phulpur, May 2001). **Thus, on a span of less than ten years from year 2000, the plant can utilize all fly ash generated. This complies with the Notification of the Government of India, 1999, for all ash generating plants.**

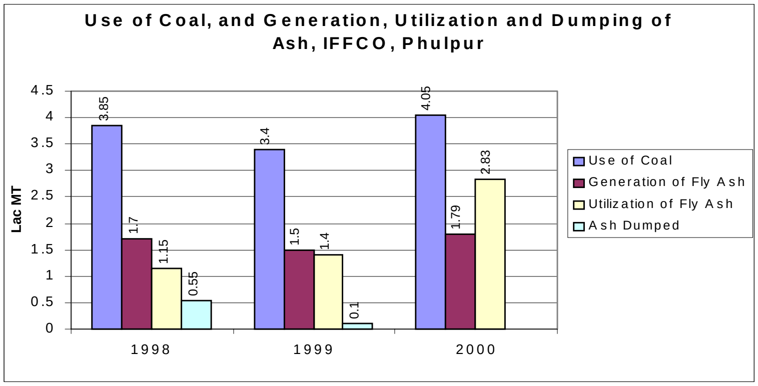


Fig. 4.1a

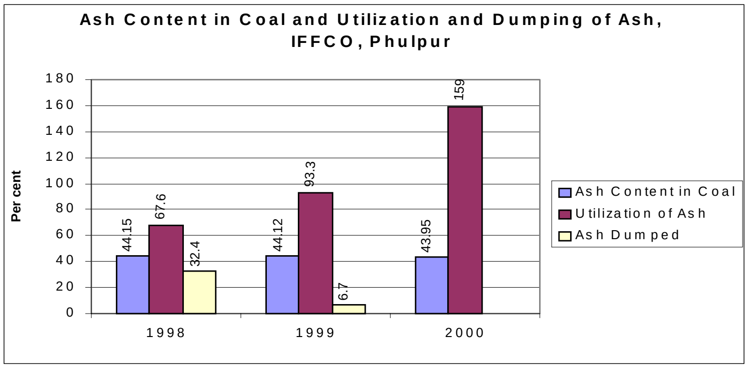


Fig. 4.1b

4.3 Method of Collection and Supply of Fly Ash: Shift from Wet Ash to Dry Ash

The plant has shifted from wet ash disposal in the former ash pond formed in the adjoining area to supply of dry ash through pneumatic conveyor system. IFFCO, Phulpur, shifted from wet ash disposal to supply of dry ash in a phased manner. For Boiler No. 1, it was done in April 2000. By November 2000, it shifted completely to supply of dry ash. To be specific, coal-based boiler generates bottom ash (20.0 per cent) and fly ash (remaining 80.0 per cent). Fly ash goes to new dry ash system while bottom ash goes to wet ash system. In volume, wet ash disposal per day is now approximately 90 to 100 tonnes per day and supply of dry ash is 350 to 360 tonnes per day. Dry fly ash is collected in hopper and supplied directly to tankers. Electro mechanical retractable chutes are supplied to load fly ash into the tanker

Photo 4.3: Ash pond of IFFCO, Phulpur.

without any dust hazard in the locality. A rotary feeder installed below the hopper discharges fly ash collected in the hopper. The retractable chute is installed below the rotary feeder.

Once the tanker is placed below the chute, manhole cover is opened up and chute lower push button is pressed from the pendent push button station. The push button is kept pressed till the lower segment of the chute comes down and rests on the manhole of the tanker. After placement of the chute, the rotary feeder is started. Rotary feeder takes out the ash from the hopper and load into the tanker by gravity discharge. When the ash heap reaches up to the manhole, the capacitance type level sensor senses the same and rotary feeder is stopped automatically by electrical interlock. The operator then presses the chute up push button and the chute segments start lifting. The button is kept pressed until the chute to clear off the tanker. After the tank is filled up completely, the chute is retracted and the tanker is driven out of the loading zone (H.V. Equipments Pvt. Ltd., Unpublished Document on IFFCO, n.d.). The disposal of dry fly ash by IFFCO, thus, is free from any hazardous spread of dust.

Photo 4.4: Ash loading for cement plant at ash pond, IFFCO, Phulpur.

In this disposal process, however, no tender (through public media) is invited by IFFCO. **What happens in practice is that truckloads of cement come to the city of Allahabad (and adjoining areas) and after unloading, these are filled by dry fly ash from IFFCO (quantity loaded is free of cost) to reach again to cement plants. There is, thus, virtually zero transportation cost for carrying fly ash from IFFCO, Phulpur, to the cement plants**.

The **fixed cost for dry ash disposal (on setting pipelines etc**.) is around Rs. 2.5 crores. The **recurring cost of dry ash disposal** is virtually nil except that certain utilities like Instrument Air and Electric Power is provided to dry ash system. **If accounted**, **the recurring cost will not exceed Rs. 0.15 per tonne of ash**. The land area that still remains covered at the end of 2001 with ash collected and filled during the earlier period, when there was no ash disposal, is more than 5 acres outside the plant area (Technical Division, IFFCO, Phulpur).

4.4 Utilization of Fly Ash: Within IFFCO, Phulpur

Photo 4.5: Construction of boundary wall using fly ash bricks inside IFFCO, Plant.

The R&D laboratory of IFFCO, Phulpur, has developed a project for utilization of fly ash in brick manufacturing. To establish this, the plant has constructed a **one-storey building** made of fly ash bricks for display at the eastern boundary of the plant (**Photo 4.6**). A project is under consideration for manufacturing 5,000 bricks per day by IFFCO. The bricks are planned to be used in Integrated Rural Development Programme (IRDP) work. IFFCO, Phulpur, is a case whose land provided during the project stage was completely Usar (barren) soil. In reclaiming usar soil, an R&D Project "Fly Ash as a Usar Reclaiment' has been conducted at Cooperative Rural Development Trust (CORDET), within the network of the Plant. As reported by the plant authority, this project has helped in reclaiming usar soil inside the plant. It has also benefited the farmers of the adjoining areas by reclaiming their usar soil with easily available fly ash at no cost. The outcome is development of **Green Belt** around the factory premises and around the township (**Photo 4.1**). The green belt around the factory acts as a protective wall against dust emissions. It also stops all possible suspended particulate matter as well as gaseous and stacks emissions. In addition, the green belt around the township serves as another protection wall against suspended particular matter and gaseous emissions. **The plant uses fly ash on a small scale to manufacture bricks**. The plant produces two and a half to three thousand fly ash bricks per day inside the plant. The bricks are used internally for construction of brick walls, pathway, and various areas of civil construction job. **The plant has recently started supplying fly ash bricks produced inside to buyers outside** (Information provided by Technical Division, IFFCO, Phulpur, May 2001).

4.5 Utilization of Fly Ash in Conventional Clay Brick Plants: Observations

We covered as high as ten conventional clay brick plants within a radius of 50 km from IFFCO, Phulpur. Of these plants, five are selected within 25-km. distance while the other five between 25 km. and 50 km. **The Notification of the Government of India gives the mandate that the plants, that use soil as a raw material within 50 km radius of any fly ash generating plant, will have to mix fly ash with clay in a pre-specified proportion (<u>Notification of the GOI, Appendix I</u>). There is, however, no record of number of brick plants within the specified radius of IFFCO, Phulpur. We have selected ten brick plants to capture the major problems and possibilities of utilizing fly ash in clay bricks.** We have selected the brick plants from all the sides of IFFCO, Phulpur so that the geographic dispersal is taken care of (**Map**). Incidentally, all the brick plants, that are spread over five blocks, are in the District of Allahabad, UP. **Of the brick plants selected, eight are newly established during 1998-2001 and the remaining two are older, established respectively in 1985 and 1990** (**Table 4.4**). The total production of bricks in number is 2,97,000 per year for all the ten brick plants, that is, 29,700 bricks on average per plant. **For production of bricks, soil digging varies between three to six feet for the plants**. The quality of the clay bricks produced in these plants is approximately uniform in size and weight. The cost of production per 1,000 bricks, however, was reported to vary from Rs. 650 to Rs. 1,000 (**Table 4.5**). **Most of the brick plant owners use lease-in land for digging purposes. Of the ten plants, 79.0 per cent of the total acquired land was on a lease-in basis**. Of the total 100 acres of land being used for brick plants, 79 acres are on lease at an average per acre land price at the market at Rs. 63,500 on average. There are, however, inter-plant variations in cost borne on lease-in account for production of bricks (**Table 4.6**). **Of the total land acquired by the brick plant owners, as high as 73.5 per cent are agricultural land,** while 22.0 per cent are non-agricultural land and **only 4.5 per cent are wasteland**. Most of the land acquired is for soil cutting purposes. It is 75.0 per cent

Photo 4.6: House made of fly ash bricks inside IFFCO. Plant.

of the total. The rest 25.0 per cent of the land within the boundary of the brick plants are meant for residential and chimney areas that are approximately equally distributed (**Table 4.7**). The operational period of brick production per year is generally six to seven months per year. The digging depth of top soil varies between three and five feet, though there is no upper limit set by the government on soil digging. Only two plants reported production period that is less than six months per year. The contract for land leased-in varies generally between three and five years. The brick plant owners hope to lease-in additional land as and when required. In view of the brick plant owners, **the brick plants are stable in terms of steady demand for bricks**. The capacity of the existing land acquired (owned and leased-in) is reported to be sufficient to meet the demand for bricks at the present rate for medium-term period. In case of higher demand for bricks or at the end of the contract period, the plant owners would go for buying land or lease-in land. Only one of the ten plants bought soil from outside, while the nine brick plants used internal soil (owned and leased-in) for digging and brick manufacturing purposes. For three plants, the quality of bricks was tested while for the rest seven plants the quality was never tested (**Table 4.8**).

Table 4.4
Selected Conventional Clay Brick Plants
(Located within fifty km. radius from IFFCO, Phulpur Unit)

Name of the Plant	Address	Year of Establishment	Distance of the Plant** from IFFCO
Ram Bihari Brick Industry	Bahadurpur, Soraon	1990	25 km.
Sakti Brick Factory	Sadapur, Phulpur	1998	8 km.
Ahuja Brick Factory*	Sadapur, Phulpur	2001	6 km.
KMM Brick Factory	Babuganj, Phulpur	1998	10 km.
Milendra Brick Factory	Malawan, Sahso	1995	12 km.
NHS Brick Factory	Goddopur, Soraon	1985	30 km.
DK Jaiswal Brick Factory	Ghurpur, Jasra	1999	46 km.
Jaiswal Brick Industry	Mohiddinpur, Naini	1999	41 km.
Raj Brick Industry	Sukhadevpur, Soraon	1994	28 km.
Mishra Brick Factory	Khauinar, Soroan	1995	35 km.

Note: * *Ahuja brick factory produced 7,500 fly ash mixed clay bricks in 1999. The bricks were sent to IFFCO, Phulpur, for quality testing. The factory owner till the date of survey received no response. Thus, the factory discontinued mixing of fly ash in clay bricks*.
** *Approximate distance*.
Source: *Field survey*.

Table 4.5
Conventional Clay Brick Plants (Selected Indicators)

Name of the Plant	Production Per Year (in number)	Brick Size (in cubic inches)	Weight Per Brick (in kg.)	Digging Depth* (in feet)	Cost per thousand bricks (in Rs.)	
					Production Cost**	Market Price**
Ram Bihari Brick Industry	65,00000	9.5x4.5x3	3.2	3	950	1000
Sakti Brick Factory	20,00000	9x4x3	2.5	5	700	800
Ahuja Brick Factory	22,00000	9x4x3	3.0	3	750	850
KMM Brick Factory	20,00000	9x4x3	2.5	5	780	850
Milendra Brick Factory	25,00000	9x4x3	2.5	5	750	900
NHS Brick Factory	30,00000	9.75x4.75x3	3.0	4	1000	1100
DK Jaiswal Brick Factory	35,00000	9x4x3	2.5	5	650	750
Jaiswal Brick Industry	25,00000	9x4.5x3	2.5	6	850	950
Raj Brick Industry	35,00000	9x4.5x2.75	3.0	5	800	950
Mishra Brick Factory	20,00000	9.5x4.5x3	3.2	6	1000	1100
Average	29,70,000	9.2x4.3x3	2.8	4.7	823	925

Note: * *Digging depth in practice*, ** *Approximate average*.
Source: *Field survey*.

Table 4.6
Land Price and Ownership Pattern of Land Acquired by Conventional Clay Brick Plants

Name of the Plant	Land Price Per Acre* (in Rs.)	Ownership of Land		Total Land (in acres)
		Lease	Own	
Ram Bihari Brick Industry	60000	23	-	23
Sakti Brick Factory	150000	2	5	7
Ahuja Brick Factory	60000	5	-	5
KMM Brick Factory	100000	2	5	7
Milendra Brick Factory	200000	3	2	5
NHS Brick Factory	60000	8	2	10
DK Jaiswal Brick Factory	80000	5	3	8
Jaiswal Brick Industry	70000	3	3	6
Raj Brick Industry	50000	15	-	15
Mishra Brick Factory	60000	13	1	14
Average	89000**	79 (79.0)	21 (21.0)	100 (100.0)

Note: * *Average land price per acre*.
** *Land price according to average market price*.
Source: *Field survey*.

Table 4.7
Type and Use of Land Acquired by Conventional Clay Brick Plants (in Acres)

Name of the Plant	Type of Land Acquired by the Plant			Land Use Pattern			Total Land Acquired
	Agricul-ture	Non-Agriculture	Waste	Residence	Chimney*	Soil Cutting	
Ram Bihari Brick Industry	15.0	4.5	3.5	2.0	1.0	20.0	23
Sakti Brick Factory	5.0	2.0	-	1.0	2.0	4.0	7
Ahuja Brick Factory	5.0	-	-	0.5	1.5	3.0	5
KMM Brick Factory	5.0	1.5	0.5	0.5	1.5	5.0	7
Milendra Brick Factory	1.0	4.0	-	0.5	1.0	3.5	5
NHS Brick Factory	10.0	-	-	1.5	2.0	6.5	10
DK Jaiswal Brick Factory	4.0	4.0	-	1.0	1.0	6.0	8
Jaiswal Brick Industry	5.0	1.0	-	0.5	1.0	4.5	6
Raj Brick Industry	13.0	2.0	-	1.0	1.5	12.5	15
Mishra Brick Factory	10.5	3.0	-	3.0	1.0	10.0	14
Total	73.5 (73.5)	22.0 (22.0)	0.5 (4.5)	11.5 (11.5)	13.5 (13.5)	75.0 (75.0)	100 (100.0)

Note: * *Chimney area is also used for soil cutting purposes*.
Source: *Field survey*.

Table 4.8
Seasonality, Stability and Capacity of Conventional Clay Brick Plants (Selected Indicators)

Sl. No.	Indicators	Brick Plants	
		Number	Per Cent
i	**Duration of Lease**		
	Below 3 years	1	10.0
	3 to 5 years	6	60.0
	Above 5 years	2	20.0
	Land Owned	1	100.0
ii	**Operational period of brick production per year**		
	Below 6 months	2	20.0
	Only 6 months	4	40.0
	Only 7 months	4	40.0
iii	**Stability of brick market by demand (future projections)**		
	Very good	1	10.0
	Good	3	30.0
	Average	3	30.0
	Poor	3	30.0
iv	**Capacity (time) of the existing land acquired to meet demand for bricks at the present rate of output**		
	3 to 5 years	3	30.0
	5 to 7 years	3	30.0
	Above 7 years	4	40.0
v	**Stability of the brick plant by the size of soil (future projections)**		
	Land Purchase/Extension	4	40.0
	Leasing-in Additional land	8	80.0
	Improbable land scarcity by size for brick manufacturing	1	10.0
	Carrying brick manufacturing from other areas (land bases)	1	10.0
vi	**Soil bought from outside the plant for construction of bricks during last five years**		
	Plants who bought soil from outside	1	10.0
	Plants who did not buy soil from outside	9	90.0
vii	**Quality of produced clay bricks tested**		
	Plants which tested quality	3	30.0
	Plants which did not test quality	7	70.0

Source: *Field survey*.

4.5.1 Manufacturing Fly Ash-Clay Bricks in Conventional Clay Brick Plants: Problems and Possibilities

As high as 70.0 per cent of the ten brick plant owners are aware of the possibility of mixing fly ash with clay in manufacturing bricks. We found only one plant that used fly ash supplied by IFFCO, Phulpur, free of cost only once in 2000, because in view of the plant owner, it did not succeed commercially. For technological testing, the fly ash brick was sent to R&D unit of IFFCO. The brick plant received no response for the next one year and hence stopped mixing fly ash in producing clay bricks.

Of the ten brick plant owners, as high as six do not like to use fly ash in clay bricks even if fly ash is made available, free of cost. The problems regarding use of fly ash in conventional clay bricks, as cited by the four brick plant owners who are willing to use fly ash if available free of cost, are shown in **Box 4.1**.

Box 4.1
Use of Fly Ash in Clay Bricks: Problems
(As conveyed by the brick plant owners)

- Lack of knowledge of the brick plant managers and labourers regarding use of fly ash in clay bricks,
- Unknown ratio in which fly ash is to be mixed with clay,
- The method of mixing clay and fly ash is not known,
- Probable problem regarding burning/heating of clay and fly ash,
- High Cost of production, probably higher than conventional clay bricks,
- Absence of market demand for fly ash bricks, because of probable higher cost, or poor quality,
- Problems in training labourers in manufacturing fly ash bricks, including training,
- Unknown mode of transport of fly ash and the problems associated with it,
- Absence of agencies to take care of marketing of clay-fly ash bricks,
- Non-fixing of sale price of clay-fly ash bricks by government,
- Indifference of the Government towards manufacturing clay-fly ash bricks.

Source: *Field Survey*.

All the plant owners who are willing to use fly ash, if available free of cost, revealed ignorance about the technology, particularly the ratio in which fly ash is to be mixed with clay. The technology includes the firing time (Table 4.9). It is reported that the firing time remains unequal for clay and fly ash for manufacturing fly ash mixed clay bricks.

In spite of the probable technological and marketing problems regarding use of fly ash in conventional clay bricks, the brick plant owners expressed their positive attitude towards using fly ash in clay bricks. Five out of ten brick plant owners emphasized on quality, cost, and price of fly ash bricks, for marketability of fly ash bricks. They understand quality of bricks mainly by the strength (weight per cubic feet) of the bricks. The clay brick plant owners understand quality and price of fly ash-clay bricks in a relative sense, relative to conventional clay bricks. Mode of transport is a major component of cost of production of fly ash-clay bricks. The major mode of transport for carrying fly ash from IFFCO, Phulpur, to brick plants is surface transport, by truck and tractor, preferably the former one. Even if fly ash is available, free of cost at the gate of IFFCO, Phulpur carrying cost for the brick plant owners of fly ash varies from Rs. 200 to above Rs. 1100, depending on the distance (**Table 4.10**).

Table 4.9
Use of Fly Ash in Conventional Clay Brick Plants: Awareness of the Owners of Plants

Sl. No.	Awareness	Number of Brick Plants
i	**Awareness about use of fly ash in construction of clay bricks**	
	Aware	7
	Not aware	3
ii	**Of the aware owners, Plants which constructed fly ash mixed clay bricks**	
	Constructed	1
	Did not construct	6
iii	**Willingness to use fly ash in construction of bricks if fly ash is available free of cost**	
	Positive attitude	4
	Negative attitude	6
iv	**Problems regarding use of fly ash in clay bricks**	
	No information about the possibility to use fly ash in clay bricks	4
	Technique of production (regarding mixing of fly ash with clay) not known	4
	Probable higher cost for producing fly ash bricks	3
	Consumers not ready to buy fly ash bricks*	1
	Transport problems for carrying fly ash	2
	Fly Ash bricks may be weaker	1
	Unequal time required regarding burning/Heating of fly ash and clay	1
	Labourers not trained	1
	Marketing problems of fly ash bricks	1
	Non-fixing of sale price of fly ash bricks by the government	2
	No incentives from the government so far	1
	Number of plants with positive attitude towards mixing fly ash in clay	4

Note * *The consumers have not revealed demand for fly ash bricks*
Source: *Field survey*.

Table 4.10
Mode of Transport and Transport Cost of Fly Ash
(From IFFCO, Phulpur, to Selected Brick Plants)

Cost per Trip on Road (16 Tonnes of Fly Ash per trip)	Mode of Transport			
	Truck		Tractor	
	Number	Per Cent	Number	Per Cent
Rs. 200 to Rs. 500	3	30.0	2	20.0
Rs. 500 to Rs. 800	2	20.0	-	-
Rs. 800 to Rs. 1100	3	30.0	-	-
Above Rs. 1100	2	20.0	-	-
Total	10	100.0	10	100.0

Source: *Field survey*.

Soil cutting and formation of pits come as natural problems in the brick plants. The brick plant owners opine that these pits can be efficiently used as ponds and hence for fisheries, and for cultivation (**Field Survey, April 2001**). In general, we found non-use and reluctance to use fly ash in conventional clay brick plants owned by individual entrepreneurs.

4.5.2 Non-utilization of Fly Ash in Conventional Clay Brick Plants: Reasons

Based on our observations of the selected brick plants within 50-km. radius of IFFCO, Phulpur, we briefly enlist the factors responsible for non-utilization of fly ash in conventional clay brick plants.

i) Availability of abundant and low cost top soil, either on ownership basis or on lease.

ii) Non-availability of dry fly ash.

iii) High cost of transportation of fly ash.

iv) Absence of assured market for fly ash bricks.

v) Absence of technology or problems in shift of technology from conventional clay bricks to fly ash mixed clay bricks.

vi) Unequal time required in burning of clay and fly ash in existing technology in conventional clay brick plants.

vii) Absence or inadequate executions of government policies/guidelines for utilization of fly ash even when there is technological permission.

viii) Absence of incentives from the government for the plants using fly ash as inputs.

ix) High cost of production of fly ash bricks and high initial cost before the break-even point is reached.

x) Absence of awareness among the potential users (conventional brick plant owners) and the final users (builders/individuals etc).

As we calculated from information collected from conventional clay brick plants, the surplus per 1000 such bricks (price-cost) came to be on average Rs. 102.00 **(Part-A, Table 4.11 and Fig. 4.2a, 4.2b, 4.2c)**. In total cost of production of such bricks, soil cost comes to be only 3.24 per cent. Soil cost per thousand bricks jumps to 6.58 per cent if fly ash replaces soil by 25.0 per cent. The cost of production of clay bricks mixed with fly ash (25.0 per cent) per thousand bricks thus becomes 103.33 per cent of cost of production if fly ash is not mixed with clay. The absolute cost difference between fly ash mixed clay bricks and conventional clay bricks per thousand bricks, thus, stands at Rs. 27.45 **(Table 4.11 Part-B and Fig. 4.2a, 4.2b, 4.2c)**. This positive cost differential is explained by transportation cost of fly ash.

Table 4.11: Conventional Clay Bricks and Fly Ash Mixed Clay Bricks: Some Cost- Benefit Projections

Observations	Indicators
Part – A	
Average brick size (in cubic inch)	9.2x4.3x3
Average weight of a brick (in kg.)	2.8
Average digging depth of soil (in feet)	4.7
Average land price per acre (in Rs.)	89,000
Average distance of bricks plants from ash generating plant (in km.)	24.1
Average transportation cost of fly ash from ash generating plant (per 16 MT)*	780
Average cost of production (per thousand bricks in Rs.)**	823
Average market price (per thousand bricks in Rs.)**	925
Part – B	
Quantity of soil in one acre land (in cubic feet)	230825.6
Quantity of soil in one acre land (in MT)	9326.287
Number of bricks that can be manufactured with one acre land (in number)	33,30,816
Quantity of fly ash required if 25% of clay is replaced by fly ash (in MT)	2331.572
Transportation cost of fly ash from ash generating plant (in Rs.) as specified by the ratio 75:25 between clay and fly ash	1,13,664
Cost of production of conventional clay bricks per thousand (in Rs.)	823
(a) Soil cost	26.72
(b) Other costs (labour, coal, water, sand etc.)	796.28
Soil cost if fly ash replaces clay by 25.0 per cent (in Rs.)	54.17
Cost of production (fly ash mixed with clay) per thousand bricks (in Rs.)	850.45
Cost Difference (fly ash mixed clay bricks – conventional clay bricks) per thousand bricks (in Rs.)	27.45

Note: (Part-A) provides *primary data, collected from field survey*.
(Part-B) cost-benefit projections with and without *fly ash mixed with clay in manufacturing bricks*.
***** *This information is based on respondents at the time of survey.*
****** *No taxes have been added in cost of production.*

Source: *Field Survey*.

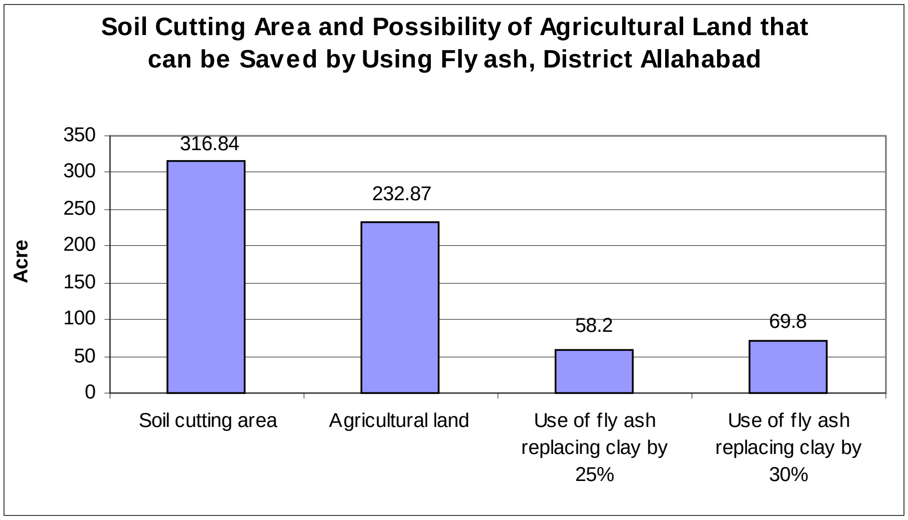


Fig. 4.2a

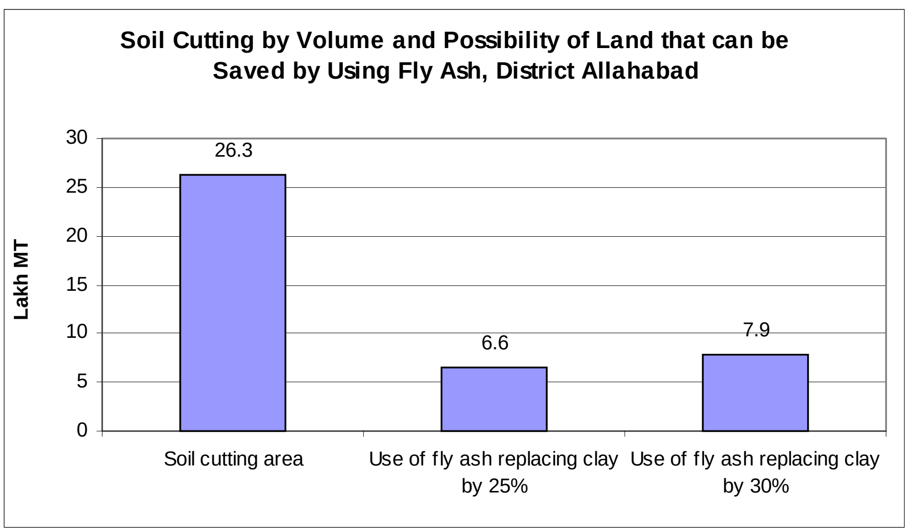


Fig. 4.2b

For the District Allahabad, the total number of conventional clay brick plants at the time of survey was 356 (of which we selected ten within the 50-km. radius of IFFCO, Phulpur). We do not have the exact number of conventional clay brick plants within this radius. Thus, we relied on District level data to arrive at some projections.

Soil cutting area (sq. metre) in any year for all these brick plants is 356.0 acres, of which agricultural land constitutes 73.48 per cent. If soil cutting implies destruction of top soil, then the total value of land that is destroyed comes to be nearly Rs. three crore for the whole district covering all clay brick plants (on the basis of average land price existing in 2001). Given the quantum of soil cutting per year, we calculate the quantity of fly ash that can replace 30.0 per cent (maximum) clay. Thus, we calculate maximum agricultural land that can be saved by using fly ash (maximum 30.0 per cent) as replacement of clay (weight to weight basis). As we see, out of a total of 232.87 acre of agricultural land, as high as 25.0 per cent can be saved (**Table 4.12**).

Table 4.12Projections Based on Major Observations of Brick Plants
(Projections for the District of Allahabad, U.P.)

Part - A	**Major Observations**	**Indicators**
1.	Type of land acquired by the factories (%)	
	(a) Agricultural land	73.5
	(b) Non-agricultural land	22.0
	(c) Waste land	4.5
2.	Average size of brick (in cubic inches)	9.2x4.3x3
3.	Average digging depth (in feet)	4.7
4.	Average weight (in kg.)	2.8
5.	Average production per year (number of bricks per factory)	29,70,000
6.	Average land price per acre (Rs.)	89,000
7.	Soil cutting area per factory (per year) in acre	.89
8.	Soil cutting in volume per factory (per year) in MT	8316
9.	Average transportation cost for per 16 MT brick plants (Rs.)	780
Part – B	**Projections**	
1.	Conventional brick plants in the district of Allahabad (2000-01), Number	356
2.	Soil cutting area per year (in acre)	316.84
3.	Land destroyed by soil cutting per year (in acre)	
	(a) Agricultural land	232.87
	(b) Non-agricultural land	69.7
	(c) Waste land	14.25
4.	Total value of destroyed land (in Rs.)	2,81,98,760
5.	Soil cutting in volume per year (in MT)	26,34,841
6.	Fly ash in volume that can be used per year (in MT)*	7,90,452.3
7.	Agricultural land per year that can be saved by using fly ash (in acre)*	69.8
8.	Fly Ash in volume required per year (in MT)**	6,58,710.2
9.	Agricultural land per year that can be saved by using fly ash (in acre)**	58.2

Note: * *Calculations based on use of fly ash replacing clay by 30%. M/s Key Iron Works; Jagadhari Road, Yamuna Nagar, Nariyana, are already using fly ash replacing clay by a maximum of 30% in bricks*.

** *Calculations based on use of fly ash replacing clay by 25% in manufacturing bricks. The use of fly ash as a percentage replacement of clay at the minimum has been set by the Ministry of Environment and Forests, Govt. of India, through Notification dated 14th September 1999*.

We do not have exact number of brick factories within a radius 50 km. from IFFCO, Phulpur, of which we have given projections on land saving etc. For the whole district (Allahabad), projections regarding use of fly ash and potential saving of agricultural land have been based on studies of 10 brick plants selected within 50 km. radius of IFFCO.

Source: *Field survey*.
- *NTPC guide for users of coal ash, October 1999*.
- *Information on conventional brick factories of Allahabad, provided by District Board, Allahabad*.

The detailed calculations for **Table 4.12** are provided below:

Calculation of A7
(Per year soil cutting rate per factory)

Average brick size (in cubic inches)	= 9.2x4.3x3	
Average brick size (in cubic feet)	= 0.77x0.36x0.25	
Volume per unit of brick	= 0.0693 Cub. ft.	
Average annual production of bricks (for the sample)	= 29,70,000	
Soil used per plant per year	= 2970000x0.0693	= 2,05,821 Cub. ft.
Average digging depth (per plant)	= 4.7 ft.	
Destroyed land area per plant per year	= 205821/4.7	= 43791.7 sq.ft.
Destroyed land per plant per year	= 43791.7/49111.8	= 0.89 Acre
One Acre	= 49,111.8 sq. ft.	

Calculation of B2

Sample soil cutting rate per plant (in acre)	= 0.89	
Total number of brick plants in Allahabad district	= 356	
Total land destroyed by the brick plants per year	= 356x.89	= 316.84 Acres

Calculation of B2 (a)
Agricultural land as percentage of total land acquired (sample)

	= 73.5 (which is used by soil cutting)	
Total land destroyed per year	= 316.84x73.5/100	= 232.87 Acres

Calculation of B2 (b)
Non-agricultural land as percentage of total land acquired = 22.0

Total land destroyed per year	= 316.84x22/100	= 69.7 Acres

Calculation of B2 (c)

Waste land (percentage)	= 4.5	
Total destroyed land per year	= 316.84x4.5/100	= 14.25 Acres

Calculation of B4

Soil cutting area per year, Allahabad District	= 316.84 Acres
Average land price per acre (in Rs.)	= 89,000 (at the time of survey)
Total land value destroyed per year	= Rs. 89,000x316.84 acre = Rs. 2,81,98,760

Calculation of B5

Average weight per brick (sample)	= 2.8 kg.	
Total number of brick plants in Allahabad district	= 316.84	
Average production of bricks per plant (sample)	= 29,70,000 (per year)	
Soil used on average per plant per year (volume)	= 2970000x2.8	= 8,316 MT
Clay used in brick construction in Allahabad district	= 8316x316.84	= 26,34,841 MT

Calculation of B6
Quantity of fly ash that can be used in manufacturing clay bricks (if a conventional brick plant uses fly ash by replacing clay by 30.0 per cent)

Total quantity of soil used in Allahabad district	=	26,34,841 MT
Quantity of fly ash that can be used	=	26,34,841x30/100 = 7,90,452.3 MT

Calculation of B7
Agricultural land that can be saved per year by use of fly ash
Total destroyed agricultural land of Allahabad district per year = 232.87 Acres
Saving of land by area
(If fly ash is used in manufacturing bricks, replacing clay by 30.0 per cent)= 232.87x30/100
= 69.8 Acres

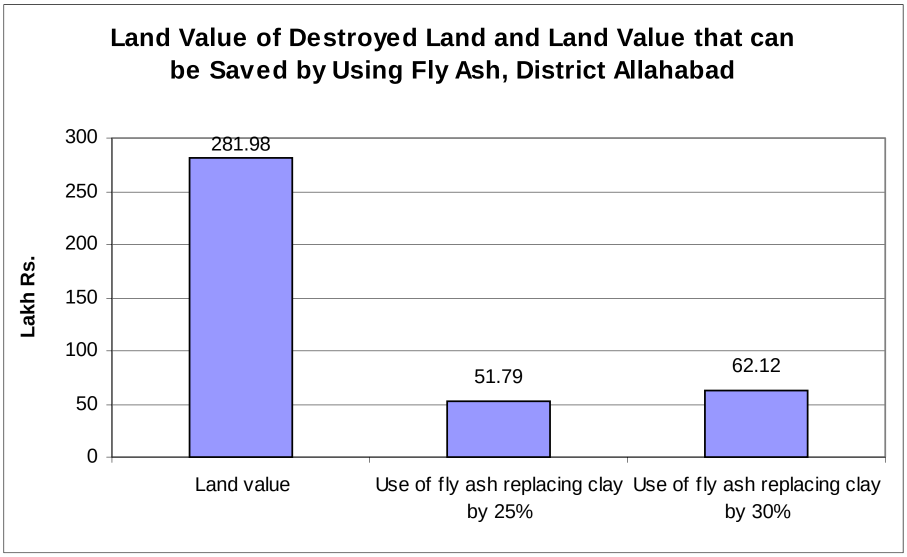


Fig 4.2c

4.6 Use of Fly Ash Supplied by IFFCO, Phulpur, to Cement Plants: Observations

The external users of fly ash supplied by IFFCO, Phulpur, are the cement manufacturers. **The plant supplies 1000 Tonnes of fly ash per day to the cement manufacturers** (Technical Division, IFFCO, Phulpur, May 2001). **The Plant, however, could not provide addresses of these cement manufacturers.** The reason may be that there are intermediaries between IFFCO, Phulpur, and cement manufacturers. These intermediaries are the operators controlling transport of fly ash **(Photo 4.7)**. We have covered three cement plants located in Rewa, Satna and Maihar,

Photo 4.7: Ash loaded truck for cement plant, from IFFCO, Phulpur.

all in Madhya Pradesh, who are reported to collect fly ash free of cost from IFFCO, Phulpur. These cement plants also receive fly ash from a number of NTPC thermal power plants. Of the total fly ash received by J.P. Cement, Rewa, Madhya Pradesh, only 10.0 per cent is received from IFFCO, Phulpur Unit. **The cement plant produces two types of cement, Ordinary Portland Cement (OPC) and Portland Pozzolona Cement (PPC). In OPC, the required raw materials are clinker and gypsum, while in PPC the required raw materials are clinker, gypsum and fly ash.** The permissible percentage of fly ash that can be used in PPC varies from a minimum at 25.0 to a maximum at 35.0. The J.P. Cement, Rewa, started using fly ash in cement in 1978-79. During the last three years, the plant raised the percentage utilization of fly ash in PPC from 16.38 in 1998-99 to 22.02 in 1999-2000 and 25.10 in 2000-2001. This happened in a state of increasing output and supply of PPC by the plant. Thus, the required volume of fly ash increased monotonically for this plant during past few years. For 2000-2001, of the required fly ash at 939 metric tonnes, IFFCO supplied 93.90 MT (**Table 4.13 and Fig. 4.3a, 4.3b**). **We have surveyed the fly ash requirements in a number of cement plants adjacent to IFFCO, Phulpur that show that there is no dearth of demand for fly ash from the cement manufacturers**. For example, Satna Cement Works, Satna, Madhya Pradesh, has been using 22.0 per cent of fly ash in cement. Its total requirement of cement per day is 934 MT **(Table 4.14)**. The fact is that it is not taking any fly ash from IFFCO, Phulpur. The distance between Satna Cement plant and IFFCO, Phulpur is around 200 km. by surface transport. Satna Cement receives fly ash from a distance of 440 km. away. It is thus not clear, why Satna Cement Plant does not lift any fly (dry) ash from IFFCO, Phulpur. We approached Maihar Cement Plant located in M.P., but could not get any information on use of fly ash.

Table 4.13
J. P. Rewa Cement, Rewa, Madhya Pradesh (Fly Ash User): A Profile

Profile	Indicators
Name of the Plant	J.P. Rewa Cement, Rewa
Location of the Plant	District – Rewa, M.P.
End product of the Plant	OPC and PPC
Sources of Fly Ash and their percentage	
NTPC, Shaktinagar NTPC, Vindhyanagar NTPC, Unchahar HINDALCO, Renukoot IFFCO, Phulpur	25.0 25.0 20.0 20.0 10.0
Percentage of Fly Ash used in Cement	

(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	16.38 22.02 25.10
Percentage of Fly Ash that can be used in Cement (minimum and maximum)	25.0 to 35.0
Year when use of Fly Ash in cement was launched in J.P., Rewa	1978-79
Annual production of cement (in MT)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	18,79,980 21,69,010 21,85,932
Annual production of PPC (in MT)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	09,56,923 (50.90) 14,15,944 (65.28) 13,65,422 (62.46)
Annual production of OPC (in MT)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	9,23,057 (49.10) 7,53,066 (34.72) 8,20,510 (37.54)
Annual supplies of Cement (in MT)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	18,78,731 21,71,801* 21,82,273
Raw materials required for manufacturing PPC, 2000-2001 (Ratios in %)	
(a) Fly Ash (b) Clinker (c) Gypsum	25.10 70.50 04.40
Quantity of Fly Ash used in PPC (in MT)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	1,56,744 3,11,802 3,42,721
Quantity of Cement produced (per day , in MT)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	5,151 5,943 5,989
Quantity of Fly Ash required (per day , in MT)	
(a)1998-1999 (b) 1999-2000 (c) 2000-2001	429 854 939
Quantity of Fly Ash taken from different sources (per day, in MT)	
(a) NTPC, Shaktinagar (b) NTPC, Vindhyanagar (c) NTPC, Unchahar (d) HINDALCO, Renukoot (e) IFFCO, Phulpur	234.75 234.75 187.80 187.80 093.90
Required raw materials used in cement production, minimum and maximum (in %)	
(a) Ordinary Portland Cement (i) Clinker (ii) Gypsum (b) Portland Pozzolona Cement (i) Clinker (ii) Gypsum (iii) Fly Ash	 95.0 - 97.0 03.0 - 05.0 60.0 - 75.0 03.0 - 05.0 25.0 - 35.0

Note: * *The quantity of Cement supplied was higher than production in 1999-2000 because of release of past stock*.
PPC = Portland Pozzolona Cement, *OPC = Ordinary Portland Cement*.
Source: *J.P. Rewa Cement, Rewa, Madhya Pradesh, June 2001*.

Table 4.14
Satna Cement Works, Satna (Fly Ash User): A Profile

Profile	Information
Name of the plant	Satna Cement Works
Location of the plant	District: Satna, Madhya Pradesh
End product of the plant	Cement
Sources of supply of fly ash	Own Power Plant and NTPC, Unchahar, U. P.
Distance from fly ash generating plant	Within the plant, second source is about 440 km. away.
Fly ash used in cement (percentage)	22.0
Percentage of fly ash that can be used in cement (minimum and maximum)	15.0 to 35.0
Year (when the scheme of mixing fly ash in ordinary cement was launched) in Satna Cement	1977 – 78
Transport cost of fly ash (per MT, in Rs.)	20 to 30
Tax exemption provided by the Govt. of India, if percentage of fly ash used in cement exceeds a minimum limit	30.0
Chemicals (previously used) replaced by use of fly ash	Calcine Clay
Quality of cement after use of fly ash	Improved
Technology used by the plant	International / Imported
Annual production of cement (in M. T.)	15,50,000
Quantity of fly ash used per year (in M .T.)	3,41,000
Quantity of fly ash required per day (in M. T.)	934
Quantity of cement produced per day (in M. T.)	4,247

Source: *Environment Unit of Satna Cement Works, Satna, Madhya Pradesh, May 2001.*

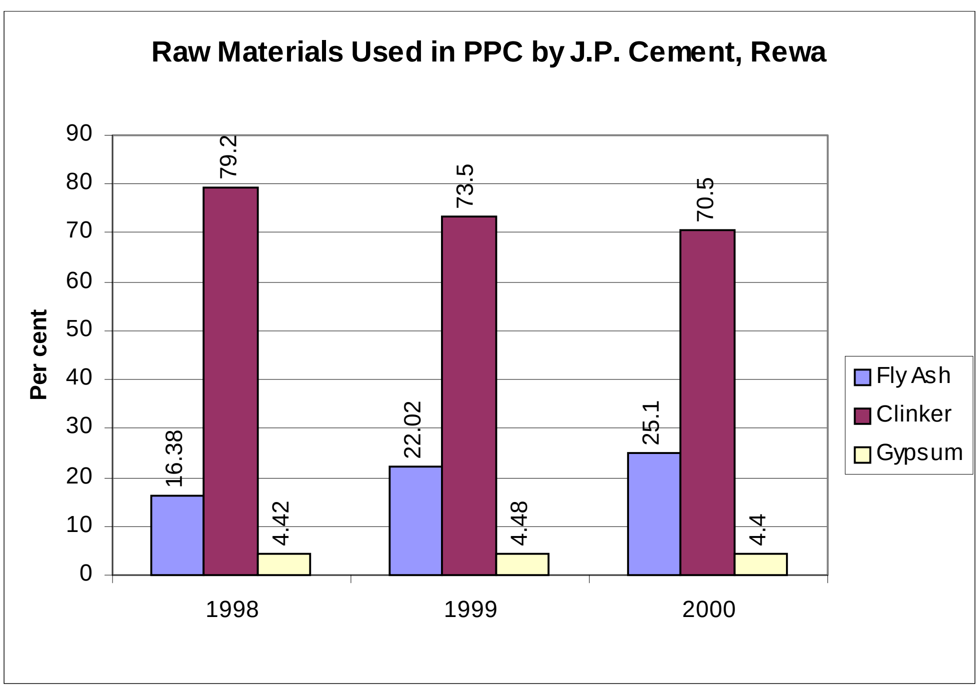


Fig. 4.3a

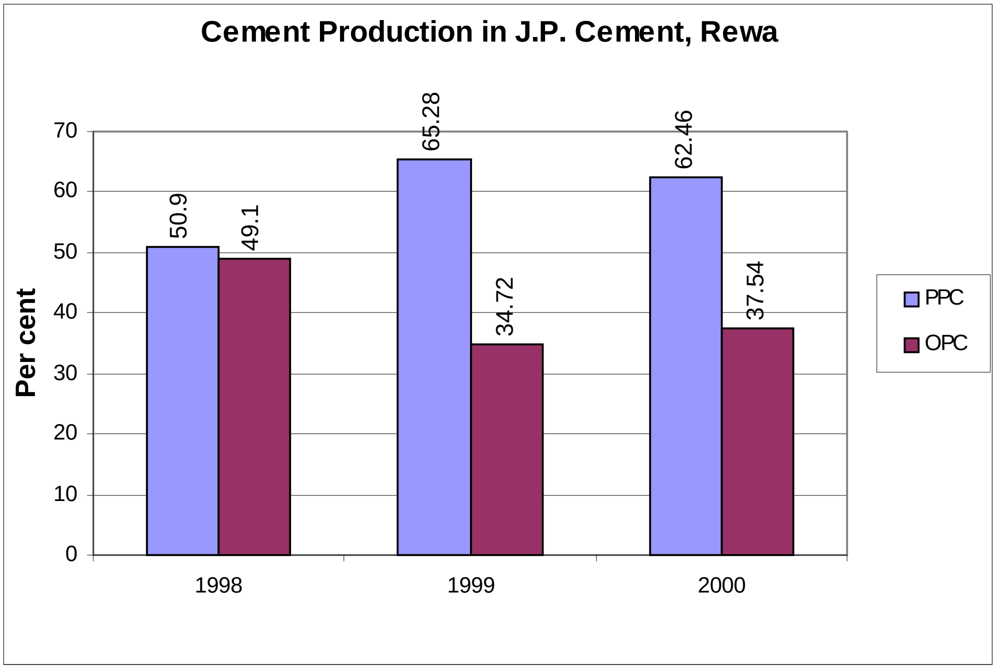


Fig. 4.3b

4.7 Fly Ash Dumping in the Areas Adjoining IFFCO, Phulpur: Effects

Because of the location and selection of area for dumping of fly ash generated by IFFCO, Phulpur, we found no effect of spread of fly ash, either air-borne, or water-borne, in the east of the plant. Hence, we selected villages in the west, south, and north sides of the plant within a radius of three km. from the plant. **The plant is reported to take care of areas within a radius of three km. from its own location. We selected seven villages, which are reported to be affected by the spread of fly ash. The selection of villages follows the pilot survey of the adjoining area.** We covered 65 households in these seven villages of which, three are located in the west, three in the south, and one in the north. Twenty-six households are surveyed from the villages in the west, twenty-nine households from the villages in the south, and ten from the north. (**Table 4.15**). We tried to cover as many households as possible from the selected villages. As reported by the households in these villages, **the adverse effect of spread of fly ash is most during the summer of each year (Box 4.2).** Therefore, we conducted the field survey during the month of May 2001.

Table 4.15
Direction-wise Settlement of Households, Adjoining Areas of IFFCO, Phulpur

Direction from IFFCO, Phulpur	Name of Villages	All Households
West	Chandauki	6
	Dailapur	12
	Kanaiti	8
	Total	26 (40.0)
South	Bhulai Ka Pura	6
	Pali	11
	Fazilapur	12
	Total	29 (46.6)
North	Saraiya	10 (15.4)
All Households		65 (100.0)

Note: 1 *The villages have been selected on the basis of pilot survey of the area.*
2 *There is no effect in the east of IFFCO, Phulpur*.
3 *The villages have been selected within a radius of 3 km. from IFFCO, Phulpur*.
4 *The sample size has been taken on the basis of direction and spread effect of fly ash*.
Source: *Field Survey*.

Box 4.2
Ranking of Time/Season in terms of Adverse Effect of spread of Fly Ash in the Adjoining Area of IFFCO, Phulpur

Season/Time	Households who revealed adverse effect (Number)	Rank
Whole of Summer	37 (56.9)	1
March -June	19 (29.2)	2
February-August	4 (6.2)	3
All Households	65 (100.0)	

Note: *Figures in parentheses show percentages of the total households*.
Five respondents reported 'no adverse effect'.
Source: *Field Survey, May 2001*.

Since these households are the respondents regarding the effect of spread of fly ash in the adjoining area, hence we looked into their interests in terms of occupation, and awareness in terms of education. Most of the households in these villages are cultivators and labourers in agriculture and related activities, while a sizeable section is in government services (**Table 4.16).** In terms of education, the households can be divided into 50:50 as those below high school standard and those above high school standard (**Table 4.17**).

Almost all the households from all the villages reported to have been experiencing adverse effect of spread of fly ash disposed by IFFCO on agricultural land (**Table 4.18**). Most affected are the agricultural areas in the West of the plant where 20.0 per cent of the households are settled within 200-meter distance from the dumping area. We covered a little less than half of total households surveyed who are settled within a distance of 200 meter from the dumping area of IFFCO. The maximum distance actually covered for households settled is up to 2000 meter from the dumping area of fly ash (**Table 4.19**). As reported by the households, the manifestation of adverse effects of spread of fly ash on the cropland in the area adjoining IFFCO, Phulpur, are many. The most prominent of these is general decline in average quantity of crops that were used to be produced before the dumping of fly ash began around 1985. In view of the households, **failure of some crops to grow, drying trees that are durable non-replenishment of dying trees by new plantations, continuous spread and silting of lime in the soil, conversion of agricultural land gradually into wasteland are the major fly ash related problems (Box 4.3)**. As reported by the households, **the crops, which were planted but could not grow in the adjoining areas, include sugarcane, bajra, vegetables, matar, and gram**. Some cultivators reported that nothing could be produced excepting paddy and wheat (**Box 4.4**). The government document shows that the major crops in the villages selected in the study area are paddy, wheat, and potato. The document shows no decline in area covered by cultivation of each of these crops during 1988-95. The document, however, does not show any indicator on productivity per unit of land of these crops over time **(Appendix Table)**. As reported by the households, the **plantations that are possible in the adjoining area are Neem, Arjun, Pipal, Eucalyptus, Babool etc. (Box 4.5)**.

Table 4.16
Occupation-wise Classification of the Households in the Adjoining Area of IFFCO, Phulpur

Occupation	Number	Per Cent
Cultivator	26	40.0
Agricultural labourer	2	3.1
Non-agricultural labourer	10	15.4
Government service	11	16.9
Private service	5	7.7
Skilled labour	4	6.1
Small business	2	3.1
Student/Unemployed	3	4.6
Jobless/Displaced	2	3.1
All households	65	100.0

Source: *Field Survey*.

Table 4.17
Educational Level of the Respondents of the Households in the Adjoining Area of IFFCO, Phulpur

Educational Level	Number	Per Cent
Illiterate	10	15.4
Literate	9	13.8
Up to Primary	12	18.5
Up to Junior High School	7	10.8
Up to High School	15	23.1
Up to Intermediate	6	9.2
Higher Education	4	6.1
Technical Education	2	3.1
All households	65	100.0

Source: *Field Survey*.

Table 4.18
Direction-wise Effect of Spread of Fly Ash on Agricultural Land

Direction from IFFCO, Phulpur	Name of Villages	Effect on Agricultural Land		All Households
		Adverse	No Effect	
West	Chandauki	6	-	6
	Dailapur	12	-	12
	Kanaiti	7	1	8
	Total	25 (39.7)	1 (50.0)	26 (40.0)
South	Bhulai Ka Pura	6	-	6
	Pali	11	-	11
	Fazilapur	12	-	12
	Total	29 (46.0)	-	29 (46.6)
North	Saraiya	9 (14.3)	1 (50.0)	10 (15.4)
All Households		63 (100)	2 (100)	65 (100)

Source: *Field Survey*.

Table 4.19
Households Surveyed in Terms of Distance from Fly Ash Dumping Area

Distance from Dumping Area (meter)	West	North	South	All Households
Below 200	13 (50.0)	1 (10.0)	14 (48.3)	28 (43.1)
200 to 400	1 (3.8)	-	3 (10.3)	4 (6.2)
400 to 1,000	3 (11.5)	2 (20.0)	10 (34.5)	15 (23.0)
1,000 to 1,500	4 (15.4)	6 (60.0)	2 (6.9)	12 (18.5)
1,500 to 2,000	5 (19.2)	1 (10.0)	-	6 (9.2)
All households	26 (100.0)	10 (100.0)	29 (100.0)	65 (100.0)

Source: *Field Survey*.

Box 4.3
Effect of Spread of Fly Ash in the Adjoining Area of IFFCO, Phulpur
(Crop Area and Plantations, as perceived by the households)

Types of Effect

- Declining productivity of crops per unit of land.
- Failure of growth of some crops.
- Conversion of agricultural land into wasteland.
- Drying trees that are durable.
- No replenishment of drying trees by new plantations.
- Spread and silting of lime in soil.
- Destruction of grazing land.

Source: *Field Survey*.

Box 4.4
Agricultural Crops which fail to Grow in the Adjoining Areas of IFFCO, Phulpur
(As perceived by the households)

Crops

- Arhar/Pulses
- Surar Cane
- Bajra
- Vegetables
- Matar
- Gram

Source: *Field Survey*.

Box 4.5
Plantations in the Adjoining Area of IFFCO, Phulpur: Possibilities
(As perceived by the households)

Trees which can be Planted

- Neem
- Arjun
- Pipal
- Eucalyptus
- Dhidhor
- Sahtoot
- Babool

Source: *Field Survey*.

The spread of fly ash is reported to have been adversely affecting the living conditions of people in the villages adjoining IFFCO, Phulpur. Most of the households reported air-borne dust and ash in the atmosphere. There is, however, no record of any laboratory-tested measurement of ash-dust in the air in the area. The major air-borne problems are recorded in **Box 4.6**.

Box 4.6
Effect of Spread of Fly Ash in the Adjoining Area of IFFCO, Phulpur: Human Health
(Major Air-borne Problems, as perceived by the households)

- Too much ash-dust in the atmosphere
- Smell of ammonia
- Absence of Fresh Air

Source: *Field Survey.*

Most of the households also reported about water-borne problems in the adjoining area. The sources of water are well, pond, and Handpump. While irrigation is done through all these sources, well and Handpump are used as sources of potable water. There is, however, no scientific (laboratory) analysis on water quality of this area. The ill effects of water in the adjoining area as perceived by the households are shown in **Box 4.7**.

Box 4.7
Effect of Spread of Fly Ash in the Adjoining Area of IFFCO, Phulpur: Human Health
(Major Water-borne Problems, as perceived by the households)

- Foul smell in water
- Water chemically polluted
- Insects in water

Source: *Field Survey.*

Almost all the households reported to have been adversely affected by the spread of fly ash in the adjoining area. The types of diseases the households reported are malaria, asthma, stomach aching, cough/chest congestion, tuberculosis, eye problems, skin problems (**Table 4.23**). **The households, however, are not used to being checked up by registered medical practitioners. Nor did we find any registered medical practitioner staying in the adjoining area that we surveyed**. The effect on human health comes also indirectly through diseases found among the domestic animals in the adjoining area. As reported by the owners of domestic animals, the types of such diseases are recorded in **Box 4.8**

Box 4.8

Effect of Spread of Fly Ash on Domestic Animals in the Adjoining Area of IFFCO, Phulpur

Types of diseases found in animals

- Grazing land is gradually being destroyed because of increasing lime content
- Animals affected by gastric diseases
- Animals affected by hoof diseases
- Declining milk output per milch animal

Source: *Field Survey*.

The diseases the households suffer from, as reported by the households in the adjoining area of IFFCO, Phulpur, are reported in **Box 4.9**.

Box 4.9

Diseases found in the Adjoining Area of IFFCO, Phulpur

(As Reported by the Households)

Types of Diseases

- Malaria
- Asthma
- Skin
- Stomach aching
- Cough/Chest congestion
- Tuberculosis
- Eye problems

Source: *Field Survey*.

The households are believed to have reported to the officials of IFFCO about the adverse effect of spread of fly ash, air-borne, and water-borne, in the adjoining area of IFFCO. The households do not know the outcome.

The U.P. Pollution Control Board, Lucknow, and the Directorate of Environment, Lucknow, could not provide any information on air and water quality in the areas adjoining IFFCO, Phulpur. The Land Reforms Department of Allahabad, however, provided information on area of productive land in the villages adjoining IFFCO, Phulpur **(Table 4.20)**. Most of the area covered by IFFCO includes its own boundary area and the ash pond area outside the boundary. We could collect from the Forest Ranger Office, Phulpur, the medicinal and other plantations inside the boundary of IFFCO, Phulpur, that seems to partially take care of air quality in a gross sense **(Table 4.21)**. The productivity per unit of land of major crops are shown in Appendix Tables.

Table 4.20
Land Quality in Areas Adjoining IFFCO, Phulpur

Name of Village	B+ Land** (In Hect.)	B Land***	C Land		Total
			Area	Ph.* Value	
Chandouki and Dailapur	8.010 (18.67)	22.491 (52.42)	12.405 (28.91)	9.10-10.20	42.906 (100.0)
Kanehati	5.860 (14.27)	19.239 (46.85)	15.963 (38.88)	9.0-10.10	41.062 (100.0)
Total	13.870 (16.52)	41.730 (49.70)	28.368 (33.78)		83.968 (100.0)

Note: * *Denotes Land Productive Value*
(Less than 8.5 Ph. = Productive Land & More than or Equal to 8.5 Ph. = Waste/Usar Land, **B + Land = Double Crop Land, ***B Land = Single Crop Land, C Land = Waste/Usar Land)
Land Reforms Departments Land Reforms Programmes Progress in 40 Villages of Phulpur. Among these Villages, 3 are the Sample Villages of the Study.
Source: *Land Reforms Department, Allahabad*

Table 4.21
Plantations Inside IFFCO, Phulpur Through Forest Department, Government of U.P.

Year	Plantation Area (in Hect.)	No. of Trees	Types of Plantations (trees)
1998-99	4.8 (13.6)	1600 (2.98)	(I) Medicinal (II) Fruit-yielding (III) Decorative (IV) Furniture and Fuel-based Major Trees (Arjun, Kanjee, Shisham, Mango, Jamun, Aonla, Praspiece, Sagon, Jangal Jalebi, Kesia Arikuli Farmish etc.)
1999-00	21.0 (59.5)	33000 (61.57)	
2000-01	4.0 (13.3)	8000 (14.93)	
2001-02*	5.5 (15.6)	11000 (20.52)	
Total	35.3 (100.0)	53600 (100.0)	

Note: * *Up to December 2001*.
Plantation in Senhuadih, Mubarakpur and Vidyut Parishad near Dhokri Village after Land Reforms By Land Reforms Department through Fly Ash.
Source: *Forest Ranger Office, Phulpur, Allahabad.*

4.8 Suggestions Offered by the People Affected by spread of Fly Ash in the Adjoining Area

Human Health-Related Facilities

For prevention of diseases in the adjoining area of IFFCO, Phulpur, the households suggested some measures, which are listed in **Box 4.10**.

Box 4.10
Required Health Facilities for Prevention of Diseases in the Adjoining Area of IFFCO, Phulpur (As perceived by the households)

- There has to be provision for regular medical check up of health for the people in the adjoining area, to be done by IFFCO,
- Necessary medicines should be distributed by IFFCO, if necessary, free of cost for the local residents,
- Measures should be taken by IFFCO to stop air-borne and water-borne pollution and diseases which is fly-ash-led,
- Measures should be taken by IFFCO to stop foul smell of ammonia and other gaseous smell.

Source: *Field Survey*.

The households offered suggestions for ensuring safe potable water and water for irrigation purposes in the adjoining area. The suggestions ask for shouldering responsibility by both IFFCO and local public bodies. The suggestions are shown in **Box 4.11**.

Box 4.11
Suggestions for Prevention of Water-borne Adverse Effect in the Adjoining Area (As perceived by the households)

- Dumping area and dumped ash should be at an altitude lower than the height of ground level of crop area,
- Proper drainage system should be made for flow of foul water,
- Water logging in the ash dumping area should be cleared on a regular basis,
- Dumping area should be relocated at a safer distance,
- Potable water should be clinically tested,
- Hand Pumps need deep boring for drinking purposes.

Source: *Field Survey*.

Photo 4.8: Ash Pond of IFFCO, Phulpur.

Photo 4.9: Plantation at Ash Pond of IFFCO, Phulpur.

Photo 4.10: Ash Loading in Ash Pond of IFFCO, Phulpur for Cement Plant.

Chapter 5 :Internalization of Fly Ash: A Study of NTPC, Dadri Unit, Gautam Buddha Nagar, Uttar Pradesh

5.1 NTPC, Dadri: A Profile

The NTPC, Dadri founded in 1986, commenced commercial production of electricity in the Thermal (coal-based section) in August 1992. The NTPC, Dadri has also one gas-based unit founded in Oct. 1989 that started commercial production of electricity in 1991. We are concerned here only with the coal-based unit. **Coal for NTPC, Dadri comes from North Karanpura Coalfields**, Bihar (now in Jharkhand). Water for cooling the system comes from Mat Branch Canal/Hindon River, UP. **Prior to 1998, the ash content in coal used by the Dadri Unit was 40.0 per cent that came down to around 35.0 per cent after 1998 (Table 5.1)**. **However, the source of coal has remained unchanged**.

Table 5.1
Profile of NTPC, Dadri

Profile	Information
Name of the plant	NTPC
Address/Location	Dhaulana Road, Vidyutnagar Dadri, Gautam Buddha Nagar
Major product	Electricity
Foundation of Dadri Thermal Power Plant	1986
Production started	August 1992
Capacity of the thermal plant in terms of production (in MW)	
(a) 1992	(4x210) 840
(b) October 2000	(4x216) 864
Foundation of Dadri Gas Plant	October 1989
Production started by Gas Plant	1991
Capacity of the Gas Plant in terms of production (in MW)	(4x204.25) 817
Area covered (in acre)	2400
Area for disposal/dumping of fly ash (in acre)	500
Required raw materials and their sources	
(a) Coal	North Karnpura, Bihar
(b) Water	Mat Branch Canal/Hindon River, U.P.
Quality of coal in terms of ash content*	
(a) Before 1998	40.0%
(b) After 1998	35.0%

Note: * *Approximate*.
Source: *NTPC, Dadri*.

5.2 Generation, Utilization, and Disposal of Fly Ash in NTPC, Dadri

The Ash Utilization Division of NTPC, Dadri was set up in 1991 that aims at maximum utilization of ash produced at its coal-based stations. The quality of ash produced conforms to the requirements of IS-3812. From 0.3 million tonnes in 1991-1992, the level of utilization increased to over 3.0 million tonnes per year at present (www.ntpcindia.com, dt.26/12/01). The Council of Power Utilities has already recognized NTPC, Dadri, by awarding National Award in 1999, for its efforts in ash utilization and safe disposal. During the first decade of its commercial production, 1992-2001, ash content (generation of fly ash in coal consumption, both fly ash and coal measured in MT) declined gradually from 40.0 to 34.41. Utilization of fly ash (both internal and external) as percentage of generation of ash initially declined from high level during early 1990s and thereafter increased steadily during 1992-2001. By implication, ash dumped in the ash mound located inside the plant increased in the early 1990s and thereafter declined. (**Table 5.2 and Fig. 5.1a, 5.1b**).

Table 5.2
Coal: Use and Ash Content
Fly Ash: Generation, Utilization, and Dumping (NTPC, Dadri)

Year	Coal Use (in lakh MT)	Generation of Fly Ash (in lakh MT)	Ash Content in Coal (in %)	Ash Utilization		Ash Dumping	
				In Lakh MT	As % of Ash Generation	In Lakh MT	As % of Ash Generation
Aug. 92 - March 93	2.57	1.03	40.0	-	-	1.03	100.0
1993-94	14.40	5.69	39.50	2.43	42.68	3.26	57.32
1994-95	22.69	10.84	39.15	7.55	69.64	3.29	30.36
1995-96	18.76	7.22	38.48	0.92	12.73	6.30	87.27
1996-97	39.85	15.32	38.45	1.50	9.79	13.82	90.21
1997-98	41.56	15.17	36.50	1.15	7.58	14.02	92.42
1998-99	44.37	15.62	35.20	2.02	12.93	13.60	87.07
1999-00	48.74	17.44	35.78	2.42	13.91	15.02	86.09
2000-01	43.06	14.82	34.41	4.49	30.32	10.33	69.68
Total	281.0	103.15	36.71	22.48	21.8	80.67	78.20

Note: 1 *The quality of coal changed from 1998-99 in terms of ash content.*
2 *The ash content could not be reduced below 35% because of non-availability of better quality of coal in India*.
3. *Commercial production in NTPC, Dadri, took off from August 1992*.
Source: *NTPC, Dadri*.

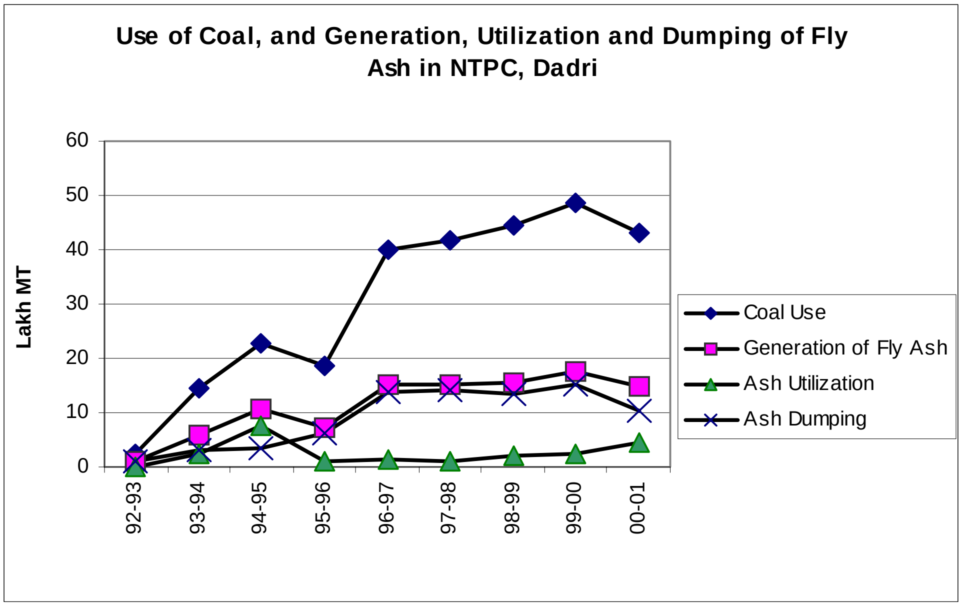


Fig. 5.1a

During 1993-2001, the Unit experienced monotonically increasing quantity of ash utilized, from around 2.5 lakh MT in 1993-94 to more than 4 lakh MT in 2000-01. Utilization of ash as percentage of generation of ash, however, oscillated over a wide range. This utilization as a percentage was as high as 42.68 in 1993-94, which increased to 69.64 the next year, but declined sharply during the next three years. During late 1990s, the percentage utilization of ash increased again. The major products, where NTPC, Dadri, supplies fly ash, are cement and asbestos (**Table 5.3 and Fig. 5.2a, 5.2b)**.

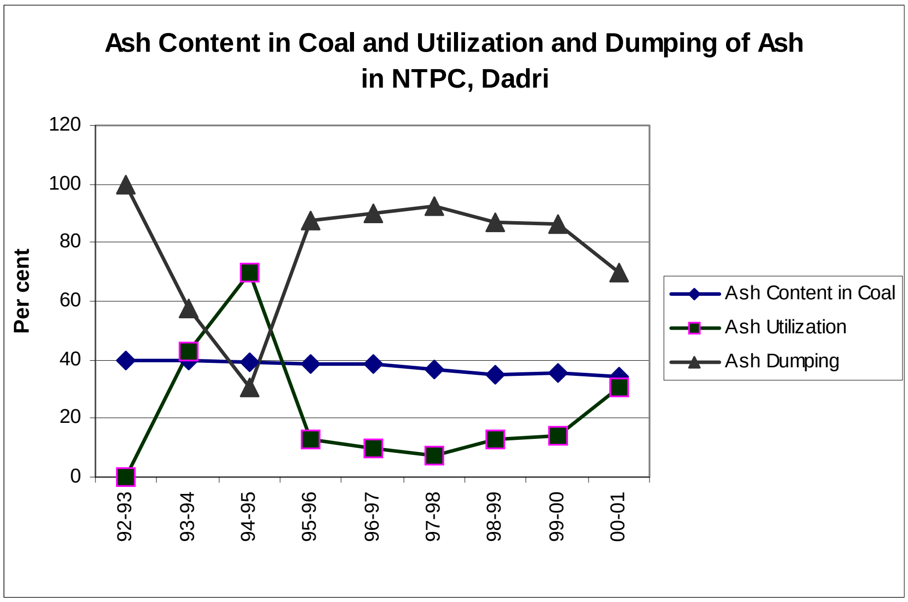


Fig. 5.1b

Table 5.3
Fly Ash Utilization by NTPC, Dadri

Year	Ash Utilization (in lakh MT)	Ash Utilization Inside the Plant		Ash Utilization Outside the Plant	
		In Lakh MT	In %	In Lakh MT	In %
Aug. 92 -March 93	-	-	-	-	-
1993-94	2.43	11.06*	81.6*	2.49*	18.4*
1994-95	7.55				
1995-96	0.92				
1996-97	1.50				
1997-98	1.15				
1998-99	2.02	1.25	61.9	0.77	38.1
1999-00	2.42	1.37	56.8	1.05	43.2
2000-01	4.49	3.44	76.6	1.05	23.4
Total	22.48	17.12	76.15	5.36	23.85

Note: * *Average for 1993-98.*

1. *Commercial production in NTPC, Dadri, took off from August 1992.*

2. *The major products from utilization of fly ash inside the plant are Bricks, Blocks, K.-Stone, Slabs, Tiles-I Blocks, Paving Mortar, Washing Powder, Chokhats, Window Chokhats, MCR Tiles, RCC Slabs etc*.
3. *The major products from utilization of fly ash outside the plant are Cement, Asbestos Sheets, Bricks, Blocks, Concrete etc*.

Source: *Engineering Office Complex, NTPC, Noida*.

The distance of the dumping site (ash mound) from the ash generating point is four-km. For carrying ash from the boiler to the ash mound, fixed cost incurred was Rs. 137 crore. The recurring cost (ash handling cost per MT) is Rs. 30. Quantity of dumping of ash per day is 3556 MT for the Dadri Unit for which average handling/dumping cost per day comes to be a little more than Rs. one lakh (**Table 5.4**).

Table 5.4
Infrastructure and Operating Cost for Ash Handling at NTPC, Dadri

Operating Cost	Indicator
Distance from ash generating point to ash mound (in km.)	4
Total fixed cost from boiler to ash mound (in Rs. crore)	137
Ash handling cost per MT (in Rs.)	30
Quantity of fly ash dumping per day on average (in MT)*	3,556
Ash handling/dumping cost per day on average (in Rs.)*	1,06,680
Mode of transport for supply of fly ash to outsiders	Truck, Tractor, Trolley etc.

Note: * *Calculated*.
Source: *NTPC, Dadri*.

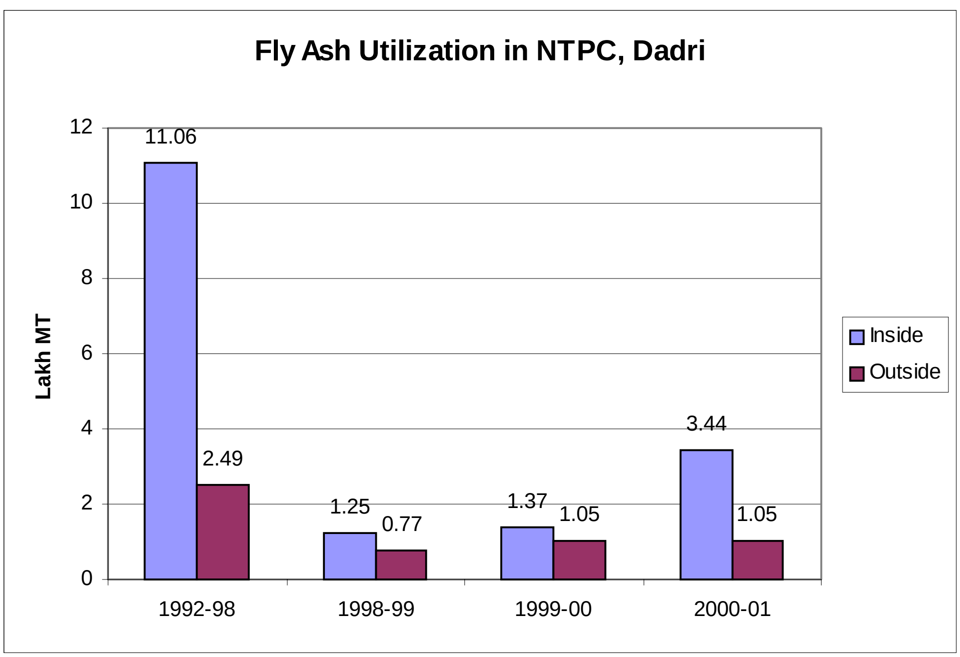


Fig. 5.2a

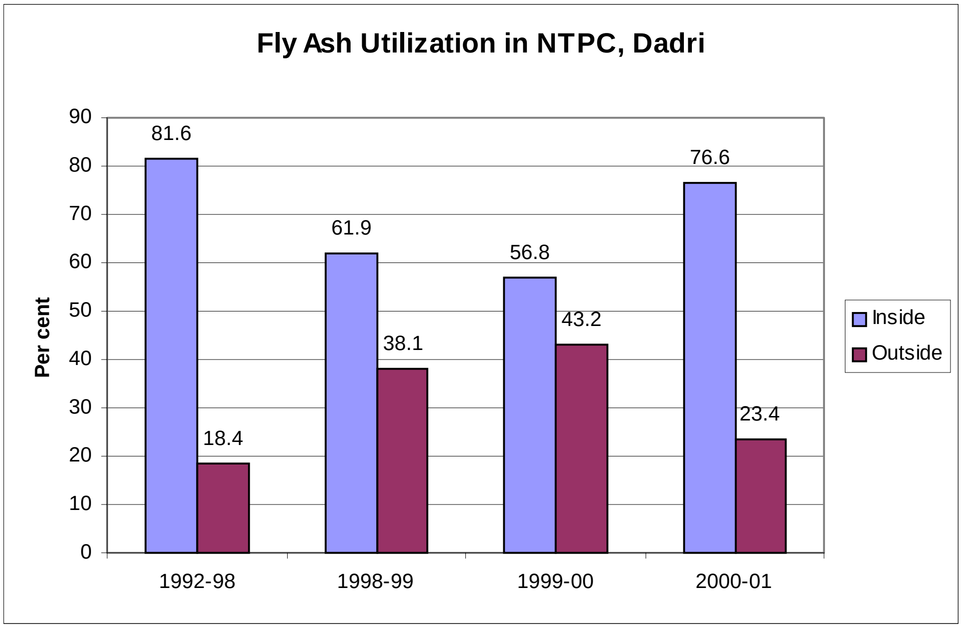


Fig. 5.2b

The major area where fly ash generated by NTPC, Dadri, is used is filling of low lying areas, including surfacing of roads, and embankments. During the last five years, 1996-2001, the supply of fly ash for external uses in brick manufacturing and ash-based building products was less than 10.0 per cent, excepting 1997-98 (**Table 5.5**).

Table 5.5
Utilization of Fly Ash in Different Sectors (in MT)

Year	1996-97	1997-98	1998-99	1999-2000	2000-01
Ash utilization for filling (Road/Embankment)	111206 (73.99)	53000 (46.01)	125155 (61.95)	137956 (56.85)	344130 (76.85)
Ash issued for entrepreneurs for use in Asbestos and Ash based building Products	39075 (26.01)	59125 (51.32)	62742 (31.05)	82560 (34.02)	79693 (17.73)
Ash issued for manufacture of ash bricks and ash based buildings products	-	3075 (2.67)	14123 (6.99)	22130 (9.12)	25537 (5.68)
Total	150281 (100.0)	115200 (100.0)	202020 (100.0)	242646 (100.0)	449360 (100.0)

Source: *NTPC, Ash Utilization Cell, Dadri*.

The NTPC, Dadri disposes dry ash, as opposed to wet ash. The benefits of disposal of dry ash are recorded in **Box 5.1**.

Box 5.1 Advantages of Dry Ash Disposal Relative to Wet Ash Disposal

- Land requirement is less.
- Water requirement is less.
- No leachate of water and associated problems.
- No necessity to maintain ash disposal pipes.
- Gradual restoration of ash disposal site as cultivable land.
- Large-scale utilization of fly ash.

Source: *Sikka and Kundu, 1999, p. 145.*

In 2001, as high as 33 types of products were being produced by NTPC, Dadri. Some of these products are shown in **Box 5.2**. We, however, did not get any information regarding the percentage of fly ash used per period in specific products.

Box 5.2
Fly Ash-Based Products Produced inside NTPC, Dadri (2000-2001)

➢ Fly ash bricks (pieces, 1367080)	➢ Flower pots (pieces, 3161)
➢ Slabs (pieces, 80554)	➢ MCR tiles (pieces, 8879)
➢ Tiles (pieces, 15012)	➢ Blocks (pieces, 32347)
➢ Kerb Stone (pieces, 24451)	➢ Boundary Pillars (number, 72)
➢ Cellular light weight concrete (cum, 5.0)	➢ Utensil cleaning power (PKT, 10000)
➢ Terrazzo tiles (pieces, 1512)	➢ Paving motor(cum, 2338)
➢ Interlocking block (pieces, 58104)	➢ Cable trench cover (pieces 2360)

Source: *Ash Utilization Cell, NTPC, Dadri*.

NTPC, Dadri Unit has been producing some major products using fly ash, where the use of fly ash as percentage of other materials required is high. For example, in Fly Ash Bricks, the percentage utilization of fly ash varies between 40.0 and 70.0, while in Tiles and Mortar, it varies between 30 and 40 per cent. The value added, thus, in 2000-2001 for Fly Ash Bricks came to be around Rs. 14 lakh, and in Mortar around Rs. 15 lakh (**Table 5.6).** NTPC, Dadri, has a number of buyers of fly ash products, shown in **Box 5.3**.

Box 5.3
Buyers of Fly Ash Products Produced by NTPC, Dadri

- IIT, Delhi
- Noida Industrial Development Authority, Noida, U.P.
- Greater Noida Industrial Development Authority, Greater Noida, U.P.
- New Sansad Bihar, Delhi
- Jalwayu Bihar, Delhi

Source: *NTPC, Dadri*.

Table 5.6
Major Fly Ash Products produced inside NTPC, Dadri, in 2000-01

Products	Production (by quantity)	Value (Rs. in Lakh)	Cost of Production Per Unit (in Rs.)	% of Fly Ash Used
Fly Ash Bricks (in lakhs)	17.7	13.8	1.01	40-70
Fly Ash Blocks	32,000	1.29	4.03	25
Different Types of Tiles (in lakhs)	1.45	7.25	5.00	30-40
Interlock Block	58,000	3.5	6.03	20-40
Mortar (in cum.)	2,400	14.92	621.67	30-40
Kerb Stones	24,500	7.74	31.59	25
Concrete Slabs	52,500	11.2	21.33	25

Note: *There are thirty-three types of products made by Ash Utilization Cell, NTPC, Dadri. These products are not sold outside the plant.*

Source: *Data provided by Sri S.K. Shengal, Assistant Engineer, Ash Utilization Cell, NTPC, Dadri.*

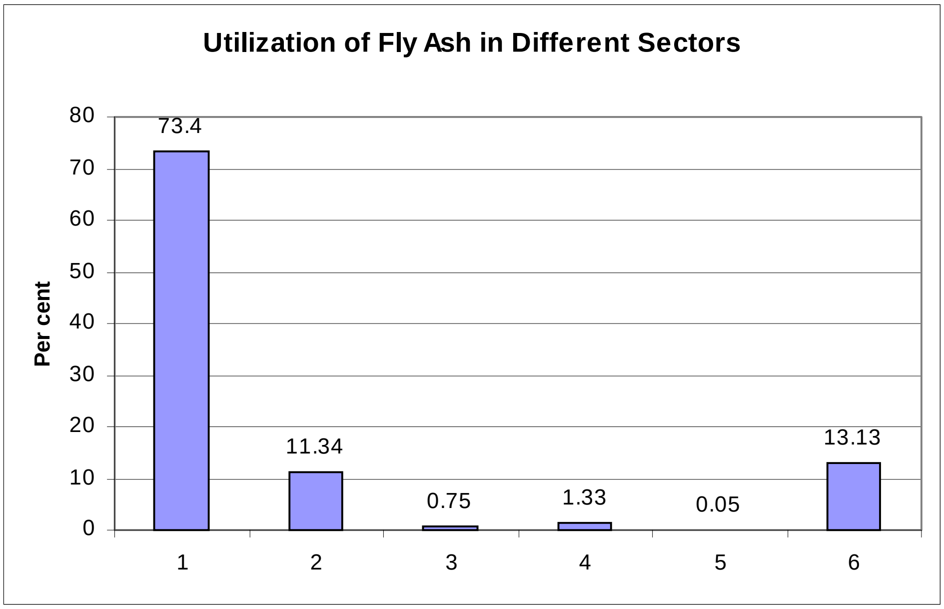
5.3 Disposal and Utilization of Accumulated Fly Ash by NTPC, Dadri

Since the beginning of commercial production up to March 2001, only 21.8 per cent of ash generated by the Thermal unit of NTPC, Dadri, has been utilized. Of this, as high as 15.99 per cent has been utilized in filling low lying areas and embankments. As low as 2.47 per cent has been utilized for manufacturing fly ash bricks, sand blocks and lacs bricks. As low as 0.16 per cent has been issued for cement manufacturing. As low as 0.29 per cent of fly ash generated has gone for road construction and 0.01 per cent in land seeping. As low as 2.86 per cent of ash generated has been issued for asbestos and concrete factories. **More than 78.0 per cent of the accumulated ash generated, thus, is dumped in ash mound** (**Table 5.7 and Fig. 5.3**).

Table 5.7
Utilization of Accumulated Fly Ash (Up to March 2001), NTPC, Dadri

Types of Utilization of Fly Ash	Utilization (in lakh MT)	Utilization as % of Fly Ash Generated
Ash Generated	103.15	100.0
Ash Mound	80.67	78.2
Ash Utilized	22.48	21.8
(a) Ash utilized in development of low lying areas/embankments	16.50	15.99
(b) Ash utilized for manufacturing fly ash bricks, sand blocks equivalent and lacs bricks	2.55	2.47
(c) Fly ash issued for cement manufacturing in cement plants	0.17	0.16
(d) Fly ash utilized in road construction	0.30	0.29
(e) Fly ash utilized in land seeping	0.01	0.01
(f) Fly ash issued for asbestos and concrete factories	2.95	2.86

Source: *Ash Utilization Cell, NTPC, Dadri.*



Note: 1 - Ash utilized in development of low lying areas/embankments, 2 - Ash utilized for manufacturing fly ash bricks, sand blocks equivalent and lacs bricks, 3 - Fly ash issued for cement manufacturing in cement plants, 4 - Fly ash utilized in road construction, 5 - Fly ash utilized in land seeping, & 6 - Fly ash issued for asbestos and concrete factories.

Fig. 5.3

Export of fly ash from NTPC, Dadri to Nepal started by installing a bagging plant below soil and is being used in biggest Dam project on "Kali Gandhki River, Nepal". Till 31 March 1999, approximately 3500 MT fly ash was exported to Nepal**.**

5.4 Utilization of Fly Ash in Conventional Clay Brick Plants: Observations

We covered ten conventional clay brick plants within a radius of 50-km. from NTPC, Dadri located in the District Gautam Buddha Nagar and Ghaziabad, UP. Of these plants, five are selected within a distance of 25-km. radius while the other five between 25 and 50 km. This selection follows the Notification, September 1999, of the Ministry of Environment & Forests, Government of India. However, **there is no record of the number of conventional clay brick plants within a radius of 50-km. from the ash generating NTPC plant. It is, thus, not possible to say the exact basis of the sample drawn. We selected a total of ten clay brick plants within the required radius on the assumption that it would represent the problems and possibilities of utilization of fly ash.** We selected the conventional clay brick plants from all the sides of the NTPC, Dadri so that geographic dispersal is taken care of (**Map**). It happened that out of the ten brick plants selected, seven are in the District of Ghaziabad and three are in Gautam Buddha Nagar. **Excepting one**

brick plant that was set up in 1988, all the plants studied were established in the 1990s (**Table 5.8).**

The capacity of the plants varies in terms of production of bricks per year. This variation in production ranges from 17 lakh pieces at the minimum to one and a half crore at the maximum by a single plant, the average size and weight per brick being approximately the same for all the plants. For production of clay bricks, soil digging varies between three and four feet for the plants. The cost of production per 1,000 bricks was reported to vary from Rs. 800 to Rs. 1,000 (**Table 5.9**).

Table 5.8: Selected Conventional Clay Brick Plants (Located within fifty km. radius from NTPC, Dadri)

Name of the Plant	Address	Year of Establishment	Distance (in km.)*
Jagpal Brick Factory	Kherea, Dhaulana, Ghaziabad	1996	15
Indian Brick Industries	Dhaulana, Ghaziabad	1992	24
Janta Brick Field	Awal Mor, Pilkua, Dhaulana, Ghaziabad	1990	18
Raj Brick Factory	Sikhera Road, Ghaziabad	1999	14
Surya Brick Factory	Bathera Mor, Pilkua, Ghaziabad	1996	15
Rajesh Brick Plant	Moor, Dadri Gautam Budh Nagar	1990	30
R.K. Brick Factory	Near Rajnagar, Ghaziabad	1988	32
Jeet Brick Factory	Bypass Road, Ghaziabad	1998	28
Singh Brick Factory	Dadri, Gautam Budh Nagar	1995	32
Bear Brick Field	Moor, Dadri, Gautam Budh Nagar	1996	30

Note: * *From brick plant to NTPC, Dadri.* **Source:** *Field survey.*

Table 5.9 : Conventional Clay Brick Plants: Selected Indicators (Source:*Field survey*.)

Name of the Plant	Production Per Year	Brick Size (in cubic inches)	Weight Per Brick (in kg.)	Digging Depth (in feet)	Cost per thousand bricks (in Rs.)	
					Production Cost	Market Price
Jagpal Brick Factory	47,00000	9x4x3	2.5	3.0	800	1100
Indian Brick Industries	1,00,00000	9x4.5x2.5	2.75	3.5	1000	1300
Janta Brick Field	52,00000	9x4.5x3	2.75	4.0	900	1000
Raj Brick Factory	32,00,000	9x4.5x3	2.7	3.0	950	1200
Surya Brick Factory	1,08,00,000	9x4.5x3	2.75	3.0	900	1000
Rajesh Brick Plant	85,00,000	9x4.5x2.5	2.5	3.0	925	1250
R.K. Brick Factory	1,50,00,000	9x4.5x3	2.75	3.0	1000	1200
Jeet Brick Factory	17,00,000	9x4.5x3	2.5	3.0	1000	1300
Singh Brick Factory	65,00,000	9x4.5x2.5	2.5	3.0	925	1300
Beer Brick Field	45,00,000	9x4.5x2.5	2.5	3.2	1000	1200
Average	70,10,000	9x4.45x2.8	2.6	3.2	940	1185

Most of the brick plant owners use lease-in land for digging purposes. **Of the ten plants, 60.0 per cent of the total acquired land was on a lease-in basis. The market price of land is high for these brick plants.** The land price per acre varies between Rs. 80,000 at the minimum and Rs. 2,50,000 at the maximum for these brick plants. The highest priced land is totally leased-in by R.K. Brick Factory. It also means huge cost involved in lease-in land (**Table 5.10**).

Table 5.10
Land Price and Ownership Pattern of Land Acquired by Conventional Clay Brick Plants

Name of the Plant	Land Price Per Acre* (in Rs.)	Use of Land (in acre)		Total Land (in acre)
		Lease-in Basis	Ownership Basis	
Jagpal Brick Factory	1,00,000	15	4	19
Indian Brick Industries	80,000	25	20	45
Janta Brick Field	80,000	15	15	30
Raj Brick Factory	1,50,000	9	12	21
Surya Brick Factory	1,25,000	13	-	13
Rajesh Brick Plant	1,50,000	20	14	34
R.K. Brick Factory	2,50,000	22	21	43
Jeet Brick Factory	2,25,000	11	4	15
Singh Brick Factory	1,25,000	13	6	19
Bear Brick Field	1,25,000	12	8	20
Average	1,41,000**	155 (59.8)	104 (40.2)	259 (100.0)

Note: * *Average land price per acre.*
** *Land price according to average market price*.
Source: *Field survey*.

The whole of the total land acquired by the brick plant owners is agricultural. There is no land acquired as were used for non-agricultural purposes or as wastes. Most of the land acquired is for soil cutting purposes, which is as high as 83.0 per cent. The rest 17.0 per cent of the land acquired by the brick plants are used as residential and chimney area (**Table 5.11**).

Table 5.11
Type and Use of Land Acquired by Conventional Clay Brick Plants (in Acre)

Name of the Plant	Agricultural Land	Land Use Pattern			Land Acquired
		Residential	Chimney*	Soil Cutting	
Jagpal Brick Factory	19	2	2	15	19
Indian Brick Industries	45	3	2	40	45
Janta Brick Field	30	2	3	25	30
Raj Brick Factory	21	1	2	18	21
Surya Brick Factory	13	2	1	10	13
Rajesh Brick Plant	34	3	2	29	34
R.K. Brick Factory	43	5	5	3	43
Jeet Brick Factory	15	2	1	12	15

Singh Brick Factory	19	2	2	15	19
Bear Brick Field	20	3	1	16	20
Total	259 (100.0)	25 (9.7)	19 (7.3)	215 (83.0)	259 (100.0)

Note: * *Chimney area is also used for soil cutting purposes*.
Source: *Field survey*.

The operational period of brick production per year is generally six months or less. Only three plants out of ten reported production period more than six months. In view of the plant owners, the brick market (final demand) is stable for future, given the current rate of production. The capacity of the existing land (owned and leased-in) is reported by the plant owners as sufficient to meet market demand at the present rate (price per one thousand piece). Though the contract for land leased-in varies generally between 3 and 5 years, the brick plant owners hope to lease-in additional land as and when required. The existing price of land per acre is not a barrier for them to lease-in additional land. For most of the brick plants, quality of bricks was not tested in any laboratory (**Table 5.12**).

Table 5.12
Seasonality, Stability, and Capacity of Conventional Clay Brick Plants
(Selected Indicators)

Sl. No.	Indicators	Brick Plants	
		Number	Per cent
i	**Duration of Lease**		
	Below 3 years	3	30.0
	3 to 5 years	4	40.0
	Above 5 years	3	30.0
ii	**Operational period of brick production per year**		
	Below 6 months	2	20.0
	Only 6 months	5	50.0
	Above 6 months	3	30.0
iii	**Stability of brick market by demand (future projections)**		
	Very good	-	-
	Good	3	30.0
	Average	7	70.0
	Poor	-	-
iv	**Stability of the brick plant by the size of soil (future projections)**		
	Use land owned	4	40.0
	Purchase land	2	20.0
	Leasing-in additional land	9	90.0
v	**Clay bought from outside the plant for construction of bricks during last five years**		
	Plant which did not buy clay from outside	1	100.0
vi	**Quality of produced clay bricks tested**		
	Plants which tested quality	2	20.0
	Plants which did not test quality	8	80.0

Source: *Field survey*.

5.5 Manufacturing Fly Ash Mixed Clay Bricks in Conventional Clay Brick Plants: Problems and Possibilities

As low as 30.0 per cent of the ten selected conventional brick plant owners reported to be aware of the possibility of using fly ash in clay bricks. No one, however, used fly ash in producing clay bricks in their plants. The reasons for non-use of fly ash in conventional clay bricks are shown in **Box 5.4**.

Box 5.4
Non-Use of Fly Ash in Conventional Clay Bricks: Reasons
(As reported by the brick plant owners)

- Lack of knowledge about use of fly ash in clay bricks,
- Reluctance to shoulder responsibility for huge investment on fly ash mixed clay bricks,
- Unknown market demand for fly ash bricks,
- High transportation cost for carrying fly ash from NTPC, Dadri to brick plants,
- Unwillingness to spend on transport for carrying fly ash,
- Unwillingness of the consumers to buy clay bricks mixed with fly ash,
- Ignorance about the technique of production when fly ash is required to be mixed with clay for manufacturing bricks,
- High cost of production, higher than clay converted bricks
- Government apathy towards manufacturing clay-fly ash bricks.

Source: *Field Survey*.

The modes of transport for carrying fly ash from NTPC, Dadri to brick plants are truck or tractor. The cost per trip on road by truck for five brick plants is reported to be as high as Rs. 1400 and above. The cost becomes a little less if the mode of transport is tractor, instead of truck (**Table 5.13**). Out of ten conventional brick plant owners, only three owners expressed willingness to use fly ash in clay bricks even when fly ash is available free of cost. This is also conditional upon Government's positive steps towards use of fly ash mixed clay bricks in major construction works.

Table 5.13
Mode of Transport and Transport Cost of Fly Ash
(From NTPC, Dadri, to Selected Brick Plants)

Cost per Trip on Road (16 MT fly ash per trip)	Mode of Transport			
	Truck		Tractor	
	Number	Per cent	Number	Per cent
Below Rs. 500	-	-	3	30.0
Rs. 500 to Rs. 800	-	-	7	70.0
Rs. 800 to Rs. 1100	4	40.0	-	-
Rs. 1100 to Rs. 1400	1	10.0	-	-
Above Rs. 1400	5	50.0	-	-
Total	10	100.0	10	100.0

Source: *Field survey*.

In general, we found short-run vision of the conventional brick plant owners, be it in leasing-in land or in investment decisions. **The availability of abundant and low cost topsoil helps also in using clay as and when required. Absence of initiatives and incentives from the Government helps in continuing production of clay bricks without mixing fly ash by any percentage**. It seems that the conventional brick plant owners will be willing to use fly ash in manufacturing clay bricks if they get support from the government, know the technology, get fly ash free of cost at the gate of the brick plant. The government support includes both purchase of fly ash mixed clay bricks and fiscal incentives.

As we calculated from information collected from conventional clay brick plants, the surplus per 1000 such bricks (price – cost) came to be on average Rs. 245.00 **(Part-A, Table 5.14 and Fig. 5.4a, 5.4b, 5.4c)**. In cost of production of such bricks, soil cost comes to be only 6.86 per cent. Soil cost per thousand bricks jumps to 11.34 per cent if fly ash replaces soil by 25.0 per cent. The cost of production of clay bricks mixed with fly ash (25.0 per cent) per thousand, thus, becomes 104.47 per cent of cost of production if fly ash is not mixed with clay. The absolute cost difference between fly ash mixed clay bricks and conventional clay bricks per thousand bricks, thus, stands at Rs. 42.09 **(Table 5.14 Part-B and Fig. 5.4a, 5.4b, 5.4c)**. This positive cost differential is explained by transportation cost of fly ash.

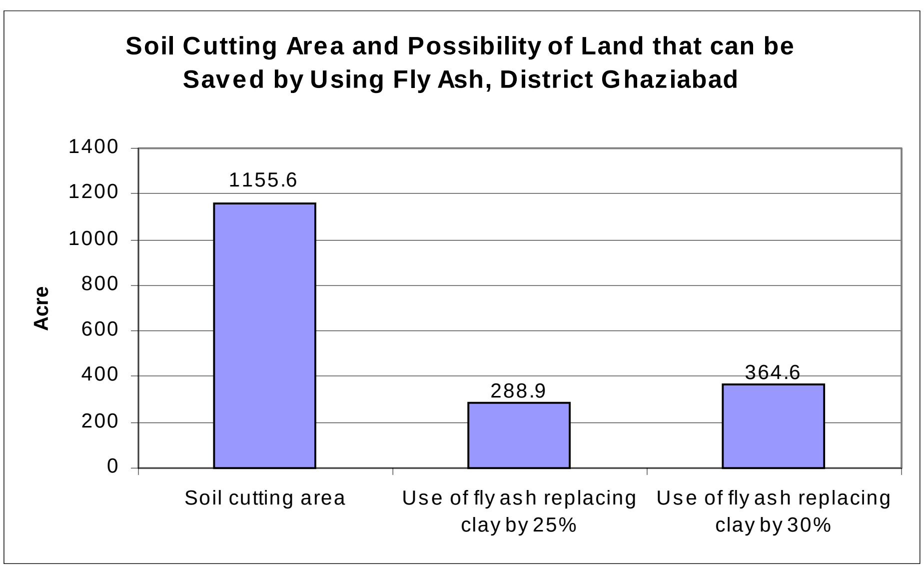


Fig. 5.4a

Table 5.14
Conventional Clay Bricks and Fly Ash Mixed Clay Bricks: Some Cost- Benefit Projections

Observations	Indicators
Part – A	
Average brick size (in cubic inch)	9x4.45x2.8
Average weight of a brick (in kg.)	2.6
Average digging depth of soil (in feet)	3.2
Average land price per acre (in Rs.)	1,41,000
Average distance from ash generating plant (in km.)	23.8
Average transportation cost of fly ash from ash generating plant (per 16 MT)*	1433
Average cost of production (per thousand bricks in Rs.)**	940
Average market price (per thousand bricks in Rs.)**	1185
Part – B	
Quantity of soil in one acre land (in cubic feet)	139366.4
Quantity of soil in one acre land (in MT)	5679.508
Number of bricks that can be manufactured with one acre land (in number)	21,84,426
Quantity of fly ash if 25% of clay is replaced by fly ash (in MT)	1419.877
Transportation cost of fly ash from ash generating plant (in Rs.) as specified by the ratio 75:25 between clay and fly ash	1,27,168
Cost of production of conventional clay bricks per thousand (in Rs.)	940
(a) Soil cost	64.54
(b) Other costs (labour, coal, water, sand etc.)	875.46
Soil cost if fly ash replaces clay by 25.0 per cent (in Rs.)	106.63
Cost of production (fly ash mixed with clay) per thousand bricks (in Rs.)	982.09
Cost difference (fly ash mixed with clay – conventional clay bricks) per thousand bricks (in Rs.)	42.09

Note: (Part-A) provides *primary data, collected from field survey*.
(Part-B) cost-benefit projections with and without *fly ash mixed with clay in manufacturing bricks*.
* *This information is based on respondents at the time of survey.*
** *No taxes have been added in cost of production.*
Source: *Field Survey*.

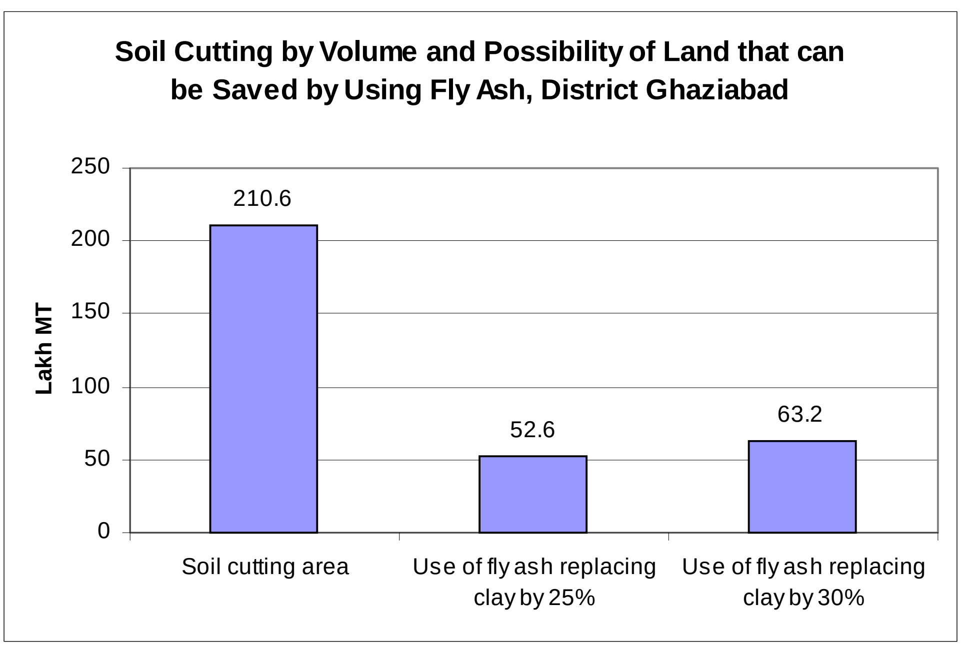


Fig. 5.4b

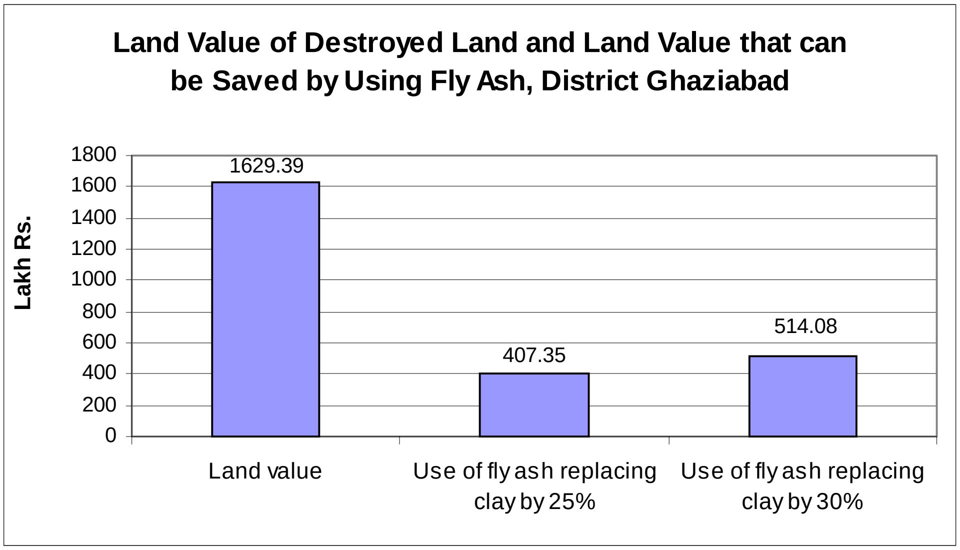


Fig. 5.4c

For the District Ghaziabad, the total number of conventional clay brick plants at the time of survey was 360 (of which we selected ten within the 50-km. radius of NTPC, Dadri). We do not have the exact number of conventional clay brick plants within this radius. Thus, we relied on District level data to arrive at some projections.

Soil cutting area (sq. metre) in any year for all these brick plants is 360.0 acres, of which agricultural land constitutes 100.0 per cent. If soil cutting implies destruction of top soil, then the total **value of land that is destroyed comes to be more than Rs. sixteen crore for the whole district covering all clay brick plants** (on the basis of average land price existing in 2001). Given the quantum of soil cutting per year, we calculate the quantity of fly ash that can replace 30.0 per cent (maximum) clay. Thus, we calculate maximum **agricultural land that can be saved by using fly ash** (maximum 30.0 per cent) as **replacement of clay (weight to weight basis)**. As we see, out of a total of 1155.6 acre of agricultural land, as high as 25.0 per cent can be saved (**Table 5.15**).

Photo 5.1a: Fly Ash Brick House, Constructed in 1998 by Ganga Brick Factory, Masoori, Ghaziabad.

Table 5.15
Projections Based on Major Observations of Brick Plants
(Projections for the District, Gautam Buddha Nagar and Ghaziabad, U.P.)

Part – A	**Major Observations**	**Indicators**
1.	Type of land acquired by the factories (%)	
	Agricultural land	100.0
2.	Average size of brick (in cubic inches)	9x4.45x2.8
3.	Average digging depth (in feet)	3.2
4.	Average weight (in kg.)	2.6
5.	Average production per year (number per factory)	70,10,000
6.	Average land price per acre (Rs.)	1,41,000
7.	Soil cutting area per factory (per year) in acre	3.21
8.	Soil cutting in volume per factory (per year) in MT	18,226
9.	Average transportation cost for sample brick plants (per 16 MT)	1,433
Part – B	**Projections**	
1.	Conventional brick plants in the district of Ghaziabad (2000-01)	360
2.	Soil cutting area per year (in acre)	1,155.6
3.	Agricultural land destroyed by soil cutting per year (in acre)	1,155.6
4.	Total land value of destroyed land (in Rs.)	16,29,39,600
5.	Soil cutting in volume per year (in MT)	2,10,61,965.6
6.	Fly ash in volume that can be used per year (in MT)*	63,18,589.7
7.	Agricultural land per year that can be saved by using fly ash (in acre)*	364.6
8.	Fly Ash in volume required per year (in MT)**	52,65,491
9.	Agricultural land that can be saved per year by using fly ash (in acre)**	288.9

Note: * *Calculations based on use of fly ash replacing clay by 30%. M/s Key Iron Works; Jagadhari Road, Yamuna Nagar, Nariyana, are already using fly ash replacing clay by a maximum of 30% in bricks.*

** *Calculations based on use of fly ash replacing clay by 25% in manufacturing bricks. The use of fly ash as a percentage replacement of clay at the minimum has been set by the Ministry of Environment and Forests, Govt. of India, through Notification dated 14th September 1999.*
We do not have exact number of brick factories within a radius 50 km. from NTPC, Dadri, of which we have given projections on land saving etc. For the whole district of Undivided Ghaziabad, projections regarding use of fly ash and potential saving of agricultural land have been based on studies of 10 brick plants selected within 50- km. radius of NTPC, Dadri.

Source: *Field survey.*

- *NTPC guide for users of coal ash, October 1999*.
- I*nformation on conventional brick factories of Allahabad, provided by District Board, Allahabad*.

The detailed calculations for **Table 5.15** are provided below:

Calculation of A7

(Per year soil cutting rate per factory)

Average brick size (in cubic inches)	= 9x4.45x2.8
Average brick size (in cubic feet)	= 0.75x0.37x0.23
Volume per unit of brick	= 0.0638 cube ft.
Average annual production of bricks (for the sample)	= 70,10,000
Soil used per plant per year	= 70,10,000x0.0638 = 4,47,238 cube ft
Average digging depth (per plant)	= 3.2 ft
Destroyed land area per plant per year	= 4,47,238/3.2 = 1,39,761.8 sq. ft
Destroyed land per plant per year	= 1,39,761.8 sq. ft/43552 =3.21 Acre
One Acre	= 43552

Calculation of B2

Sample soil cutting rate per plant (in acre)	= 3.21
Total number of brick plants in (old) Ghaziabad	= 360
Total land destroyed by the brick plants per year	= 360x3.21 = 1155.6 Acres

Calculation of B2 (a)

Agricultural land as percentage of total land acquired (sample)	= 100.0
Total land destroyed per year	= 1155.6x100/100 = 1155.6 Acres

Calculation of B4

Soil cutting area per year, (old) Ghaziabad district	= 1155.6 Acres
Average land price per acre (in Rs.)	= 1,41,000 (at the time of survey)
Total land value destroyed per year	= 1,41,000x1155.6 =Rs. 16,29,39,600

Calculation of B5

Average weight per brick (sample)	= 2.6
Total number of brick plants in (old) Ghaziabad	= 1155.6
Average production of bricks per plant (sample)	= 70,10,000
Soil used on average per plant per year (volume)	= 70,10,000x2.6 = 18,226 MT
Total clay used in brick construction in (old) Ghaziabad district	= 18,226x1155.6
	= 2,10,61,965.6

Calculation of B6

Quantity of fly ash that can be used in manufacturing clay bricks (if a conventional brick plant uses fly ash by replacing clay by 30.0 per cent)

Total quantity of soil used in (old) Ghaziabad district	= 2,10,61,965.6
Quantity of fly ash that can be used	= 2,10,61,965.6x30/100
	= 63,18,589.7

Calculation of B7

Agricultural land that can be saved per year by use of fly ash

Total destroyed agricultural land of (old) Ghaziabad district per year	= 1155.6
Saving of land by area	
(If fly ash is used in manufacturing bricks, replacing clay by 30.0 per cent)	= 1155.6x30/100
	= 364.6 Acres

5.6 Fly Ash-Sand-Lime-Gypsum Brick Plants: Observations Regarding Actual and Possible Use of Fly Ash

We could locate as high as seven fly ash-sand-lime-gypsum brick plants within 50-km. radius from NTPC, Dadri that use fly ash generated by the latter. These plants are new, established after 1998. These are functioning plants, in the sense that most of the other fly ash brick plants that we could locate within 50-km. radius were found to be closed during the period of survey. Of the seven such plants studied, three are within 25 km. radius, three are outside 25 km. but inside 50 km. radius, and one is just at a distance of 25 km. We assume that these seven selected fly ash brick plants can reveal the problems and possibilities of utilization of fly ash in manufacturing bricks, including market viability. For each of the plants, total establishment cost (excluding land cost) is less than Rs. 4 lakh (**Table 5.16**).

Table 5.16
Selected Fly Ash Brick Plants: A Profile
(Located within 50 km. radius from NTPC, Dadri)

Name of the Plant	Address	Distance form NTPC, Dadri (in km.)	Year of Establishment	Total Establishment Cost, Excluding Land Cost (in Rs.)
Sarswati Brick Factory	Phurgari, Massoori, Ghaziabad	16	2000	70,000
Om Brick Factory	Faridnagar, PO Khas, Ghaziabad	28	2000	80,000
Ganga Brick Factory	Bhargari, Masoori, Ghaziabad	18	1998	1,70,000
Neelam Brick Factory	Bhengel Phase-II, Greater Noida	30	1998	1,00,000
Eco Vision Industries	Surajpur Industrial Area, Ghaziabad	28	2000	4,00,000
Drona Brick Manufactures	Kazipur, Bypass Road, Ghaziabad	22	1998	4,00,000
Anand Brick Factory	Surajpura, Bhangel Phase-II Greater Noida	25	2001	2,00,000

Source: *Field survey*.

These plants have been successfully producing fly ash bricks, with varying capacity of production per year. The actual production per hour reflects the capacity production per hour for each of these plants. The bricks are as good as conventional clay bricks by size and weight. The cost of production per 1000 bricks also is the same as, and often lower than, conventional clay bricks (**Table 5.17**).

Photo 5.1b: Fly Ash Brick House, Constructed in 1998 by Ganga Brick Factory, Masoori, Ghaziabad.

Photo 5.2: Mixer Machine with gypsum and fly ash.

Table 5.17
Fly Ash Brick Plants (Selected Indicators)
(Located within 50-km. radius from NTPC, Dadri)

Name of the Plant	Production Per Year (No. of Pieces)	Production Till the Date of Survey (No. of Pieces)	Capacity of Brick Production Per Hour (No. of Pieces)	Actual Production Per Hour (No. of Pieces)	Brick Size (in cubic inches)	Weight Per Brick (in kg.)	Production Cost Per '000 Bricks (in Rs.)	Market Price Per '000 Bricks (in Rs.)
Sarswati Brick Factory	90,000	90,000	375	375	9x4.45x2.75	2.2	950	1250
Om Brick Factory	1,00,000	1,00,000	500	450	9x4.45x2.75	2.2	950	1300
Ganga Brick Factory	7,50,000	22,50,000	625	560	9x4x3	2.5	1000	1300
Neelam Brick Factory	2,33,000	7,00,000	500	500	9x4.25x3	2.5	1000	1250
Eco Vision Industries	3,33,000	5,00,000	625	560	9x4.25x3	2.5	1150	1400
Drona Brick Manufactures	5,00,000	15,00,000	625	625	9x4.5x3.5	3.0	1050	1250
Anand Brick Factory*	-	-	-	-	9x4.5x3	2.5	-	-
Average	3,34,333	8,56,666	542	511	9x4.34x3	2.49	1016	1292

Note: * *The factory started production in 2001*.
Source: *Field survey*.

There is no supply constraint so far as availability of raw materials for manufacturing fly ash bricks in these plants are concerned (**Table 5.18**).

Table 5.18
Raw Materials for Manufacturing Fly Ash Bricks: Sources of Raw Materials

Raw Materials	Sources of Supply
Fly Ash (Dry)	NTPC, Dadri
Gypsum	Bhiwari (Raj.) & Local
Sand	Badarpur, Delhi, and Hardwar, U.P.
Lime	Local

Source: *Field survey*.

The raw materials are mixed in ratios that are more or less the same for all the plants. It shows average weight of 60-65 per cent for dry fly ash, 10-15 per cent for sand, 5-10 per cent for gypsum, and 10-30 per cent for lime (**Table 5.19 and Fig. 5.5)**.

Table 5.19
Ratios of Raw Materials practiced for manufacturing Fly Ash Bricks (Percentage)

Name of the Plant	Dry Fly Ash	Gypsum	Sand	Lime	Total
Sarswati Brick Factory	60	8	10	22	100
Om Brick Factory	65	10	15	10	100
Ganga Brick Factory	60	5	10	25	100
Neelam Brick Factory	65	10	15	10	100
Eco Vision Industries	65	5	15	15	100
Drona Brick Manufactures	65	5	15	15	100
Anand Brick Factory	65	10	15	10	100
Average	64	8	13	15	100

Source: *Field survey*.

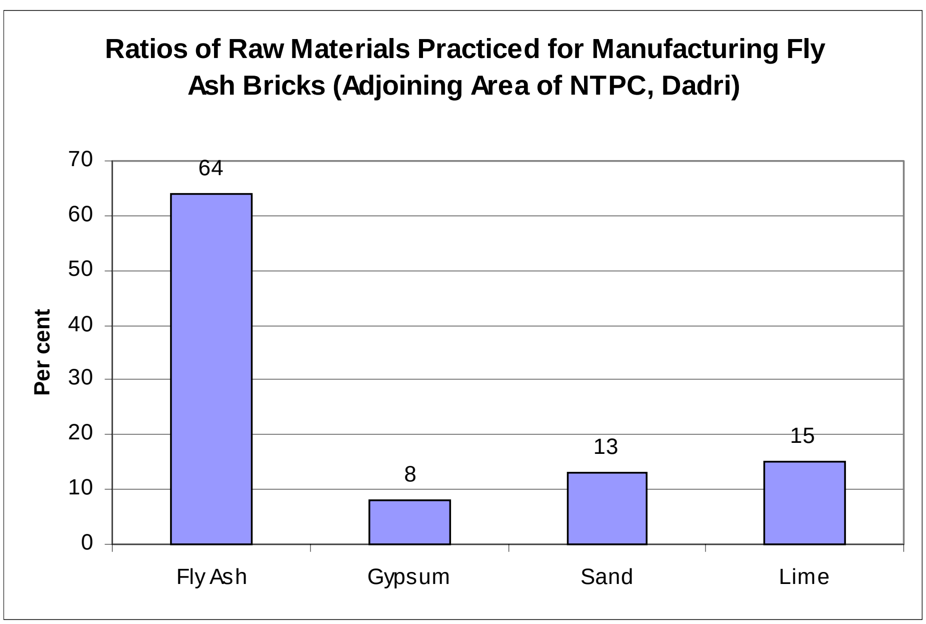


Fig. 5.5

The mode of transport for carrying dry fly ash from NTPC, Dadri to the brick plants is surface transport by truck, excepting one plant that uses tractor. The transportation cost is borne by the brick plant owners that vary between Rs. 80 and Rs. 200 per MT. The major cost for production of fly ash bricks is cost respectively on gypsum and lime. Cost on fly ash (only transportation cost incurred on fly ash) as a percentage of total raw material (gypsum, sand, lime, and fly ash) cost is low for all the fly ash brick manufacturers studied. The percentage varies between 4.00 and 9.5 **(Table 5.20, 5.21 and Fig. 5.6a, 5.6b)**.

Photo 5.3: Mixture Machine for manufacturing Fly Ash Bricks (with sand-lime-gypsum).

Table 5.20
Mode of Transport and Transportation Cost of Fly Ash

Name of the Plant	Transportation Cost to Carry Fly Ash (Per Tonne in Rs.)	Mode of Transport
Sarswati Brick Factory	100	Truck
Om Brick Factory	125	Truck
Ganga Brick Factory	80	Truck
Neelam Brick Factory	175	Truck
Eco Vision Industries	200	Truck
Drona Brick Manufactures	125	Truck
Anand Brick Factory	175	Tractor

Source: *Field survey.*

Table 5.21
Input Costs on Raw Materials, Labour Cost, and Land Rent (in Rs.)
(Fly Ash-Sand-Lime-Gypsum Brick Plants)

Name of the Plant	Input Costs (per Tonne)			Labour Cost per head per day	Others (Land Rent Monthly)	Total Raw Material Cost (Per MT) Plus FA Cost** (G+S+L+FA)	FA Cost** (Transportation Cost) as % of Total Raw Material Cost
	Gypsum	Sand	Lime				
Sarswati Brick Factory	1025	270	600	70	-	1995	5.01
Om Brick Factory	975	300	600	70	-	2000	6.25
Ganga Brick Factory	1000	300	675	80	-	2055	3.8905
Neelam Brick Factory	975	350	600	75	-	2100	8.33
Eco Vision Industries*	1000	400	700	70	10000	2300	8.69
Drona Brick Manufactures	900	375	650	80	7000	2050	6.09

*							
Anand Brick Factory	900	300	700	80	-	2075	8.48
Average	968	328	646	75	-	2082	6.72

Note: * *These plants have taken land on rental basis.*
** *FA cost is the transportation cost of fly ash only. (G: Gypsum; S: Sand; L: Lime; FA: Fly Ash)*
Source: *Field survey*.

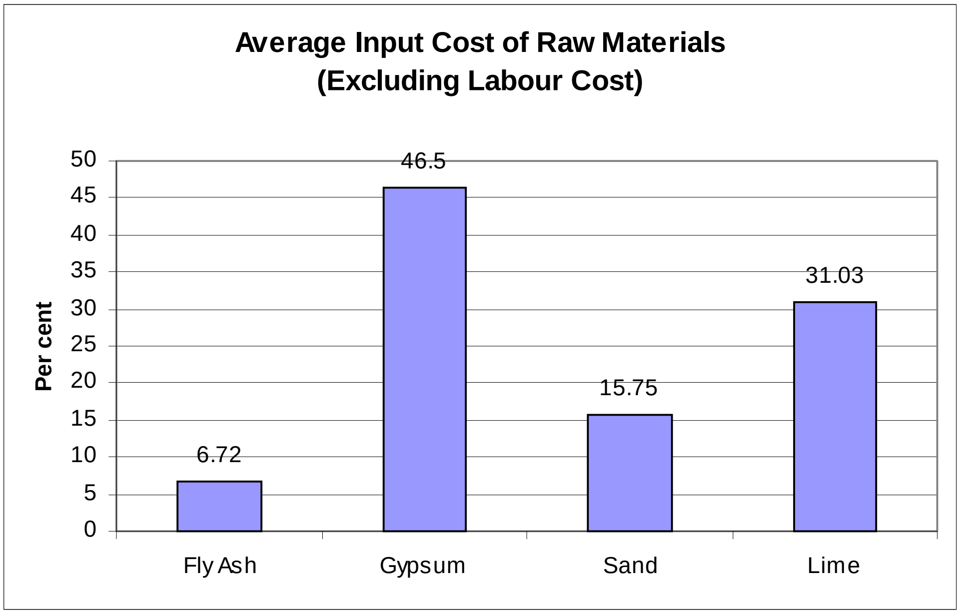


Fig. 5.6a

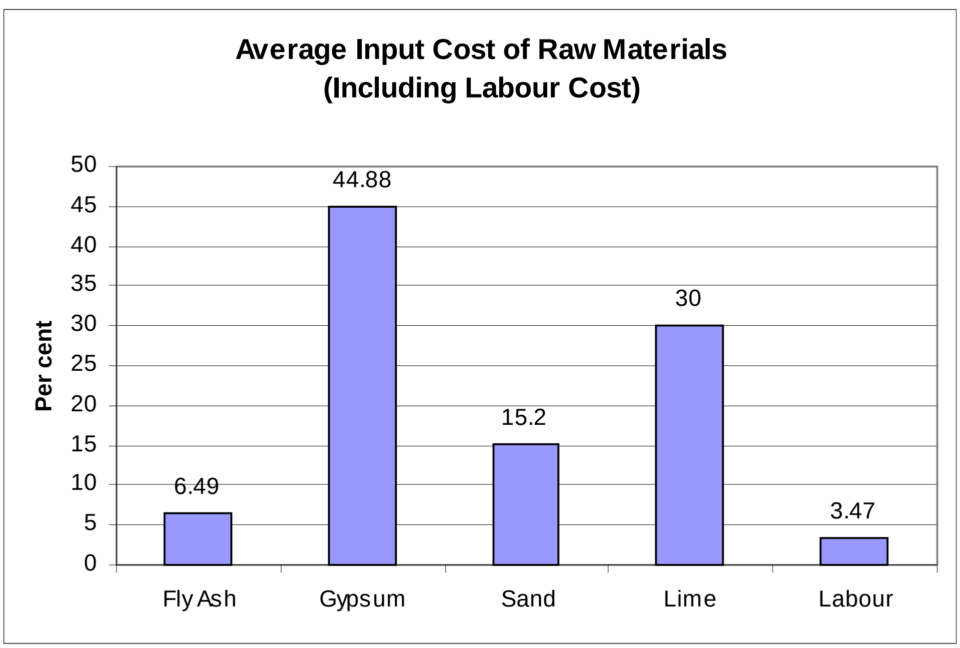


Fig. 5.6b

If we take 100 as the index of use of raw materials for manufacturing **fly ash-sand-lime-gypsum** bricks, then the **ratio** comes to be (on average for all the seven such brick plants studied adjacent to NTPC, Dadri) **64:13:15:8**. On the basis of input costs calculated on the items (sand-lime-gypsum) plus transportation cost of fly ash, we have calculated the number of such bricks (per 100 MT raw materials). Addition of labour cost (per unit of bricks as final output) shows cost of production of such bricks per unit. This estimated cost, Rs. 0.91 per brick, is slightly less than **reported cost**, Rs. 1.02 per brick, the gap between reported and **estimated cost** is marginal. **Since market price per brick is Rs. 1.29, as reported by the brick plant owners, hence the market feasibility is ensured for fly ash-sand-lime-gypsum bricks, even with positive transportation cost of fly ash** (**Table 5.22).**

Table 5.22
Cost of Production of Fly Ash-Sand-Lime-Gypsum Bricks

Materials and Labour (by quantity and cost)	Indicators
Raw materials (ratios in percentages)	
Fly ash	64
Gypsum	8
Sand	13
Lime	15
Average labour cost (per head/hour), in Rs.	75
Actual production of bricks in number (Average/hour)	511
Average cost of raw materials (per MT, in Rs.)	
Gypsum	968
Sand	328
Lime	646
Transportation cost of fly ash (from ash generating plant) per MT (in Rs.)	140
Weight per brick (average in kg.)	2.49
COST OF PRODUCTION#	
Input costs (in MT/Rs.)	
Transportation cost of fly ash (64 MT fly ash)	8,960
Gypsum (8 MT)	7,744
Sand (13 MT)	4,264
Lime (15 MT))	9,490
Input cost (in Rs.)##	30,458
Number of fly ash bricks that can be manufactured by 100 MT raw materials	40,161
Labour cost of 40161 bricks (in Rs.)	5,925
Total input cost including labour cost (in Rs.)	36,383
Cost of production per brick (in Rs.)*	0.91
Cost of production per brick (in Rs.)**	1.02
Market price per brick (in Rs.)**	1.29

Note: # *Cost of production given without adding any taxes*. **Source**: *Field Survey*.
Input costs here include raw materials (equivalent 100 MT) cost plus transportation cost of fly ash.
* *Cost of production based on calculation*.
** *Production and market price shown as reported by fly ash brick plant owners*.

The market price per unit of clay brick comes to be around Rs. 0.93 for District Allahabad while the reported cost of production per unit comes to be Rs.0.80, showing surplus for plant owners. For District Ghaziabad, the market price comes to be Rs. 1.19 while the reported cost of production per unit comes to be Rs. 0.94, showing surplus. As opposed to this, market price of fly ash-sand-lime-gypsum brick is Rs. 1.29 per unit, higher than conventional clay bricks, while the reported cost of production per brick comes to be Rs. 1.02 and estimated cost Rs. 0.91. **Though there is surplus in manufacturing and marketing fly ash-sand-lime-gypsum bricks, there is at the same time positive price-differential between fly ash bricks and clay bricks (Table 5.23)**. **Manufacturing and marketing fly ash bricks, thus, requires relative cost reduction**.

Table 5.23
Cost of Production and Market Price of Clay Bricks and Fly Ash Bricks, Districts Allahabad and Ghaziabad, U.P.

Clay Bricks and Fly Ash Bricks	Cost and Price of Brick per unit (in Rs.)
Allahabad (conventional clay bricks)	
Cost of Production (Per Brick)**	0.80
Market price (per brick)**	0.93
Ghaziabad (conventional clay bricks)	
Cost of Production (Per Brick)	0.94
Market price (per brick)	1.19
Ghaziabad (fly ash-sand-lime-gypsum bricks)	
Cost of production (per brick)*	0.91
Cost of production (per brick)**	1.02
Market price (per brick)**	1.29

Note: * *It is based on calculation*.
** *As reported by the brick plant owners*.
Source: *Field survey*.

For the District Ghaziabad (areas adjoining NTPC, Dadri), we can **compare benefits and costs shown by conventional clay brick plants and fly ash-sand-lime-gypsum brick plants**. Regarding end-use, both the types of bricks are similar by size and weight. There are, however, many differences in terms of social cost. **While conventional clay bricks increasingly exhaust agricultural land as we observed, the production of fly ash bricks saves agricultural land (by both square and cubic metre). However, both cost of production per unit and market price per unit are higher in case of fly ash-sand-lime-gypsum bricks. While net surplus (Revenue – Cost) is positive for both types of brick plants, it is much higher for clay bricks per plant based on annual production level** (**Table 5.24**). Since plant size is much higher (by capacity production) for clay bricks, hence clay brick plants record on average higher net benefits. However, **calculated over 1,000 pieces of bricks, fly ash-sand-lime-gypsum brick plant shows more net benefits. Thus, there are reasons to promote fly ash brick plants**.

Photo 5.4: Compress Machine used to manufacture fly ash bricks (with sand-lime-gypsum).

Photo 5.5: Manufactured Fly Ash Bricks (with sand-lime-gypsum) on display.

Table 5.24
Conventional Clay Bricks and Fly Ash-Sand-Lime-Gypsum Bricks in Ghaziabad District: Comparison of Benefits

Indicators	Conventional Clay Bricks	Fly Ash Bricks
Average size of brick (in cubic feet)	.75x.37x.23	.75x.36x.25
Agricultural land acquired by factory (%)	100	-
Average weight (in kg.)	2.6	2.49
Average production per year (number)	70,00,000	2,21,833
Soil cutting area per factory (acre)	3.21	-
Cost of Production per thousand bricks (Rs.)	940	1016
Market price per thousand bricks (Rs.)	1185	1292
Cost of production per factory (Annual output, in Rs.)	65,80,000	2,25,382
Market value (revenue) of annual output (Rs.)	82,95,000	2,86,608
Net annual benefit per factory (Rs.)	17,15,000	61,226

Source: *Field Survey*.

Average production per year of conventional clay bricks is 31.55 times that of fly ash bricks. Market value (revenue) of annual output for clay bricks is 28.94 times that of fly ash bricks. Net annual benefit per factory in case of clay bricks is 28.01 times that of fly ash bricks. Given the scope of scale economy in fly ash brick production, there may come changes of similar net benefit in fly ash brick production.

5.6.1 Fly Ash Bricks: Quality and Marketing

While reporting the problems regarding marketing of fly ash bricks, the fly ash brick plant owners argued for marketability of these bricks once the quality of these bricks is understood by the buyers. The quality is shown in **Box 5.5**.

Box 5.5
Fly Ash Bricks: Quality (As Conveyed by Brick Plant Owners in Areas Adjoining NTPC, Dadri)

- Salt does not affect fly ash bricks,
- Size of a fly ash brick is often bigger than a clay brick,
- Strength of a fly ash brick is more than a clay brick,
- Strength of fly ash bricks increases with sunlight and water,
- Strength of fly ash bricks increases with time,
- There is no need of plaster on the wall constructed by fly ash bricks,
- The colour of the fly ash bricks seems acceptable to the final consumers.

Note: *Strength of bricks understood by weight and durability*.
Source: *Field Survey*.

The problems regarding marketing of fly ash bricks as conveyed by the brick plant owners are shown in **Box 5.6**.

Box 5.6
Marketing of Fly Ash Bricks: Problems
(As Conveyed by Brick Plant Owners in Areas Adjoining NTPC, Dadri)

- Consumers' ignorance about fly ash bricks,
- Ignorance about the technology for manufacturing fly ash bricks,
- Absence of Government as a buyer of fly ash bricks,
- Absence of any support from local public administration for marketing of fly ash bricks,
- Absence of publicity about the quality of fly ash bricks in the market,
- Price of fly ash bricks not yet fixed by the government,
- No protection or support from the government for encouraging production of fly ash bricks.

Source: *Field Survey*.

5.7 Utilization of Fly Ash in Manufacturing Bricks: Suggestions

The suggestions offered by the fly ash brick producers for use of fly ash in brick production are presented in **Box 5.7**.

Box 5.7
Utilization of Fly Ash in Manufacturing Bricks: Suggestions

- Government should arrange for testing of fly ash bricks,
- Government should publicize the strength and other qualities of fly ash bricks,
- Government should come forward as the first and biggest buyer of fly ash bricks,
- Government should provide technology (knowledge and training) free of cost to the brick plant owners,
- Technology Office/Park should be established at each District for access of the brick plant owners to the technology,
- Government should not impose Excise duties on machines for manufacture of fly ash bricks,
- Transportation cost of fly ash should be the responsibility of the supplier of fly ash,
- In case transportation cost is borne by the brick manufacturer, the Government has to subsidize the cost,
- There has to be sales tax rebate on volume and value of fly ash bricks,
- The price of fly ash bricks has to be fixed by the Government.

Source: *Field Survey*.

5.7.1 Fly Ash-Sand-Lime-Gypsum Brick Plants Located Adjacent to NTPC, Dadri: Availability of Technology

All the selected brick plants reported that they got the technology for manufacturing fly ash mixed bricks from NTPC, Dadri. Only one brick plant (ECO

Vision Industries) reported to have taken support from Central Building Research Institute (CBRI), Roorkee. Ash utilization cell of NTPC, Dadri, reported that its ash utilization unit has different types of machines, understood in terms of their capacity of production per period. The value of these machines ranges from rupees thirty thousand to four lakh at the time of study. **The NTPC is reported to be ready to provide total technological support to any potential entrepreneur willing to set up a fly ash brick plant like technique of production, input ratio (fly ash, sand, lime, and gypsum) and dissemination of information in this regard. However, no formal training has so far been organized by the NTPC, Dadri, in this regard**. We got information about availability of two types of machines for manufacturing fly ash bricks. These are mixing machine and pressure machine, available in Ghaziabad, Delhi and Hyderabad. The ash utilization cell of NTPC also has a module room, where all types of products are available for display to the potential consumers and manufacturers of fly ash bricks.

5.8 Use of Fly Ash Supplied by NTPC, Dadri, in Cement Plants: Observations

The cement manufacturers are the main external users of fly ash supplied by NTPC, Dadri. We could locate the Diamond cement, Jhansi, UP, that takes 11.4 MT of fly ash per day from NTPC, Dadri. The distance between NTPC, Dadri, and Diamond Cement, Jhansi, is around 350 km. This is the reason why the Diamond Cement, Jhansi, takes most of its required fly ash from UP Electricity Board, Parichha, to the tune of 64.6 MT per day, that is located at a distance of 5 km. from the cement plant. The cement plant began using fly ash in cement production in 1986. The technical ratio in which fly ash is mixed is given as Fly Ash: Clinker: Gypsum as 38:55:07 for producing Portland Pozzolana Cement. During 1998-2001, the percentage use of fly ash increased steadily from 36.0 per cent to 38.0 per cent **(Fig. 5.7)**. Of the total fly ash required by Diamond Cement, 15.0 per cent comes from NTPC, Dadri, and remaining 85.0 per cent from UP Electricity Board, Parichha. The annual production of cement, however, has remained fixed, targeted and actual. The transportation cost of fly ash, that is total fly ash cost, stands at Rs. 2,500 per MT for NTPC, Dadri while only Rs. 500 for UP Electricity Board (**Table 5.25**). NTPC, Dadri, thus, has lower chance of increasing supply of fly ash to Diamond Cement, unless the transport cost is borne by NTPC, Dadri.

Table 5.25
Diamond Cement, Jhansi, Uttar Pradesh (Fly Ash User): A Profile

Profile	Information
Name of the Plant	Diamond Cement, Jhansi
Location of the Plant	District – Jhansi, U.P.
End product of the Plant	PPC
Year of Foundation	1983
Year when production started	1986
Year when Fly Ash began to be used in cement	1986
Fly Ash that can be used in Cement(Minimum and Maximum, in percentage)	25.0 to 40.0
Annual production of cement (in Metric tonnes)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	73,000 73,000 73,000
Quantity of Cement produced (per day , in Metric tonnes)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	200 200 200
Raw materials required for manufacturing PPC, 2000-2001 (ratios in percentage)	
(a) Fly Ash (b) Clinker (c) Gypsum	38.0 55.0 07.0
Raw materials required in manufacturing Cement (Minimum and Maximum, in percentage)	
Portland Pozzolona Cement (a) Clinker (b) Gypsum (c) Fly Ash	 50.0 – 75.0 03.0 – 10.0 25.0 – 40.0
Fly Ash used in Cement (in percentage, of volume)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	36.0 37.0 38.0
Sources of Fly Ash and their percentages	
U.P. Electricity Board, Parichha NTPC, Dadri	85 15
Transportation Cost of Fly Ash from Ash Generating Plant (in Rs., Per MT)	
U.P. electricity board, Parichha NTPC, Dadri	0500.0 2500.0
Distance of Fly Ash Generating Plant from Cement Plant (in KM.)	
U.P. electricity board, Parichha NTPC, Dadri	5 350
Annual supplies of Cement (in Metric tonnes)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	73,000 72,500 72,500
Annual quantity of Fly Ash used in PPC (in Metric tonnes)	
(a) 1998-1999 (b) 1999-2000 (c) 2000-2001	27,740 27,740 27,740
Quantity of Fly Ash required (per day , in Metric tonnes)	
(a)1998-1999 (b) 1999-2000 (c) 2000-2001	72 74 76

Contd...

Profile	Information
Fly Ash taken from different Sources (per day, in Metric tonnes)	
(a) U.P. Electricity Board, Parichha (b) NTPC, Dadri	64.6 11.4
Sources of Clinker	Damoh, M.P.
Distance of Damoh (in KM.)	300
Transportation Cost of Clinker From Damoh (in Rs., Per MT)	20

Note: *PPC = Portland Pozzolona Cement*
Source: *Diamond Cement, Jhansi, Uttar Pradesh, December 2001*.

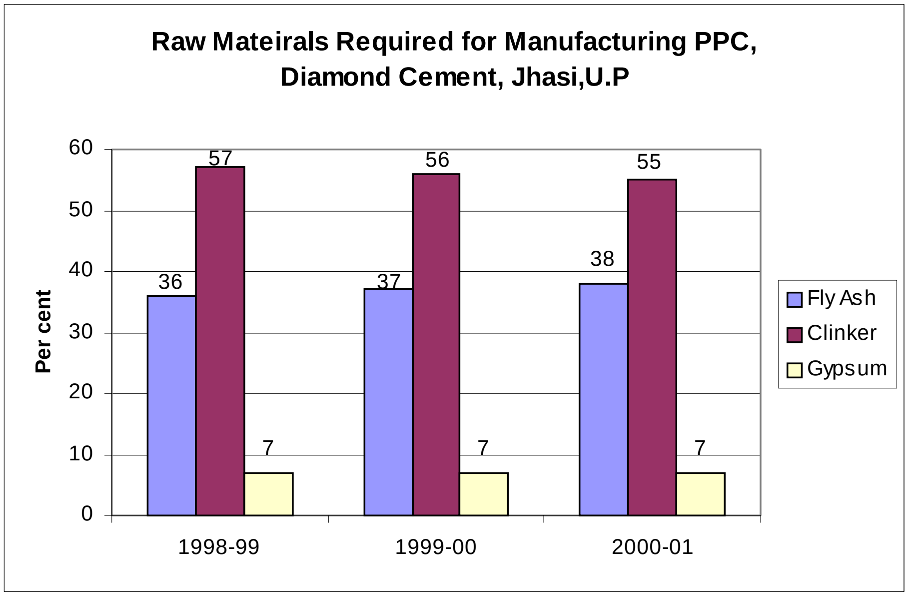


Fig. 5.7

5.9 Disposal of Fly Ash in the Adjoining Areas of NTPC, Dadri: Effects on Human Health and Cropland

Because of the location and selection of disposal/dumping area of fly ash generated by the NTPC, Dadri, **we found no effect of spread of fly ash, either air-borne or water-borne, in the west of the plant. Hence, we selected households settled in the villages in the east, north, and south of the plant within a radius of 2 km. from the location of the NTPC, Dadri (Table 5.26)**. **Based on the pilot survey, we selected seven villages,** of which three are in the east, two in the north, and two in the south. **We covered a total of 65 households** in these seven villages, of which 28 are in the east, 17 in the north, and 20 in the south (**Table 5.27**). As reported by the households in these villages, the adverse effect of spread of fly ash is highest during the summer of each year (**Box 5.8**). Hence, we conducted the field survey during summer.

Box 5.8
Ranking of Time/Season in Terms of Adverse Effect of Spread of Fly Ash in the Adjoining Area of NTPC, Dadri

Season/Time	Households who Revealed Adverse Effect	Rank
Whole of summer	54 (53.1)	1
When the wind blows	6 (9.2)	2
Whole of the year	5 (7.7)	3
All households	65 (100)	

Source: *Field Survey*.

Table 5.26
Households Surveyed in Terms of Distance from Fly Ash Dumping Area

Distance from Dumping Area (in Meter)	East	North	South	All Households
400 to 1,000	11 (39.3)	2 (11.8)	15 (75.0)	28 (43.1)
1,000 to 1,500	12 (42.8)	5 (29.4)	5 (25.0)	22 (33.8)
1,500 to 2,000	4 (14.3)	-	-	4 (6.2)
2,000 to 2,500	1 (3.6)	10 (58.8)	-	11 (16.9)
All Households	28 (100.0)	17 (100.0)	20 (100.0)	65 (100.0)

Source: *Field Survey*.

Table 5.27
Direction-wise Settlement of Households, Adjoining Areas of NTPC, Dadri

Direction	Name of Villages	All Households
East	Muthyani	13
	Jarcha	8
	Gulawathi	7
	Total	28 (43.1)
North	Khagaura	7
	Uncha Amipur	10
	Total	17 (26.2)
South	Silarpur	15
	Patardi	5
	Total	20 (30.7)
All Households		65 (100.0)

Source: *Field Survey*.

The selection of the households covered primarily the cultivators. The occupation-wise distribution of the households shows that we covered around 80.0 per cent of the total households in the adjoining area of NTPC, Dadri (**Table 5.28**). The education-wise distribution shows that most of the households covered are literate

(**Table 5.29**). The households, who reported reduced rate of growth of crops, cover all crops, particularly, paddy, wheat, sugar cane, maize, vegetables etc. (**Box 5.9**). Almost all the households reported to have been experiencing adverse effect of spread of fly ash disposed by NTPC, Dadri. **The adverse effect is reported by a number of indicators. This includes effect on agricultural land** (**Table 5.30**). The derived effects include reduced quantity of crops produced per acre due to spread of fly ash. It also includes drying crops, reduced growth of crops, increasing input costs on nourishing crops affected by spread of fly ash (**Box 5.10**). The government document, however, does not have any record on productivity per unit of land of these crops in the villages covered. A total of 46 out of 65 households reported reduced rate of growth of crops.

Table 5.28
Occupation-wise Distribution of Households in the Adjoining Area of NTPC, Dadri

Occupation	Number	Per cent
Cultivation	51	78.5
Agricultural labour	2	3.1
Non-agriculture labour	2	3.1
Government service	2	3.1
Private service	6	9.2
Small business	1	1.5
Jobless/Displaced	1	1.5
All households	65	100.0

Source: *Field Survey*.

Table 5.29
Literacy Level of the Respondents of the Households in the Adjoining Area of NTPC, Dadri

Educational Level	Number	Per cent
Illiterate	3	4.6
Literate	5	7.7
Up to Primary	5	7.7
Up to Junior High School	8	12.3
Up to High School	17	26.2
Up to Intermediate	18	12.3
Higher Education	9	13.8
All households	65	100.0

Source: *Field Survey*.

Box 5.9
Crops experiencing decelerating growth of Output

- Paddy
- Wheat
- Sugar cane
- Mustard
- Potato
- Maize
- Vegetables

Source: *Field Survey*.

Table 5.30
Direction-wise Effect of Fly Ash on Agricultural Land adjoining NTPC, Dadri

Direction from the NPTC, Dadri	Name of Villages	Effect on Agricultural Land		All Households
		Adverse	No Effect	
East	Muthyani	11	2	13
	Jarcha	8	-	8
	Gulawathi	6	1	7
	Total	25 (46.3)	3 (27.3)	28 (43.0)
North	Khagaura	7	-	7
	Uncha Amipur	2	8	10
	Total	9 (16.7)	8 (72.7)	17 (26.2)
South	Silarpur	15	-	15
	Patardi	5	-	5
	Total	20 (37.0)	-	20 (30.8)
All households		63 (100.0)	11 (100.0)	65 (100.0)

Source: *Field Survey*.

Box 5.10
Effect of Spread of Fly Ash on Crop Area and Plantations Adjoining NTPC, Dadri
(Perception of the Households)

- Declining crop production per acre
- Diseases found in crops
- Working problems in crop field
- Drying crops
- Reduced growth of crops
- Increased input costs on nourishing crops

Source: *Field Survey*.

The major air-borne problems in the villages are reported to be too much ash dust in the atmosphere, breathing problems due to absence of fresh air, too much heat due to power plant operations, and accumulation of ash in the ash mound (**Box 5.11**). Thus, **the households complained about their health being adversely affected by air-borne spread of fly ash**. The major water-borne problems in these villages are foul smell in water in the wells and dust/ash mixed in water in wells, which are generally consumed by people in these villages (**Box 5.12**). **There are no resident registered medical practitioners to give report on medical check up of the households. There is also no record of any scientific measurement (laboratory) of air and water quality for the area.**

Box 5.11
Households Affected by Spread of Fly Ash in the Adjoining Area of NTPC, Dadri
(Major Air-Borne Problems, as perceived by the households)

- Too much ash dust in the atmosphere,
- Breathing problems due to absence of fresh air,
- Too much heat due to power plant operations and ash mound,
- Health adversely affected by spread of fly ash.

Source: *Field Survey*.

Box 5.12
Households Affected by Spread of Fly Ash in the Adjoining Area of NTPC, Dadri
(Major Water–Borne Problems, as perceived by the households)

- Foul smell in well water,
- Too much dust/ash in well water.

Source: *Field Survey*.

The types of diseases that the households reported to have been suffering from include eye-related problems, tuberculosis, asthma, cough and chest congestion, cholera, malaria, breathing problems, stomach-aching etc. (**Box 5.14**). Suggestions offered by the households, affected by the spread of fly ash, include provision for regular medical check up of health and supply of necessary medicines and arrangement for medical treatment for the people at the cost of NTPC, Dadri. The suggestions also include measures, to be initiated by the Dadri Unit, to stop air-borne pollution in the adjoining area, through plantations (**Box 5.15**). The suggestions also include educating people about how to prevent diseases that emerge from drinking of ash-mixed water, and inhaling ash-mixed dust (**Box 5.13**).

Box 5.13
Prevention of Diseases in the Adjoining Areas of NTPC, Dadri
(Required Health Facilities, as perceived by the people affected)

- There has to be provision for regular medical check up of health for the people in the adjoining area, at the cost of NTPC,
- Necessary medicines and treatment should be shouldered by NTPC free of cost,
- The NTPC, Dadri, has to educate the people of adjoining area about prevention of diseases,
- Measures should be taken by NTPC, Dadri, to stop air-borne pollution in adjoining areas,
- NTPC, Dadri, should develop proper plantations on all sides of ash mound.

Source: *Field Survey*.

Box 5.14
Diseases found in the Adjoining Areas of NTPC, Dadri
(As Reported by the Households)

- Eye problems
- Tuberculosis
- Asthma
- Cough/Chest congestion
- Cholera
- Malaria
- Problems in breathing
- Stomach aching/pain

Source: *Field Survey*.

Box 5.15
Plantations on Adjoining Areas of Ash Mound: Possibilities
(Perception of the Households)

- Babool
- Useful trees
- All trees (with more care)
- No trees can be planted near ash mound
- Trees planted but are drying

Source: *Field Survey*.

5.10 Effect of the Ash Mound on the Adjoining Area as Perceived by NTPC, Dadri

As planned by the Dadri Unit of NTPC, the ash mound will have a final height of 55.0 meter and a volume of 5,30,00,000 cubic meter, covering an area of 375 acres **(Table 5.31)**. The side slope of ash mound are 1 in 4.5 for the lowest slope and subsequent slopes with a gradient of 1 in 4 with three beams 10.0 meter wide at a height interval of 15.0 meter for access and to assist erosion control. The stability analysis has determined that for designed permanent slopes, the factor of safety for ash mound is greater than 2. This factor of safety is reduced to 1.35 when a horizontal seismic component of acceleration of 0.05 is taken into account (Sikka and Kundu, 1999, p. 147). Ash is planned to be dumped in the Ash Mound depending upon the functioning of the system and weather conditions. During monsoon or system non-availability (like during horizontal shifting of field conveyor), ash is dumped in 'Temporary Ash Storage Area' from where ash is transferred to permanent ash mound area through reclaimer machines. A drainage blanket under the ash mound allows water to flow freely to the perimeter ditch and helps to maintain the strength of the deposited ash. It also protects the ground water from the toxic leachate contamination.

Table 5.31
Ash Mound, NTPC, Dadri (Basic Information)

Ash Dumping Area, in acre (Bottom Circumference of Ash Mound)	500
Height of Ash Mound, (in Meter) (i) Upper Limit (ii) Present Height	 55 30
Target Duration of Dumping in Ash Mound (forty years)	1993-2033
Accumulated Ash, up to March 2001 (in lakh MT)	84
Distance of Ash Mound from Ash Generation Plant (in km.)	04
Total Fixed Cost of Ash movement to Ash Mound from Boiler (Rs. crs.)	137
Ash Handling Cost per MT (in Rs.)	30
Average Dumping Quantity per day (in MT)	3556
Ash Handling/Dumping Cost per day (in Rs.)	10,6680

Source: *NTPC, Dadri*.

The determinants that show probable pollution from ash mound are either air-borne or water-borne. These problems were kept in mind when the mound was constructed at the Dadri Unit. **Box 5.16** shows what were designed for pollution control when the mound was constructed.

Box 5.16

Planning Pollution Control at the Time of Construction of Ash Mound, NTPC, Dadri

- FBA and PFA are never mixed; they are handled separately. Ashes are put in pre-selected areas to give shape to the final mound form.
- Only conditioned PFA (15.0 to 20.0 per cent moisture by weight) is handled to control the fugitive dust. The initial compaction is from dropping the ash from the spreader, movement of bulldozers.
- After deposition of ash by Boom spreader, mobile equipment is required to spread and roll the ashes in desired profiles.
- After a sufficient area is available for ash formation, a vibratory roller is employed to firm up the surface and increase the resistance of the ash to dust blow.
- Mound construction will follow a construction sequence at multi-layers to ensure the stability of the ash mound.

Source: *Sikka and Kundu, 1999, p.148*.

The method of handling ash is eco-friendly in the sense that it aims at eliminating dust emissions. The methods by which the Plant minimizes dust emissions and hence air pollution are shown in **Box 5.17**.

Box 5.17
Existing Measures to Minimize Dust Emissions, NTPC, Dadri

Measures	Purpose
Belt Conveyors	Before being discharged into conveyors from the silos, fly ash will be conditioned with water with the help of hydro mix dust conditioner (HMDC). Each conveyor transfer point is fitted with water sprays, fixed sprinklers are also used at a number of points along the conveyors in order to dampen the ash. This is particularly needed if the ash shows signs of being dried during transportation.
Ash Moving Equipment	Relative to dust nuisance created by transportation of ash to ash mound, the very construction of ash mound by ash moving equipment is dustier. The plant takes care of this problem by judicious use of mobile equipment.
Wind Erosion	Stabilization of top and intermediate surface is done by application of water or spraying chemicals like polymer to control air-borne dust, particularly during summer. For short-term management of air-borne pollution, spreading of cut grass on the top surface helps, while for long-term control and surface stabilization, the mound needs adequate and appropriate vegetation.
Site Traffic	Permanent roads inside the plant are planned to be surfaced and cleaned and sprayed with water (by Bowser) as and when necessary. Vehicle speed is restricted.

Source: *Sikka and Kundu, 1999, p. 148*.

5.11 Tasks to Ensure Stabilization of Ash Mound, NTPC, Dadri

The dry ash disposal technique as adopted by the Dadri Unit of NTPC is well planned. Still then, for control of dust emissions and stabilization, the ash mound needs vegetation. This requires identification of grass, shrub and plantations that survive on the hard and harsh environment of the ash mound.

5.11.1 Plantations on Ash Mound in NTPC, Dadri: Possibilities

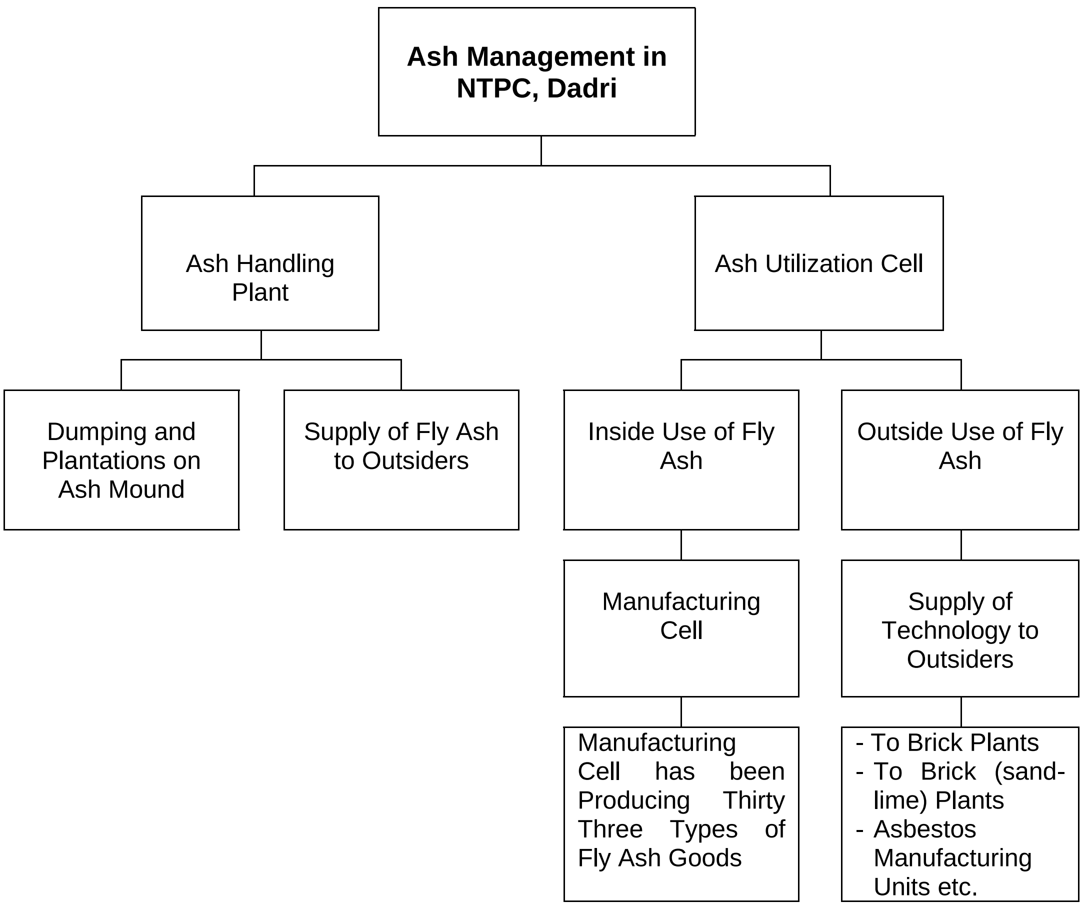
Photo 5.6: Ash Mound of NTPC. Dadri.

The Ash handling plant of NTPC, Dadri has evolved a technique for plantation on the ash mound. As reported by the NTPC officials, the ash-dumped area after being selected for commercial plantations is first covered by a special type of grass called Sasbenia Species. This grass accumulates nitrogen from sunlight. After growth of this grass, trees like Baganvari, Australian Babool, Kanail, shrubbier (Thorny Bush) are planted. These trees increase the fertility of soil and improve the organizational structure of soil. The thorny trees are cut after they attain a certain height. The ash-mixed land becomes fertile for plantation of any commercial tree after thorny trees are cut. Following this technique, any commercial tree can be planted on ash mound. The ash-handling unit of NTPC, Dadri, has successfully done this experiment. This technique takes two years to convert the ash-based land for said purposes. This is visible from many commercial trees like Tick, Shisham, Rubber, and Bamboo planted on ash mound inside NTPC, Dadri (**Map**). The cost of plantation per square meter is Rs. 4 to Rs. 5.

Photo 5.7: Ash Mound of NTPC, Dadri.

Photo 5.8: Plantations in NTPC, Dadri Unit.

5.12 Ash Management in NTPC, Dadri



Chapter 6: Fly Ash: Generation, Management, Utilization, and Possibility of Reduction of Ash Content in Selected Plants

6.1 Major Observations: IFFCO, Phulpur, and NTPC, Dadri

IFFCO, Phulpur

IFFCO, Phulpur, has installed necessary equipments for controlling the quality of liquid effluents and of gaseous emissions. Liquid effluents are treated before being discharged into the main effluent nallah outside the plant premises. The quality of the effluent lies within the standard laid down by the Pollution Control Board, U.P.

The dumping of fly ash by IFFCO, Phulpur, in the form of Ash Pond may not exhaust the area required outside the plant as the ash is being supplied regularly to cement manufacturers. The rate of utilization of fly ash exceeds the rate of generation so that on a span of less than ten years from year 2000, the plant can plan to utilize all fly ash generated. This utilization covers both internal and external uses.

The plant has shifted completely from wet ash disposal in the ash pond formed in the adjoining area to supply dry ash through pneumatic conveyor system. This shift has occurred in two phases, the first phase began in April 2000, and the second phase in November 2000. Dry fly ash is collected in hopper and supplied directly to tankers. Electro mechanical retractable chutes are supplied to load fly ash into the tanker without any dust hazard in the locality.

NTPC, Dadri

Coal for NTPC, Dadri, comes from North Karanpura Coalfields in Bihar (now in Jharkhand). Before 1998, the ash content in coal used by Dadri was 40.0 per cent that came down to around 35.0 per cent after 1998. However, the source of coal has remained unchanged. The NTPC, Dadri has formed an Ash Mound inside the plant premises for storage of fly ash. In addition, it supplies fly ash that it generates to cement and asbestos plants.

The NTPC, Dadri, supplies dry ash, and not wet ash. Since the beginning of commercial production in August 1992 till the end of March 2001, around 22.0 per cent of fly ash generated by the unit has been utilized. Almost 16.0 per cent of this has gone for filling low-lying areas and embankments. The rest 6.0 per cent has gone for manufacturing bricks, blocks, cement, and asbestos. Around 78.0 per cent of the accumulated ash generated, thus, is dumped in Ash Mound (**Table 6.1**).

The observation that nearly the whole of the fly ash generated at IFFCO, Phulpur, is utilized compared to a mere 30.0 per cent of it at NTPC, Dadri, needs explanation. The Dadri plant produces more than eight times ash compared to that of IFFCO, Phulpur (**Tables 4.3 and 5.2**). Hence, the total volume of ash utilization at Dadri is about 2.5 times that at Phulpur.

Table 6.1
Major Indicators based on Utilization of Fly Ash: IFFCO, Phulpur, and NTPC, Dadri

Sl. No.	Indicators	NTPC, Dadri	IFFCO, Phulpur
1	Distance from ash generating plant to ash mound/pond/disposal area (in km.)	04	Just outside the plant boundary
2	Total fixed cost from boiler to ash mound/pond/ disposal area (in Rs. crore)	137.0	2.5
3	Ash handling (recurring) cost, per MT (in Rs.)	30.0	1.5
4	Average dumping quantity of fly ash (in MT) per day	3556	450
5	Ash handling (recurring) cost (in Rs.) per day	1,06,680	675
6	Ash content in coal (2000-01) (in %)	34.41	40.5
7	Coal consumption (in lakh MT), 2000-01	43.06	4.05
8	Generation of ash (in lakh MT), 2000-01	14.82	1.64
9	Ash utilization (in lakh MT), (quantity and percent), 2000-01	4.49 (30.32%)	2.83* (159.0%)*
10	Ash dumping (in MT), 2000-01	10,32,763 (69.68%)	Nil
11	Mode of transport for supply of fly ash to outside users	Truck, Tractor, Trolley etc.	Truck
12	Transportation cost for carrying of fly ash per km./MT (in Rs.)	3.65	1.6
13	Ash mound /pond /disposal area (in acres)	500	5
14	Land price (Rs. Per acre) - government rate - lease-in rate for brick plants	 N.A. 1,41,000	 N.A. 63,500
15	Accumulated ash at present time (up to march 2001) (in lakh MT)	84.0	15.0
16	Upper limit of ash dumped in ash mound/pond (in lakh MT)	154.0	23.0

Note: *N.A.= Not available*.
* *IFFCO, Phulpur, installed dry ash collection system in April 2000, and hence utilization exceeded generation*.

Source: *NTPC, Dadri and IFFCO, Phulpur*.

6.2 Conventional Clay Brick Plants (located within 50-km. radius from IFFCO, Phulpur, and NTPC, Dadri): Reasons for Non-Utilization of Fly Ash

- The Notification of the MOE&F, GOI, Sept., 1999, says that it will be mandatory for clay users in conventional brick plants located within a radius of 50-km. of any ash generating plant to mix fly ash with clay in a pre-specified proportion.
- The R&D laboratory of IFFCO, Phulpur, has developed a project for utilization of fly ash in brick manufacturing. These bricks are used both internally and externally.
- We did not find any record of the number of conventional clay brick plants within a radius of 50 km. from IFFCO, Phulpur, and NTPC, Dadri.

We selected a total of ten clay brick plants within the radius, as per GOI Notification, 1999, to capture the major problems and possibilities of utilization of fly ash.

6.2.1 Non-Utilization of Fly Ash in Conventional Clay Bricks: General Reasons

(Brick Plants located within 50-km. radius of IFFCO, Phulpur, and NTPC, Dadri)

Positive Reasons	Negative Reasons
Land for conventional clay brick plant is easily available (purchase or lease-in) in the districts, Allahabad and Ghaziabad. - The price of land is within reach (purchase or lease-in) of the brick plant owners in both the districts. - The brick plant owners lease-in land on easy terms and conditions (like extendable tenure of contract, no upper limit on digging of top soil fixed by Government etc.). - Landowners with large agricultural land like to lease-out land at low rent. - The technique of production of conventional clay bricks is known. - Skilled labour is easily available for conventional clay brick plants at a low wage. - It is difficult to assess the actual level of output in conventional clay brick plants. Thus, the plant owners can conceal the benefits that they derive via avoidance in terms of taxes etc. - There are no problems of marketing of conventional clay bricks. - The organizational and administrative formalities (registration etc.) to set up a conventional clay brick plant are easy. - Reliability of conventional clay bricks in the market is high. - The clay bricks ensure stable benefits for conventional brick plant owners	- Conventional clay brick plant owners do not know the technology of mixing fly ash in clay bricks. There is no compulsion imposed by the government on use of fly ash in clay bricks. - The transportation cost of fly ash from ash generating plant is high relative to cost for land leased-in. - The private consumers believe that the strength of fly ash mixed clay bricks is less relative to clay bricks. - The labourers already employed in conventional clay brick plants are not trained for manufacturing fly ash mixed clay bricks. - The conventional clay brick plant owners do not know the raw materials and infrastructure requirements for manufacturing fly ash-mixed clay bricks. - The conventional clay brick plant owners do not know the 'technology supplying agency' for manufacturing fly ash mixed bricks. - The conventional clay brick plant owners do not know the market demand for fly ash mixed clay bricks. - The consumers are not aware about fly ash mixed clay bricks. - The conventional clay brick plant owners do not know the method of receiving fly ash from the ash generating plants. - Subsidy is yet to be provided to those plants which want to mix fly ash in clay to produce bricks. - The government is not using fly ash-mixed bricks in public sector. Thus, reliability of fly ash bricks remains questionable to private final consumers.

6.3 Fly Ash-Sand-Lime-Gypsum Brick Plants Located within 50-km. Radius from IFFCO, Phulpur, and NTPC, Dadri: Observations Regarding Actual and Possible Use of Fly Ash

We did not find any fly ash-sand-lime-gypsum brick plants within the radius of 50-km. from IFFCO, Phulpur. In addition, we did not find any record of number of fly ash-sand-lime-gypsum brick plants within a radius of 50 km. from NTPC, Dadri. We could locate as high as seven functioning fly ash-sand-lime-gypsum brick plants located within 50-km. radius from NTPC, Dadri, that use fly ash generated by the latter. There is no supply constraint so far as availability of raw materials for manufacturing fly ash bricks in these plants are concerned. All the seven fly ash brick plants reported that they got technology for manufacturing fly ash-sand-lime-gypsum bricks from NTPC, Dadri. NTPC, Dadri is ready to provide total technological support to any potential entrepreneur willing to set up a fly ash brick plant. This technological support includes information on technique of production, input ratio (fly ash, sand, lime, and gypsum) and dissemination of information in this regard. However, no formal training has so far been organized by NTPC, Dadri, in this regard.

Since market price per unit of fly ash-sand-lime-gypsum brick is Rs. 1.29, as reported by the brick plant owners, hence the market feasibility is ensured for such bricks plants, even with positive transportation cost of fly ash **(Table 5.22, p. 67)**. Though there is surplus in manufacturing and marketing fly ash-sand-lime-gypsum bricks, there is at the same time positive price-differential between fly ash bricks and clay bricks. Manufacturing and marketing fly ash bricks, thus, require steps for relative cost reductions.

6.4 Cement Plants, which receive Fly Ash from IFFCO, Phulpur, and NTPC, Dadri: Utilization of Fly Ash

Cement Plants as Users of Fly Ash from IFFCO, Phulpur

The permissible percentage of fly ash that can be used in Portland Pozzolana Cement (PPC), as reported by the users of fly ash varies from a minimum at 25.0 to a maximum at 35.0. Based on the survey of a number of cement plants like J.P. Cement, Rewa, and Satna Cement, Satna, we observed that there is no dearth of demand for fly ash from the cement manufacturers. J.P. Cement is taking only 10.0 per cent of its total requirements of fly ash from IFFCO, Phulpur.

It is difficult to locate all the cement plants as buyers of fly ash generated in IFFCO, Phulpur, because of operation of intermediaries (truck operators). IFFCO, Phulpur, could not provide addresses of cement plants, which are users of fly ash that it generates and supplies.

Neither the IFFCO, Phulpur, nor the cement manufacturers incur any transportation cost for carrying fly ash from IFFCO to cement plants.

Cement Plants as Users of Fly Ash from NTPC, Dadri

The cement manufacturers are the main external users of fly ash supplied by NTPC, Dadri. We could locate the Diamond cement, Jhansi, UP, that takes 11.4 MT of fly ash per day from NTPC, Dadri. The distance between NTPC, Dadri, and Diamond Cement, Jhansi, is around 350 km. This is the reason why the Diamond Cement, Jhansi, takes most of its required fly ash from UP Electricity Board, Parichha, around 64.6 MT per day, which is located at a distance of 5 km. from the cement plant. The cement plant began using fly ash in cement production in 1986. The technical ratio in which fly ash is mixed is given as Fly Ash: Clinker: Gypsum as 38:55:07 for producing Portland Pozzolana Cement. During 1998-2001, the percentage use of fly ash increased steadily from 36.0 per cent to 38.0 per cent. Of the total fly ash required by Diamond Cement, 15.0 per cent comes from NTPC, Dadri, and remaining 85.0 per cent from UP Electricity Board, Parichha. The annual production of cement, however, has remained fixed, targeted and actual.

The transportation cost of fly ash, that is total fly ash cost, stands at Rs. 25 per MT for NTPC, Dadri while only Rs. five for UP Electricity Board **(Table 5.25, p. 71-72)**. NTPC, Dadri, thus, has lower chance of increasing supply of fly ash to Diamond Cement, unless the transport cost is borne by NTPC, Dadri.

6.5 Effect of Spread of Fly Ash in the Areas Adjoining IFFCO, Phulpur, and NTPC, Dadri

In the Areas Adjoining IFFCO, Phulpur

IFFCO, Phulpur, is reported to take care of areas within a radius of 3 km. from its own location (plant boundary). We surveyed seven villages and 65 households settled within 2000 meter from the Plant, following pilot survey. The exact number of the households settled within the radius of three km. from IFFCO, Phulpur is not known. We selected the households in the villages in a manner such that the categories of households by occupation and literacy are taken care of. We selected these households in a dispersed manner within each village. Half of the households surveyed are settled within a radius of 200 meter (from the dumping area, it being just outside the boundary of the plant). Almost all the households from all the villages reported to have been experiencing adverse effect of spread of fly ash disposed by IFFCO on agricultural land through leachate. The human health problems are reported to be related with quality of air and water.

The Directorate of Environment, UP, and the Pollution Control Board, Government of UP, could not provide any record of the quality of air and water in the areas inhabited by people adjoining IFFCO, Phulpur. We did not find any registered medical practitioner who could confirm the health-related problems conveyed by the people in the adjoining area.

In the Areas Adjoining NTPC, Dadri

We selected seven villages following pilot survey and sixty-five households in the areas adjoining NTPC, Dadri. The selection of households followed what we did in case of surveying areas adjoining IFFCO, Phulpur, in the district of Allahabad. The households reported adverse effect in terms of a number of indicators. This includes adverse effect on agricultural land. The households also complained about their health being adversely affected by air-borne spread of fly ash. We did not find any resident registered medical practitioners to give medical reports of the households affected by spread of fly ash. The Directorate of Environment, UP, and the Pollution Control Board, Government of UP, could not provide any record of the quality of air and water in the areas inhabited by people adjoining NTPC, Dadri.

6.6 Reduction of Ash Content in Coal Combustion: Possibilities in IFFCO, Phulpur, and NTPC, Dadri

In 1991-92, coal and lignite accounted for around 55.0 per cent of the total primary energy consumption in India. Of the total coal consumed in India, the electricity-generating sector consumes around 67.0 per cent. Coal reserves in India is around 1.0 per cent of global proven coal reserves (GOI, DST, TIFAC, 1995, Oct., p. 4-5, 7).

In India, 70.0 per cent of extraction of coal comes from open cast mines at present and the underground mines contribute the balance (GOI, DST, TIFAC, 1995, Oct., p. 9). Both the quality of coal and the method of combustion determine the effluents produced during combustion of coal. The heat value of the fuel is determined by

UHV = 8900 -- 138(A+M),

where,

UHV = Useful Heat Value,

A = Ash Content in percentage

M = Moisture Content in percentage.

Coal available from different sources is graded in terms of the UHV. Using this technique, available coal in India has been classified into seven grades, A to G. For superior grades (A, B, C), the (A+M) percentage is less than 30.0 while for inferior grades (E, F, G), the (A+M) percentage is more than 30.0. In between lies the intermediate grade, D. The inferior grade coal constitutes around 70.0 per cent of total usable coal available in India (GOI, DST, TIFAC, 1995, Oct., p. 59-60).

The elements that make up coal as a fuel, and the oxidant including other gases present with the oxidant, in which it is burnt, will ultimately be discharged into the environment. The nature of the effluents will be influenced by the combustion conditions. While emissions of carbon dioxide will be largely determined by the characteristics of the fuel, SO_2 emissions will depend on both the sulphur content of coal and on the combustion system employed (GOI, DST, TIFAC, 1995, Oct., p.11). The need for supplying cleaner coal to the coal using plants, particularly thermal power stations, assumes critical importance in terms of better utilization of power systems and significant reduction in environmental degradation. Use of clean coal also leads to higher useful heat value (UHV) because it generates lower ash content by percentage and total quantity per unit of generation of electricity.

NTPC, Dadri, reported using clean (washed) coal since 1998 for reduction in ash content. The source of coal has remained unchanged (As reported by Atrea, A.K., Sr. Manager, Ash Utilization Cell, NTPC, Dadri). The coal used by IFFCO, Phulpur, has an ash content of 40.0 per cent at the minimum and 48.0 per cent at the maximum. IFFCO, Phulpur, has no plan to change the source of

coal that it receives nor its R&D (laboratory) has any plan to go for clean (washed) coal to reduce ash content (As reported by Misra, D., Dy. Manager, IFFCO, Phulpur).

6.6.1 Clean Coal Technology: Meaning

Following the definition of United Nations, clean coal technology comprises all technological innovations, which reduce environmental impacts throughout the coal-fuel cycle. In general, clean coal technology include

i) technologies to control air pollution, like SO_x and NO_x, particulate matter, and toxic elements;

ii) systems for producing power and other coal based industries much more efficiently, cleanly and economically than conventional technologies;

iii) technologies that open up new markets in the transportation, industrial and domestic sectors (GOI, DST, TIFAC, 1995, Oct., p. 73).

Availability of clean coal at the consumer end would depend upon a number of factors in the chain of activities from coal mine planning, mining, stacking/reclaiming handling, preparation/beneficiation, transport, blending etc.. The physical and chemical characteristics of coal constitute the basic determinants of availability of clean coal (GOI, DST, TIFAC, 1995, Oct. p. 32).

In India, while there was no report of production of inferior grade coal in 1947, the production of inferior grade coal as percentage of total coal production was 9.0 per cent in 1972-73, 18.0 per cent in 1980-81, 29.0 per cent in 1984-85, 56.7 per cent in 1989-90. The problem is projected to increase to 79.0 per cent in 2004-2005 (GOI, DST, TIFAC, 1995, Oct. p. 33).

6.6.2 Coal Cleaning: Method

'Coal cleaning aims at reducing both the sulphur content and the mineral trace elements in the organic coal material and hence their emission to the atmosphere. At the same time the resulting coal has a higher heating value and there is a lower ash load on the boiler. The emissions of sulphur and trace elements, as well as the amount of ash and particulates, are linked to the composition of coal (Chadwick, Highton, and Lindman, 1987, p. 98). Sulphur may be removed during coal cleaning by physical and chemical means, or a combination of both. If coal has substantial organic sulphur content or if ash levels of less than 10 per cent are required, then physical methods must be replaced or supplemented by chemical ones. Coal may be treated with aqueous solvents (alkaline or acid solutions) or by encouraging limited hydrogenation. Both treatments aim at breaking the chemical bonds between the sulphur and the rest of the coal molecule. A chemical method (the Mayer Method) of removing iron pyrites utilizes a solution of iron sulphate to finally precipitate elemental sulphur. Iron pyrites, as one of the main forms of sulphur, is not a part of the coal molecule, it forms in cleats and remains relatively stable. The other forms of sulphur in coal are organic sulphur, sulphates and sulphides. Since physical methods of coal cleaning are not efficient in reducing the sulphur content, hence plants frequently adopt chemical methods to limit hazardous environmental effluents (Chadwick, Highton, and Lindman, 1987, p. 99).

6.6.3 Clean Coal for Power Sector: Problems

In India, of the total coal resource of around 196.8 BT, the Coking Coal constitute 29.3 BT, the balance 157.5 BT being Non-Coking Coal. In Non-Coking Coals, the inferior coal constitutes 70.0 per cent of the total. Regarding depth wise (by digging) occurrence of the coals, the coals broadly amenable to open cast mining 0-300 metre depth range constitute 69.0 per cent of the total Non-Coking coals (GOI, DST, TIFAC, 1995, Oct., p. 75-76). In Non-Coking coal, there are opportunities of washing coal to various ash levels, for example, for power sector the ash content could come down to 34.0 --35.0 per cent. Washed coal is required for the power sector (long distance units), in addition to some other sectors.

In India, the principal non-coking coal users in 1993-94 were, power (60.0 per cent), cement (4.0 per cent), and railways (0.7 per cent). In the 'others' category (that includes more than 20,000 users), it is 23.0 per cent (GOI, DST, TIFAC, 1995, Oct., p. 81). In the power sector, the old and the small units are designed to use superior grades of coal, while the large capacity units (210 MW, 500 MW) in operation and planning in future are designed to operate with high ash coal (for example, in NTPC, Dadri, the ash content is now 35.0 per cent). The constraint is meagre resources of coking coal and the need to restrict imports of coking coal to the extent possible.

Pulverized fuel combustion is a preferred technique because of its relative insensitivity to quality of coal, the short residence time of the fuel in the furnace, so the furnace regulation becomes relatively easy. It also becomes possible to perform high degree of uniform fuel combustion at a high temperature. The requirement for reducing the ash content in coal, thus, lies in grinding of coal to reasonable tolerance limits. The disadvantage of this technique lies in sulphur emissions. Sulphur emissions depend upon the sulphur content of the coal.

6.6.4 Super Clean Coal – Organo Refining: Possibilities

Coal can be beneficiated by such techniques as physical beneficiation, chemical leaching, solvent refining (SRC), organosolvo-refining and chemical and thermo-mechanical conversions. The physical techniques have limitations in ash. The chemical leaching techniques involve the use of corrosive and costly acids and alkalis, the recovery of which is difficult so that they may act as pollutants. The SRC process involves cost of hydrogen and the requirement of high-pressure reactors and equipments, erosion and corrosion of walls, valves and pipes. The chemical and thermo-mechanical coversion techniques such as carbonisation, hydro-carbonisation, gastification, hydro-gastification, hydrogenation and liquifaction etc. require high temperatures and pressures making the operations cost-intensive. It is in this context that organosolvo-refining for production of super clean coal at milder conditions of temperature (below 365ºC) and ambient pressure was conceived by IIT, Delhi. The super clean coal obtained through experiments has higher calorific value (8,000 Kcal/kg approx) and has higher volatile matter contents (40-45 per cent approximately). This is an almost zero ash coal (GOI, DST, TIFAC, 1995, Oct., p. 151-152).

6.6.5 Plant Expansion and Reduction of Relative Ash Content

As we observed, generation of fly ash increased at a rate higher than the rate of coal consumption at the national level. This is because of exhaustion of superior grade coal or gradual increase in use of inferior grade coal. Even if, thus, at the level of a particular plant the ash content is reduced by using clean coal, the possibility of reducing ash content will be limited at the national level for all the coal using plants. The assumption is that the economy is not going to import coal with lesser ash content.

Chapter 7 : Cost-Benefit Analysis on Retaining Fly Ash vis-a-vis its Alternative Uses

Based on the study of two selected plants, IFFCO, Phulpur, and NTPC, Dadri, respectively located in the districts, Allahabad and Ghaziabad, Uttar Pradesh, we calculate the costs and the benefits on retaining fly ash vis-a-vis its alternative uses.

7.1 Cost (Fixed and Recurring) for Disposal of Fly Ash by IFFCO, Phulpur, and NTPC, Dadri

The fixed cost for dry ash disposal (on setting pipelines etc.) **for IFFCO, Phulpur, was around Rs. 2.5 crores**. **The recurring cost of dry ash disposal** is virtually nil except that certain utilities like Instrument Air and Electric Power is provided to dry ash system. **If accounted**, the recurring cost **will not exceed Rs. 0.15 per tonne of ash**. The land area that still remains covered at present with ash collected and filled during the earlier period, when there was no ash disposal, is more than 5 acres outside the plant area (Technical Division, IFFCO, Phulpur).

The distance of the ash mound from the ash generating point at NTPC, Dadri, is four-km. **For carrying ash from the boiler to the ash mound, fixed cost incurred was Rs. 137 crore. The recurring cost (ash handling cost per MT) is Rs. 30**. Quantity of dumping of ash per day is 3556 MT for the Dadri Unit for which average handling/dumping cost per day comes to be a little more than Rs. one lakh (**Table 5.4, p. 50**).

7.2 Land Cost for Land Leased-in: The Case of Brick Plants Adjoining IFFCO, Phulpur, and NTPC, Dadri

Most of the brick plant owners within 50-km radius of IFFCO, Phulpur, and NTPC, Dadri, use lease-in land for digging purposes. Of the total land being used by the brick plants adjoining IFFCO, Phulpur, around 80.0 per cent are on lease. Of the total land being used by the brick plants adjoining NTPC, Dadri, around 60.0 per cent are on lease.

Average land price per acre at the market for brick plant owners who leased-in land within 50-km radius of IFFCO, Phulpur, is Rs. 89,000. There are inter-plant variations in cost borne on lease-in account for production of bricks. The land price per acre varies between Rs. 80,000 at the minimum and Rs. 2,50,000 at the maximum for the brick plants located within 50-km radius of NTPC, Dadri. The average land price, thus, comes to be Rs. 1,41,000.

The availability of abundant and low cost topsoil helps in using clay as and when required. Absence of initiatives and incentives from the Government helps in continuing production of clay bricks without mixing fly ash by any percentage. It seems, the conventional brick plant owners will be willing to use fly ash in manufacturing clay bricks if they get fiscal benefits from the government, know the technology, get fly ash free of cost at the gate of the brick plant. The government support also includes purchase of fly ash mixed clay bricks by the Government at a specified price.

7.3 Land Saving (Area, Volume, and Value) by Replacing Clay by Fly Ash

Soil cutting area (sq. metre) in any year for all the brick plants within 50-km. radius of IFFCO, Phulpur is 316.84 acres of which agricultural land constitutes 73.48 per cent. Assuming soil cutting destroys topsoil, the total value of land that is destroyed comes to be around Rs. three crore for the whole district covering all clay brick plants (on the basis of average land price existing at present). Given the quantum of soil cutting per year, we calculate the quantity of fly ash that can replace 30.0 per cent (maximum) clay. Thus, we calculate maximum agricultural land that can be saved by using fly ash (maximum 30.0 per cent) as replacement of clay (weight-to-weight basis). As we see, out of a total of 232 acre of agricultural land, as high as 25.0 per cent can be saved (**Table 4.12, p. 32**).

Soil cutting area (sq. metre) in any year for all the brick plants within 50-km. radius of NTPC, Dadri, is 1155.6 acres, of which agricultural land constitutes 100.0 per cent. If soil cutting implies destruction of top soil, then the total value of land that is destroyed comes to be more than Rs. sixteen crore for the whole district covering all clay brick plants (on the basis of average land price existing in 2001). Given the quantum of soil cutting per year, we calculate the quantity of fly ash that can replace 30.0 per cent (maximum) clay. Thus, we calculate maximum agricultural land that can be saved by using fly ash (maximum 30.0 per cent) as replacement of clay (weight-to-weight basis). As we see, out of a total of 1155.6 acre of agricultural land, as high as 25.0 per cent can be saved (**Table 5.15, p. 60**).

7.4 Cost-Benefit Analysis on Retaining Fly Ash vis-a-vis its Alternative Uses

The purpose is to estimate costs of retaining fly ash and alternative ways (uses) of disposing it in terms of opportunity costs. The opportunity cost of the current use of fly ash is its worth in some alternative use. We think of opportunity cost in terms of particular alternatives. In the context of alternative use, the question is whether the alternative use will affect a potential Pareto improvement as compared with the existing situation. It is the uses to which fly ash would be put in the absence of ash pond/ash mountain that become the relevant alternatives for the measurement of opportunity costs (Mishan, 1981, p. 65).

- Cost for Disposal of fly ash in Ash Pond/Ash Mountain = Private Cost + Social Cost.
- Private Cost = Fixed Cost + Recurring Cost of the Plant, for disposal of fly ash.
- Recurring cost has to cover transport cost for carrying fly ash to the users.
- Social Cost = Damage of adjoining crop area + Non-Use of topsoil covered by fly ash + Health Effect on man and animals.
- Benefits in use of Fly ash in bricks/cement = Private Benefits + Social Benefits.
- Private Benefits = Value Addition in fly ash bricks.
- Social Benefits = Saving topsoil (by the proportion of fly ash mixed with clay in bricks/cement) + Saving fertility of crop area.

- Cost in use of fly ash in bricks/cement = Transportation cost* + cost on bringing technology/training of manpower + other infrastructure cost like installing machines/chimney etc.

* If the brick/cement plant owner is to bear transportation cost of fly ash.

Cost-Benefit Information on Dumping and Possible Management of Fly Ash

Plant: NTPC, Dadri

Fixed Cost = Rs. 137. Crs.

Recurring Cost = Rs. 30 per MT

Ash Generation = 11.78 Lakh MT per year

Total Recurring Cost (for disposal of fly ash generated per year) = (Recurring Cost x Ash Generation) = Rs. (30 x 11.78 lakh MT) = Rs. 353.4 Lakh

Total Dumping Area (Ash Mound) = 500 Acres = 202.43 Hectare

Average Annual Production of Wheat in Ghaziabad District = 29.99 Quintal per Hectare

Production Loss per year due to Ash Mound Area = 202.43x29.99 = 6070.87 Quintal

Price of Wheat per Quintal* = Rs. 620.00

Production Loss = Rs. 620x6070.87 = Rs. 37,63,943.00

Average Annual Production of Rice per Hectare in Ghaziabad District = 20.72 Quintal

Production Loss due to Ash Mound = 20.72x202.43 = 4194.35 Quintal

***** Rate Fixed by Government of India.

Plant: IFFCO, Phulpur

Fixed Cost = Rs. 2.2 Crs.

Recurring Cost = Rs. 1.5 per MT

Ash Generation = 1.79 Lakh MT per year

Total Recurring Cost (for disposal of fly ash generated per year) = (Recurring Cost x Ash Generation = Rs. (1.5 x 1.79 lakh MT) = Rs. 2.86 Lakh

Total Dumping Area (Ash Pond) = 5 Acres = 2.02 Hectare

Average Annual Production of Wheat in Allahabad District = 17.78 Quintal per Hectare

Production Loss per year due to Ash Pond Area = 17.78x2.02 = 35.91 Quintal

Price of Wheat per Quintal* = Rs. 620.00

Production Loss = Rs. 620x35.91 = Rs. 22,264.20

Average Annual Production of Rice per Hectare in Allahabad District = 17.23 Quintal

Production Loss due to Ash Pond = 17.23x2.02 = 34.80 Quintal

***** Rate Fixed by Government of India.

Based on above information, we calculate the costs and benefits on account of dumping and possible reuse of fly ash generated by the selected ash generating plants. We offer this information in **Tables 7.1, 7.2, 7.3** and **7.4**.

Table 7.1 and **Table 7.2** show that the land value (at current market price of land) covered by NTPC, Dadri, for ash mound for dumping of fly ash comes to be Rs. 7.05 crores. This would have been zero had the plant took the measures to supply (dry) fly ash at the point of generation. The land area covered also stops its alternative use in cultivation, the value of which, if accounted, comes to be more than Rs. 67.0 Lakhs per year.

NTPC, Dadri, thus, can not only get rid of recurring cost of Rs. 353.4 lakhs per year for dumping of ash on ash mound, but also can add to its benefits, by sale or lease-out land covered for alternative uses.

Table 7.1
Private Cost of Disposal of Fly Ash in NTPC, Dadri

Particulars	Observations
Total dumping areas of the plant (in acre)	500
Average land cost (per acre in Rs.)	1,41,000.00
Investment (Rs. Crs.) on land on account of dumping of fly ash by the plant	7.05
Annual production loss due to ash mound (a) Wheat (in quintal) (b) Rice (in quintal)	 6,070.87 4,194.35
Fixed Cost (Rs. Crs.) from boiler to ash mound	137.00
Annual ash generation rate (in lakh MT)	11.79
Ash handling cost per MT (in Rs.)	30.00
Annual recurring cost (Rs. Crs.)	3.54

Note: *Calculated form cost-benefit information*.

Table 7.2
Social Benefits Calculated on the Basis of Dumping Areas Acquired by NPTC, Dadri

Particulars	Observations
Total dumping areas (ash mound) in NTPC, Dadri, (in Acre)	500
Dumping areas (in Hectare)	202.43
Average annual production of wheat in district Ghaziabad (in quintal/Hect.)#	29.99
Annual loss of production due to dumping area # (a) Wheat (in quintal) (b) Rice (in quintal)	 6071 4195
Price of Wheat (per quintal in Rs.)* (fixed by GOI)	620.00
Average minimum market price of Rice (per quintal in Rs.)**	700.00
Annual loss of production due to continuing ash dumping in the covered area (in Rs.) (a) Wheat (b) Rice	 37,64,020 29,36,500
Potential Net Annual Benefit to Society (in Rs.)	67,00,520

Note: # *State Statistical Handbook, 1992*.
* B*ased on information collected from the office of Mandi Samiti, Allahabad, 2001-02*.
** C*alculated on the basis of minimum market price in 2001-02*.

Table 7.3 shows the value (cost) of clinker that can be saved if fly ash is mixed with clinker and gypsum in a specified ratio (around 25.0 per cent of fly ash mixed). This also shows the net benefits that a cement plant producing PPC can have if it replaces clinker by using fly ash. This benefit to cement plant comes to be Rs. 248.12 crores per year.

Table 7.3
Cost-Benefit Analysis of Use of Fly Ash in Ordinary Portland Cement (OPC) and Portland Pozzolona Cement (PPC)

Particulars	Observations
Annual production of OPC (in MT)	820510
Raw materials required for OPC (in %) (a) Clinker (b) Gypsum	 96.0 4.0
Raw materials required for PPC (in %) (a) Clinker (b) Gypsum (c) Fly Ash	 70.50 4.40 25.10
Clinker cost including transportation cost (per MT in Rs.)*	12,000.00
Gypsum cost including transportation cost (per MT in Rs.) **	9,000.00
Difference of clinker in % (OPC – PPC)	25.5
Quantity of clinker that can be saved by use of fly ash (in MT)	2,09,230
Value of clinker that can be saved per year (Rs. Crs.)	251.08
Difference of Gypsum in % (OPC – PPC)	- 0.4
Additional quantity of Gypsum use of PPC (in MT)	3,282
Additional value of Gypsum use of PPC (Rs. Crs.)	2.95
Net benefit per year of a cement plant if it uses fly ash (Rs. Crs.)#	248.12

Note: *The calculation is based on information provided by JP Reewa Cement Plant, Reewa M.P*.

* *The information has been taken from Mr. J.P. Srivastava, Sales Officer, Chunar Cement Factory, Kajarhat, District Mirzapur, U.P*.

** *The information has been taken from Mr. Shakeel, Account Officer, Chunar Cement Factory, Kajarhat, District Mirzapur, U.P*.

\# *The transportation cost has not been deducted due to non-availability of information*.

Table 7.4 shows that on the basis of use of fly ash in PPC, given the specified ratio of around 25.0 per cent of fly ash used, we calculate the total PPC that can be produced if total fly ash generated by NTPC, Dadri, is used in PPC. Though cost on gypsum rises with respect to use of fly ash in PPC, clinker cost drastically gets reduced, so that net benefits for any cement plant producing PPC rises.

Table 7.4
Economic Benefits in Use of Fly Ash Generated in NTPC, Dadri, Per Year: The Case of Cement Plant

Particulars	Observations
Annual generation rate of fly ash in NTPC, Dadri (in MT)	11,78,857
Use of fly ash in PPC (in %)	25.10
PPC that can be produced after use of total generation of fly ash (in MT)	46,96,641
Required raw materials for production of 46,96,641 MT of OPC (a) Clinker (in MT) (b) Gypsum (in MT)	 45,08,775 1,87,866
Required raw materials for production of 46,96,641 MT PPC (a) Clinker (in MT) (b) Gypsum (in MT) (c) Fly Ash (in MT)	 33,11,132 2,06,652 11,78,857
Differential use of raw materials for PPC that is, (OPC – PPC) (a) Clinker (in MT) (b) Gypsum (in MT)	 11,97,643 -18,786
Value that can be saved after use of fly ash (Rs. Crs.) (a) Clinker (b) Gypsum	 1,437.17 -16.90
Net benefit of the cement plant after use of fly ash (Rs. Crs.)*	1420.26

Note: *The calculations are based on per year average generation rate of fly ash in NTPC, Dadri*.
** The transportation cost has not been deducted due to non-availability of information*.

7.4.1 Cost-Benefit Projections for Conventional Clay Bricks and Fly Ash Mixed Clay Bricks

We now concentrate on **cost-benefit projections** for conventional clay bricks and fly ash mixed clay bricks. We cover each of the districts, Allahabad and Ghaziabad, for encompassing IFFCO, Phulpur, and NTPC, Dadri. For both the districts, bricks are more or less similar by quality (size and weight). **For the district Allahabad, the total number of conventional clay brick plants at the time of survey was 356 while for the district Ghaziabad, it was 360. We selected ten such brick plants located within the 50-km. radius of each of the ash generating plants, IFFCO, Phulpur, and NTPC, Dadri. There is no record of the number of conventional clay brick plants within the specified radius. Thus, we relied on district level data to arrive at some projections.**

For the district Allahabad, however, average digging depth for clay bricks is much higher. Average land price for the district Ghaziabad is much higher relative to that of Allahabad. The average distance of the clay brick plants from the ash generating plant, however, is same for both the districts. This is because of selection of clay brick plants within the radius of 50 km. in accordance with the Notification of the GOI, 1999. The average transportation cost for carrying fly ash (per 16 MT) is much higher for Ghaziabad; both the average cost of production per 1000 bricks and average market price are higher relative to those of Allahabad (**Table 4.11 Part-A, p. 31, and Table 5.14, Part-A, p. 58**). There is variation in quantity of soil that is exhausted (used) between the districts for brick manufacturing because of variations in digging depth. The quantity of soil used (in cubic metre) is more in case of district Allahabad relative to Ghaziabad. Naturally, the number of clay bricks that can be manufactured per acre (sq. metre) of land is much higher for district Allahabad relative to Ghaziabad. **On the assumption of 25.0 per cent clay replaced by fly ash (on weight-to-weight basis), the quantity (volume) of fly ash that can be used, thus, is higher for Allahabad relative to Ghaziabad. For this ratio-specific utilization of fly ash (75:25), the transport cost of fly ash from the ash generating plant is lower for the district Allahabad (Table 7.5).**

The cost of production of fly ash mixed clay bricks per 1000 is marginally more when 25.0 per cent of clay is replaced by fly ash, for both the districts. Per 1000 bricks, the cost-difference is Rs.27 for Allahabad, and Rs. 42 for Ghaziabad. As percentage of cost of production of clay bricks in the respective districts, these are 3.33 and 4.47 (**Table 4.11 Part-B, p. 31, and Table 5.14, Part-B, p. 58**).

7.4.2 Net Benefits (Total Benefits – Total Cost) for Utilization of Fly Ash in Conventional Clay Brick Plants and Fly Ash-Sand-Lime-Gypsum Brick Plants

While production of conventional clay bricks increasingly exhausts agricultural land as we observed, the production of fly ash bricks saves agricultural land (by both area and volume). However, both cost of production per unit and market price per unit are higher in case of fly ash-sand-lime-gypsum bricks. While net surplus (Revenue – Cost) is positive for both types of brick plants, it is much higher for clay bricks per plant based on annual production level **(Table 5.23, p. 68)**. Since plant size is much higher (by capacity production) for clay bricks, hence clay brick plants record on average higher net benefits. Calculated over 1,000 pieces of bricks, fly ash-sand-lime-gypsum brick plant shows more net benefits. Thus, there are reasons to promote fly ash brick plants.

On the assumption of 25.0 per cent clay replaced by fly ash (on weight-to-weight basis), the quantity (volume) of fly ash that can be used is higher for district Allahabad relative to district Ghaziabad. For this ratio-specific utilization of fly ash (75:25), the transport cost of fly ash from ash generating plant is lower for the district Allahabad.

Table 7.5
Fly Ash Utilization in Brick Plants, Allahabad and Ghaziabad, UP

Sl. No.	Indicators	Allahabad	Ghaziabad*
1.	Average annual production of bricks per plant	29,70,000	70,10,000
2.	Total number of brick plants	356	360
3.	Average annual production of bricks in district	1,05,73,20,000	2,52,36,00,000
4.	Soil cutting area per plant per year (in acres)	0.89	3.21
5.	Soil cutting volume per plant per year (in MT)	8,316	18,226
6.	Soil cutting area per year, in district (in acres)	316.84	1,155.6
7.	Soil cutting in volume per year(in MT)	26,34,841	2,10,61,965.6
8.	Land price per acre (in Rs.)	89,000	1,41,000
9.	Value of destroyed land per year (in Rs.)	2,81,98,760	16,29,39,600
10.	Fly ash in volume that can be used per year (in MT), if 25.0 per cent of clay is replaced by fly ash	6,58,710.2	52,65,491.0
11.	Fly ash in volume that can be used per year (in MT), if 30.0 per cent of clay is replaced by fly ash	7,90,452.3	63,18,589.1
12.	Agricultural land (in acres) that can be saved by using fly ash on a 30.0 per cent basis	58.2	288.9
13.	Agricultural land (in acres) that can be saved by using fly ash on a 30.0 per cent basis	69.8	364.6
14.	Cost of land that can be saved by using fly ash on a 25.0 per cent basis (in Rs.)**	51,79,800	1,26,90,000
15.	Cost of land that can be saved by using fly ash on a 30.0 per cent basis (in Rs.)**	62,12,200	1,52,28,000

Note: * *Includes both the districts, Ghaziabad and Gautam Buddha Nagar*.

** *Cost on account of clay converted bricks can be saved more if fly ash is delivered to production site of the brick plant free of cost by ash generating plant.*

7.5 Tax on Volume of Fly Ash Stored

As explained, NTPC, Dadri, being the generator of fly ash, will have to shoulder its reuse and recycling. As we calculated, the transportation cost per truck, that caries on average 16 MT of fly ash per trip, comes to be Rs. 1,433.00 on average from NTPC, Dadri to the clay brick plants located with 50 km. radius of the Dadri plant. Either the NTPC, Dadri Unit shoulders this transportation cost of fly ash, or the government of India as the fiscal authority imposes tax on volume (in MT) of fly ash dumped so far, that is, accumulated/stored, and on fly ash that is generated per period (day/year etc.).

On the assumption that Rs. 1,433.00 per 16 MT is the total tax payable by the ash generator on the said volume of fly ash, that is, 16 MT, the tax rate per MT of fly ash comes to be Rs. 89.59. The assumption is based on the transportation cost of fly ash.

Average dumping/storage of fly ash per day by NTPC, Dadri is 3,556 MT, so that tax on volume of fly ash stored per day by NTPC, Dadri, comes to be Rs. 3,20,040.00, on the basis of Rs. 90.00 rate of tax per MT (tax rate taken in round figure). Imposition of the tax rate at Rs. 90 per MT on the ash generator, calculated at present rate of transport cost of fly ash etc., will compel the ash generator to transport it free of cost to ash users (bricks plants etc.) or pay taxes to the government.

Chapter 8 : Policy Recommendations

The purpose of this study is to prevent and minimize generation of waste, and maximize reuse and recycling. The study also aims to production of reusable goods from waste and saving scarce resources assisted by the participation of government authorities and other stakeholders. The study concentrates on fly ash as a waste generated in coal-using industrial plants. Saving topsoil by utilization of fly ash in possible value-added goods requires a number of measures. These measures include:

Recommendations for Ash Generating Plants

⇒ disposal and dumping of ash by the ash management/utilization cell of the ash generating plant should be maintained in a planned way,

⇒ identification and selection of the site for dumping fly ash should be made in advance so that human settlements are not displaced, nor is there any adverse effect on agricultural land,

⇒ there has to be transparency in disclosure of fly ash generated per plant per year and hence accountability of fly ash generator. It should also be the responsibility of ash generating plant to make public announcement regarding the quality of ash being generated, the receivers of fly ash who utilize the ash generated by the plant, the quantity of accumulated ash up to date,

⇒ transportation cost of fly ash from the ash generating unit to the ash utilization unit to be imposed on the generator of ash,

⇒ soil testing of the brick plants to examine its possible mixing with fly ash generated by the coal-based plants within 50-km radius, testing to be done free of cost for the brick plants by MOE&F, GOI,

Recommendations for Government

⇒ the government will have to announce through Notification or G.O. what the ash generating plants will have to do regarding dumping and disposal of fly ash, before these ash generating units are given licenses to setup these plants,

- ⇒ the location of such ash generating plants has to be at a safe distance from existing human settlement and plantation area,
- ⇒ the government, or the appropriate authority on its behalf, will have to circulate its Notification including amendment, if any, regarding utilization of fly ash among micro level public bodies and public administration,
- ⇒ a record of quality of soil, air, and water within a reasonable area adjoining ash generating plants should be maintained by the Pollution Control Board, GOI, and also by the State Pollution Control Board and Directorate of Environment,
- ⇒ imposing tax per unit (volume on weight basis) of fly ash stored by the ash generating plant,
- ⇒ reducing rate of tax per unit or total tax exemption on fly ash mixed clay bricks, so that it has an encouraging effect on production of fly ash mixed clay bricks,
- ⇒ tax reduction/tax exemption on fly ash users for productive purposes,
- ⇒ documenting quality of fly ash products and its dissemination by Government/ appropriate authority,
- ⇒ eco-labeling of fly ash bricks, e.g., fixing logo on the environmentally safe fly ash bricks,
- ⇒ a record of the number of conventional clay brick plants within the radius of 50-km from major fly ash generating plants, to be maintained by MOE&F, GOI,
- ⇒ the government has to be a buyer of clay-mixed fly ash bricks, and fly ash-sand-lime-gypsum bricks,
- ⇒ the price per unit of fly ash bricks, both clay-mixed fly ash bricks and fly ash-sand-lime-gypsum bricks, should be fixed by the government on the basis of input cost,
- ⇒ mine filling and land filling, keeping in mind transportation cost of fly ash from the point of generation to the site (land and mine),

Recommendations in General

- ⇒ supplying technology to the potential users of fly ash for manufacturing value-added goods,
- ⇒ providing cost-free training to the managers and manpower in general engaged in utilizing fly ash in value-added goods,
- ⇒ providing information on alternative products and technologies through public media for utilization of fly ash,
- ⇒ the results of soil testing be made known to the actual and potential users of fly ash,
- ⇒ the price of bricks fixed per unit has to be known to both the buyers and producers of fly ash mixed clay bricks.

Reducing ash-content in coal being utilized by the selected plants requires coal cleaning or using washed coal, as explained in **Chapter 6**. Using clean coal, however, involves cost of cleaning and search for non-inferior coal (grade A, B, C). In the context of exhausting superior grade coal in India, the major coal-users may have to depend on government intervention for ultimate import of coal with lower ash content on a selective basis.

The suggestions that we have offered center on brick plants. We found no problems for the cement plants so far as utilization of fly ash in clinker and gypsum for manufacturing cement is concerned. We concentrated our study on possibility of utilization of fly ash in manufacturing bricks and cement, as these are the major areas of utilization of fly ash in India, as we explained in **Chapter 3 (Box 3.2, p. 16)**. The alternative products where fly ash can be utilized for value-addition of products have been discussed in **Chapter 2 (Box 2.4, p. 10)**.

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Appendix 1

The Gazette of India: Extraordinary[Part II – Sec. 3(ii)]

MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

New Delhi, the 14th September, 1999

S.O. 763(E).- ....

1. **Use of fly ash, bottom ash or pond ash in the manufacture of bricks and other construction activities.-**

(1) No person shall within a radius of fifty kilometers from coal or lignite based thermal power plants, manufacture clay bricks or tiles or blocks for use in construction activities without mixing atleast 25 per cent of ash (fly ash, bottom ash or pond ash) with soil on weight to weight basis.

(2) The authority for ensuring the use of specified quantity of ash as per para (1) above shall be the concerned Regional Officer of the State Pollution Control Board or the Pollution Control Committee as the case may be. In case of non-compliance, the said authority, in addition to cancellation of consent order issued to establish the brick kiln, shall move the district administration for cancellation of mining lease. The cancellation of mining lease shall be decided after due hearing. To enable the said authority to verify the actual use of ash, the thermal power plant shall maintain month-wise records of ash made available to each brick kiln.

(3) In case of non-availability of ash from thermal power plant in sufficient quantities as certified by the said power plant, the stipulation under para (1) shall be suitably modified (waived/relaxed) by the concerned State/Union Territory Government.

(4) Each coal or lignite based thermal power plant shall constitute a dispute settlement committee which shall include the General Manager of the thermal power plant and a representative of all India Brick and Tile Manufacture's Federation (AIBTMF). Such a committee shall ensure unhindered loading and transport of ash without any undue loss of time. Any unresolved dispute shall be dealt with by a State/Union Territory level committee to be set up by State/Union Territory Government comprising Member Secretary of the State Pollution Control Board/Pollution Control Committee, representatives of Ministry of Power in the State/Union Territory Government and a representative of AIBTMF.

2. <u>Utilization of ash by Thermal Power Plants.-</u>

All coal or lignite based thermal power plants shall utilize the ash generated in the power plants as follows:-

(1) Every coal or lignite based thermal power plant shall make available ash, for at least ten years from the date of publication of this notification, without any payment or any other consideration, for the purpose of manufacturing ash-based products such as cement, concrete blocks, bricks, panels or any other material or for construction of roads, embankments, dams, dykes or for any other construction activity.

(2) Every coal or lignite based thermal power plant commissioned subject to environmental clearance conditions stipulating the submission of an action plan for full utilization of fly ash shall, within a period of nine years from the publication of this notification, phase out the dumping and disposal of fly ash on land in accordance with the plan. Such an action plan shall provide for thirty per cent of the fly ash utilization, within three years from the publication of this notification with further increase in utilization by atleast ten per cent points every year progressively for the next six years to enable utilization of the entire fly ash generated in the power plant atleast by the end of ninth year. Progress in this regard shall be received after five years.

(3) Every coal or lignite based thermal power plant not covered by para (2) above shall, within a period of fifteen years from the data of publication of this notification, phase out the utilization of fly ash in accordance with an action plan to be drawn up by the power plants. Such action plan shall provide for twenty per cent of fly ash utilization within three years from the date of publication of this notification, with further increase in utilization every year progressively for the next twelve years to enable utilization of the entire fly ash generated in the power plants.

(4) All action plans prepared by coal or lignite based thermal power plants in accordance with sub-para (2) and (3) of para 2 of this notification, shall be submitted to the Central Pollution Control Board, concerned State Pollution Control Board/Committee and concerned regional office of the Ministry of Environment and Forests within a period of six months from the date of publication of this notification.

(5) The Central and State Government Agencies, the State Electricity Boards, the National Thermal Power Corporation and the management of the thermal power plants shall facilitate in making available land, electricity and water for manufacturing activities and provide access to the ash lifting area for promoting and setting up of

ash-based production units in the proximity of the area where as is generated by the power plant.

(6) Annual implementation report providing information about he compliance of provisions in this notification shall be submitted by the 30th day of April every year to the Central Pollution Control Board, concerned State Pollution Control Board/Committee and the concerned Regional Office of the Ministry of Environment and Forests by the coal or lignite based thermal power plants.

3. <u>Specification for use of ash-based products.-</u>

(1) Manufacture of ash-based products such as cement, concrete blocks, bricks, panels or any other material or the use of ash in construction activity such as in road laying embankments or use as landfill to reclaim low lying areas including back filling in abandoned mines or pitheads or for any other use shall be carried out in accordance with specifications and guidelines laid down by the Bureau of Indian Standards, Indian Bureau of Mines, Indian Road Congress, Central Building Research Institute, Rookee, Central Road Research Institute, New Delhi, Building Materials and Technology Promotion Council, New Delhi, Central Public Works Department, State Public Works Departments and other Central and State Government agencies.

(2) The Central Public Works Department, Public Works Departments in the State/Union Territory Governments, Development Authorities, Housing Boards, National Highway Authority of India and other construction agencies including those in the private sector shall also prescribe the use of ash and ash-based products in their respective applications, including appropriate standards and codes of practice, within a period of four months from the publication of this notification.

(3) All local authorities shall specify in their respective building by-laws and regulations the use of ash and ash-based products and construction techniques in building materials, roads, embankments or for any other use within a period of four months from the date of publication of this notification.

[F.No. 16-2/95-HSMD]
V. RAJAGOPALAN, Jt. Secy.

Appendix 2

Table: Crop Pattern in Selected Villages, Adjoining Area of IFFCO, Phulpur

Year	Fasali Year	Wheat (Crop area in Hectare)	Paddy (Crop area in Hectare)	Potato (Crop area in Hectare)
Village: Bhulai Ka Pura				
1986	1394	58.591	54.385	0.795
1987	1395	57.591	54.385	0.795
1988	1396	51.266	42.334	3.733
1989	1397	41.159	42.334	4.192
1990	1398	43.895	29.692	2.858
1991	1399	48.215	23.526	3.829
1992	1400	55.572	48.561	3.583
1993	1401	59.246	46.80	2.651
1994	1402	60.342	48.280	1.881
1995	1403	60.342	48.280	1.881
Village: Dailapur				
1989	1397	39.003	24.000	7.295
1990	1398	37.092	22.358	1.781
1992	1400	36.551	20.442	1.363
1993	1401	35.896	18.021	4.310
1994	1402	34.956	19.392	2.319
Village: Kanehati				
1995	1403	174.534	190.093	1.580
1996	1404	174.027	208.880	11.820
1997	1405	171.449	207.110	12.715
1998	1406	176.412	189.210	3.238
1999	1407	230.456	230.676	Not available
Village: Pali				
1988	1396	98.215	75.296	4.564
1989	1397	95.334		6.716
1990	1398	94.144	90.673	7.817
1991	1399	86.340	83.613	7.205
1992	1400	88.224	78.150	6.055
1993	1401	99.018	77.225	4.754
1994	1402	100.225	80.122	4.785
1995	1403	100.225	80.122	4.785
Village: Fazilapur				
1988	1396	20.139	18.255	0.440
1989	1397	19.078	18.585	0.588
1990	1398	19.072	18.585	0.186
1991	1399	19.556	20.972	0.832
1992	1400	19.803	21.584	0.687
1993	1401	21.245	20.203	0.652
1994	1402	20.411	20.585	0.685
1995	1403	20.411	20585	0.685
Village: Chandouki				
1988	1396	130.420	129.450	Not available
1989	1397	110.890	134.374	1.180
1990	1398	112.268	135.917	1.159
1991	1399	Not available	141.629	Not available
1992	1400	113.268	134.616	1.583
1994	1402	129.859	129.835	Not available
1995	1403	109.872	126.628	3.930
1996	1404	109.872	126.628	3.930
1997	1405	116.398	126.628	4.330
1998	1406	138.460	142.362	3.453
1999	1407	134.753	136.279	0.551
Village: Saraiya				
1988	1396	90.217	82.680	2.710
1989	1397	91.234	83.593	2.547
1990	1398	95.117	101.945	0.497
1991	1399	94.201	100.913	0.375
1992	1400	85.695	80.519	0.327
1993	1401	85.795	80.519	0.320
1994	1402	85.795	80.576	0.326
1995	1403	95.795	80.516	0.326
1996	1404	87.042	81.799	3.015
1997	1405	85.907	79.702	2.810
1998	1406	85.907	79.702	2.810

Source: *Tehsil, Phulpur, Allahabad*.