Ascertaining the Quality of Fly Ash Discharged by M/s Maithon Power Ltd., Dhanbad and its Effect on Environment, Air and Water and its Effects on Agriculture

Sponsor

Jharkhand State Pollution Control Board, Ranchi

[Towards compliance of order dated 13.03.2014 of
Hon’ble High Court of Jharkhand at Ranchi in WP (PIL) No. 2663 of 2011]

CSIR- National Environmental Engineering Research Institute (NEERI),
Nehru Marg, Nagpur 440 020 (Maharashtra)

November 2014

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FOREWORD

Maithon Power Limited (MPL) is a joint venture company between the Tata Power Company Limited (TPC), Mumbai and Damodar Valley Corporation (DVC), Kolkata. MPL has set up a 1050 MW (2 X 525 MW) Maithon Right Bank Thermal Power Project (MRBTPP) at the right bank of river Barakar in Dhanbad District of Jharkhand State.

Unit 1 & Unit 2 (525 MW each) of the coal based power plant started its operation on Sept 1, 2011 and July 24, 2012, respectively. The plant generates large amount of fly ash, which is being disposed-off mainly in abandoned mines and ash pond. It is apprehended that the disposal of large amount of fly ash might adversely affect the surrounding environment of the disposal sites.

In view of the above, Jharkhand State Pollution Control Board (JSPCB), Ranchi in compliance to the order (dated March 13, 2014) of Hon'ble High Court of Jharkhand at Ranchi in WP (PIL) No. 2663 of 2011; requested M/s National Environmental Engineering Research Institute (NEERI), Nagpur for ascertaining the quality of the ash discharged by M/s Maithon Power Limited (MPL), Dhanbad and for assessing its effect on environment, air, water and its effects on agriculture.

The field study undertaken during Summer 2014 for assessment of air quality, water quality, soil quality/agriculture and fly ash characterization formed the basis for ascertaining the impact of ash disposal on the surrounding areas of ash pond and abandoned mines. The report presents the findings of the study as per the scope of work identified.

The co-operation and assistance rendered by the staff of JSPCB in preparation of this report are gratefully acknowledged.

Nagpur
November 2014

(S.R. Wate)
Director

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Chapter 1

Introduction

1.1 Preamble

Regarding compliance of order dated 13.03.2014 of Hon'ble High Court of Jharkhand at Ranchi in WP (PIL) No. 2663 of 2011;Member Secretary, Jharkhand State Pollution Control Board (JSPCB), Ranchi requested M/s National Environmental Engineering Research Institute (NEERI), Nagpur for ascertaining the quality of the ash discharged by M/s Maithon Power Limited (MPL), Dhanbad and for assessing its effect on environment, air, water and its effects on agriculture vide letter No. PC/75/2011/D-911 dated 27.03.2014.

The operative part of order dated 13.03.2014 of Hon'ble High Court of Jharkhand at Ranchi reads as follows:

8. Having regard to the report filed by the Jharkhand State Pollution Control Board (Annexure B) and the various other Annexures and averments made in the supplementary counter-affidavit, we direct the Jharkhand State Pollution Control Board to engage M/s National Environmental Engineering Research Institute (NEERI), Nagpur for ascertaining the quality of flyash discharged by M/s Maithon Power Limited, Dhanbad and for assessing its effect on environment, air, water and its effects on agriculture.

9. We direct M/s NEERI, Nagpur to render its cooperation with Jharkhand State Pollution Control Board for compliance with the order of this Court dated 06.01.2014 and order dated 13.03.2014 (this order). We also direct the Ministry of Environment and Forests, Government of India to submit its response on the report of the Jharkhand State Pollution Control Board and also specific submission made by the learned counsel appearing on behalf of the petitioner.

In response to above mentioned JSPCB letter,NEERI had submitted scope of work to JSPCB vide letter No. EIRA/Gen-56/2014 dated 11.04.2014 for acceptance. JSPCB accepted the scope of work.

1.2 Scope of Work

- Identification and quantification of flyash (such as bottom ash, silo ash) generation pattern from M/s Maithon Power Plant
- Physico-chemical characterization of flyash samples
- Assessment of current ash disposal practices
- Assessment of anticipated impacts due to flyash disposal practices on the environment in terms of air quality, water quality, soil quality within the impact zone of 1-2 km from the ash disposal site
- Assessment of present status of air quality, water quality and soil quality in the impact zone of 1-2 km from the ash disposal site (through collection of limited primary data)
- Assessment of impact of ash disposal on agriculture
- Delineation of environmental quality management plan due to disposal of flyash activities

Additional Scope of Work (vide JSPCB letter dated 22-07-2014)

NEERI received JSPCB letter no. D-2245 dated 22-07-2014 that mentions about the copy of order dated 10.07.2014 of Hon'ble High Court of Jharkhand at Ranchi passed in WP (PIL) No. 2663 of 2011. The operative part related to NEERI, Nagpur reads as follows :

"4. Having regard to the said letter dated 09.07.2014 of NEERI, the matter be listed in the 2nd week of November, 2014. The Jharkhand State Pollution Control Board is directed to furnish a copy of the report of NEERI to the learned counsel appearing on behalf of the petitioner as well as to the learned counsel appearing for the Union of India –Mr. M. Khan, in advance before the date of hearing.

5. At this stage, on behalf of the petitioner, it is submitted that the abandoned mines are being filled up by fly ash of Maithon Power Ltd. and other industries. It was further submitted that if the abandoned mines are filled up by the fly ash, it will greatly affect the underground water and the water will not be a potable water and ultimately the same will affect the health of the people of Dhanbad. NEERI shall examine this aspect also viz. (i) Filling up a abandoned mines by fly ash; (ii) If so, effect of such filling up of abandoned mines with fly ash.

In reference to the above mentioned letter, NEERI informed JSPCB via. Email dated 27-07-2014 that primarily the issue being addressed is related to effect of flyash disposal from the Maithon Power Ltd., the additional questions indicated in JSPCB letter dated 22-7-2014 are also being considered in the same context. Accordingly, details of disposal/filling of flyash in abandoned mines by Maithon Power Ltd. were sought from JSPCB, as detailed below:

1. A copy of hydro-geological study, if any, has been carried out in the region, may also be provided.
2. How many abandoned mines are existing in Dhanbad region.
3. How many abandoned mines are being filled up by fly ash.
4. How many industries are discharging fly ash in those abandoned mines.
5. Details about the abandoned mines w.r.t. Latitude, Longitude, Area, Geo-technical details, etc.
6. Based on the above inputs, further requirements for the study will be assessed.

After sending reminder email on Aug 7, 2014 and letter dated Aug 12, 2014, JSPCB furnished the following details of disposal/filling of flyash in abandoned mines by Maithon Power Ltd. vide memo no. JSPCB/14/75/2011/D-2838 dated 12-09-2014:

M/s Eastern Coalfield Ltd. (ECL) has allotted abandoned mines to MPL in Mugma area:

(i) Mandaman Colliery Mines (Longitude: 86°44’49.77”E, Latitude: 23°45’36.30”N)
(ii) Lakhimata Colliery Mines (Longitude: 86°44’36.83”E, Latitude: 23°45’42.22”N)

The aspect of abandoned mines ash disposal by MPL has also been addressed in the study report by NEERI.Other studies related to abandoned mines were also carried out by CSIR-Central Institute of Mining and Fuel Research (CIMFR), Dhanbad and National Institute of Hydrology (NIH), Roorkee.Findings of these studies are also included in this report as Chapter 6.

1.3 Visit of NEERI Team to M/s MPL and Abandoned Mines

After agreeing to the scope of work in April 2014, an eleven member NEERI team visited Maithon Power Limited-Dhanbad, its surrounding areas and abandoned mines from 06.05.2014 to 15.05.2014 for site surveys, discussions with officials of JSPCB & MPL, collection of relevant documents and conducting field surveys for air quality monitoring and collection of water, soil and ash samples.After having discussions with JSPCB & MPL officials, site visit and setting the protocols for field sample collection, five team members returned on 08.05.2014.Photographs showing visit of NEERI Team (along with officials of JSPCB and MPL) to MPL site (including ash pond area) and abandoned mines are depicted in **Exhibit 1.1** and **Exhibit1.2**, respectively.

Location of differentfacilities of MPL and abandoned mines are shown in google map, as **Fig. 1.1**. It can be seen that Maithon Reservoir is at a distance of approx. 300 m from the ash pond, whereas distances of abandoned mines from MPL and Maithon reservoir are approx. 7 km and 5 km respectively.Co-ordinates of these locations are given in **Table 1.1**.

Table 1.1

Co-ordinates of Different Facilities of MPL and Abandoned Mines

Area	**Longitute**	**Latitude**
MPL Facilities		
CHP (Track Hopper)	23° 48’ 57.70” N	86° 44’ 48.89” E
Intermittent Silo	23°49’ 14.16” N	86° 45’ 41.11” E
Hydrobin	23° 49’ 14.69” N	86° 45’ 42.04” E
ESP Area	23° 49’ 14.58” N	86° 45’ 36.69” E
Ash Pond	23° 50’ 03.24” N	86° 44’ 30.65” E
Abandoned Mines		
Mandaman Colliery Mine	23^{o} 45’ 36.30” N	86° 44’ 49.77” E
Lakhimata Colliery Mine	23^{o} 45’ 42.22” N	86° 44’ 36.83” E

1.4 Maithon Power Plant

1.4.1 Brief about MPL

Maithon Power Limited (MPL) is a joint venture company between the Tata Power Company Limited (TPC), Mumbai and Damodar Valley Corporation (DVC), Kolkata. MPL has set up a 1050 MW (2 X 525 MW) Maithon Right Bank Thermal

Power Project (MRBTPP) at the right bank of river Barakar in Dhanbad District of Jharkhand State (India).Basic information about the Maithon Power Plant is given in **Table 1.2**.

Table 1.2

Basic Information about M/s Maithon Power Plant

Sr. No.	Description	Details
1	Owner	Maithon Power Limited
2	Power Title	2 x 525 MW Maithon Right Bank TPP
3	Location	On the right bank of the river Barakar in the Nirsa cum Chirkunda C.D. block of Dhanbad district, Jharkhand at a road distance of about 7.5 Km north of G.T road and 10 Km north of Mugma railway station on the Howrah-Mughalsarai grand Chord line of the Eastern Railway
4	Elevation Above Sea Level	156 m to 177 m above mean Sea level
5	Nearest Railway Station	Mugma railway station about 10 km
6	Name of Railway	Eastern Railway division of Indian Railways
7	Nearest Airport	Kolkata (280 Km from Maithon)
8	Port Facility	Kolkata Port (280 Km from site)
9	Present Power Genration capacity	2 x 525 MW
10	Date of Installation & Operation	Unit 1 - 1st September 2011 Unit 2 - 24th July 2012

Future Plan

MPL is in the process of obtaining Environment Clearance from MoEF for setting up Phase 2 of the project, withpower generation capacity of 2x 660 MW.

1.4.2 Coal Consumption, Ash Generation and Ash Disposal/ Utilization

The power generation at MPL started in September 2011 and July 2012 from Unit 1 and Unit 2 respectively. The total annual requirement/consumption of coal, ash generation and disposal/utilization of ash during 2011-12 to 2014-15 (up to Aug 2014) is given below in **Tables 1.3 & 1.4.**

Table 1.3

Annual Coal Consumption, Ash Generation and Ash Disposal / Utilization during 2011-12 to 2013-14

Particulars	FY' 11-12	FY' 12-13	FY' 13-14	Total
Coal Consumption (MT)	778224	2883911	3993972	7656107
Ash Generation (MT)	353320	1245497	1771535	3370352
Ash Generation (%)	**45.40**	**43.19**	**44.36**	**44.02**
Ash Disposal / Utilization (MT)	1274	368391	1988563	2358228
Ash Disposal /Utilization (%)	**0.36**	**29.58**	**112.25**	**69.97**

MT – Metric Ton; % - Percent

Table 1.4

Monthly Coal Consumption, Ash Generation and Ash Disposal / Utilization during 2014-15 (up to August 2014)

Month	Coal Consumption (MT)	Ash Generation		Ash Disposal / Utilization	
		(MT)	(%)	(MT)	(%)
April'14	360637	150494	41.73	175086	116.34
May'14	352458	157972	44.82	144898	91.72
June'14	361778	152851	42.25	211715	138.51
July'14	407692	160957	39.48	137372	85.35
Aug'14	357604	148155	41.43	166787	112.58
Total	**1840169**	**770429**	**41.87**	**835858**	**108.49**

Average ash generation during 2011-2014 is estimated to be about 44% of the total coal consumption, whereas overall ash disposal/utilization was about 70%. During 2014-15 (up to August 2014), ash generation was 41.87%, whereas ash disposal/ utilization was 108.49%. This means that earlier stored ash in the premises is also sent out along with the current ash geneated.

1.4.3 Ash Disposal/Utilization : Mode and Quantity

Ash is being disposed off in abandned mines, ash pond and also utilized in cement/brick plant. Total quantity of ash disposed off/utilized upto August 2014 is 4140781 MT. Out of this, as much as 76.61% is disposed in abandoned mines, 22.86% in ash pond and only 0.53% ash has been utilized so far in cement/brick plant. Break up of ash disposal/ utilization is given in **Table 1.5.**

Table 1.5

Ash Disposal/Utilization upto August 2014

Ash Disposal / Utilization Mode	Ash Quantity Disposed/ Utilized (up to Aug'14)	
	(MT)	(%)
Abandoned Mines	3172280	76.61
Ash Pond	946694	22.86
Cement/ Brick Plant	21807	0.53
Total	**4140781**	**100.00**

1.4.4 Transport of Ash to Abandoned Mines

Ash is being handled through silo, hydrobin and ash pond for disposal to abandoned mines.

1.4.4.1 Fly Ash Transportation from Main Silos to Abandoned Mines

Fly Ash from ESP field/ APH hoppers is air conveyed through fully closed pipe conveying system to intermediate silos and then to main silos. Water conditioning arrangement is attached to each silo before loading onto Hyvas. The ash in moist condition is then transported in covered Hyvas to abandoned mines, allocated by Eastern Coalfield Ltd. (ECL) for disposal. In open cast abandoned mines, ash is dumped and stowed with layer of soil. To control fugitive dust emissions in abandoned mines, water sprinkling tankers have been deployed.

1.4.4.2 Bottom Ash Transportation from Hydrobin to Abandoned Mines

Bottom ash collected from boiler bottom ash hopper is discharged to Hydrobin, from where, ash is loaded in open Hyvas. After water conditioning,it is being transported to abandoned mines in covered Hyvas.

1.4.4.3 Ash Transportation from Ash Pond to Abandoned Mines

For any emergency in plant operation, both fly ash and bottom ash are discharged to ash pond as slurry, from where, ash loaded in hyvas is being transported to abandoned mines in covered Hyvas.

Ash loading, transport and disposal through Hyvas in abandoned minesalong with water sprinking system are depicted in **Exhibits 1.3** and **1.4**.

All the aspects, as indicated in the scope of work have been studied, and are presented in the following Chapters:

Chapter 2 :Fly ash Characterization and Leaching Study

Chapter 3 : Effect on Ambient Air Quality

Chapter 4 : Effect on Water Quality

Chapter 5 : Effect on Soil Quality and Agriculture

Chapter 6 : Effect of Fly ash filling in Abandoned Mines

Chapter 7 : Conclusions and Recommendations.

Table 5.3

Textural Class of Soil Samples

Sr. No.	Sampling Location	Particle Size Distribution (%)			Textural Class
		Sand	Clay	Silt	
1.	Ratanpur Village	81	4	15	Loamy sand
2.	Barbindia Village	62	13	25	Sandy loam
3.	Tulsibhita Village	82	5	13	Loamy sand
4.	Kashitand Village	28	42	30	Clay
5.	Jaspur village	79	6	15	Loamy sand
6.	Near DVC Water Tank (GH)	29	41	30	Clay
7.	Vrindavanpur Village	80	5	15	Loamy sand
8.	Marama Aamdanga Village	92	2	6	Sand
9.	Gopalpura Village	79	7	14	Loamy sand

Table 5.4

Physical Characteristics of Soil Samples

Sr. No.	Sampling Location	Bulk Density (g/cm^3)	Porosity (%)	Water Holding Capacity (%)
1.	Ratanpur Village	1.1	32	29
2.	Barbindia Village	1.3	29	22
3.	Tulsibhita Village	1.0	37	38
4.	Kashitand Village	1.3	31	23
5.	Jaspur village	1.0	44	42
6.	Near DVC Water Tank (GH)	1.1	40	35
7.	Vrindavanpur Village	1.0	33	31
8.	Marama Aamdanga Village	1.1	29	23
9.	Gopalpura Village	1.3	38	34

Table 5.5

Chemical Characteristics of Soil Extract

Sr. No.	Sampling Location	pH (1:2)	EC (dS/m)	Calcium	Magnesium	Sodium	Potassium
				meq/l			
1	Ratanpur Village	6.4	0.56	0.20	0.20	0.54	0.27
2	Barbindia Village	6.7	0.67	0.18	2.08	0.23	0.16
3	Tulsibhita Village	6.3	0.85	0.24	1.20	0.41	0.11
4	Kashitand Village	6.1	0.77	0.14	2.80	0.43	0.10
5	Jaspur village	6.7	0.58	0.62	0.88	3.6	0.21
6	Near DVC Water Tank (GH)	6.5	0.51	0.40	0.12	0.44	0.22
7	Vrindavanpur Village	7.2	0.58	4.00	0.42	1.49	2.33
8	Marama Aamdanga Village	6.7	0.57	0.62	1.84	1.63	0.45
9	Gopalpura Village	6.8	0.54	0.58	0.72	2.11	0.20

Table 5.6

Cation Exchange Capacity of Soil Samples

Sr. No.	Sampling Location	Ca++	Mg++	Na+	K+	CEC	ESP (%)
		cmole (p^+) kg^{-1}					
1	Ratanpur Village	0.8	0.2	0.66	0.99	8	8
2	Barbindia Village	0.4	0.2	0.82	0.55	10	8
3	Tulsibhita Village	6.0	0.2	0.81	1.10	10	8
4	Kashitand Village	0.4	0.4	0.44	1.01	9	5
5	Jaspur village	8.0	0.4	2.46	1.25	11	23
6	Near DVC Water Tank (GH)	3.0	0.6	0.45	0.95	14	3
7	Vrindavanpur Village	7.4	2.6	1.56	12.54	12	13
8	Marama Aamdanga Village	1.0	0.4	0.96	0.88	5	20
9	Gopalpura Village	2.0	2.4	1.59	0.55	11	15

Table 5.7

Relationship of CEC with Productivity of Soil

CEC Classification	CEC Range (cmol (p+) Kg^{-1})	Productivity	Location Sr. Nos.
Very low	<10	Very low	1,2,3,4,6
Low	10-20	Low	5,7,8,9
Moderate	20-50	Moderate	
High	>50	High	

Table 5.8

Relationship of CEC with Adsorptivity of Soil

CEC Classification	CEC Range (cmol (p+) Kg-1)	Adsorptivity	Location Sr. Nos.
Limited or Low	<10	Limited or Low	1,2,3,4,6
Moderate	10-20	Moderate	5,7,8,9
High	20-30	High	
Very High	>30	Very High	

Table 5.9

Fertility Status of Soil Samples

Sr. No.	Sampling Locations	Organic Carbon (%)	N	P_2O_5	K_2O
			kg/ha		
1.	Ratanpur Village	0.41	241	33	37
2.	Barbindia Village	0.98	182	32	14
3.	Tulsibhita Village	0.41	286	28	29
4.	Kashitand Village	0.42	203	46	24
5.	Jaspur village	0.25	289	20	24
6.	Near DVC Water Tank (GH)	0.55	228	16	36
7.	Vrindavanpur Village	0.98	208	12	25
8.	Marama Aamdanga Village	0.42	223	20	35
9.	Gopalpura Village	0.41	120	13	16
Guideline Values					
Level in poor quality soil		<0.5	<280	<23	<133
Level in medium quality soil		0.5-0.75	280-560	23-57	133-337
Level in fertile soil		>0.75	>560	>57	>337

Table 5.10

Heavy Metal Content in Soil Samples

Sr. No.	Villages Name	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn	Hg
		mg/kg										
1	Ratanpur Village	11	0.7	16	7.4	5.8	14489	212	12.2	5	37	0.02
2	Barbindia Village	0.5	0.6	10	2.9	3.1	12724	69	5.3	3	11	0.04
3	Tulsibhita Village	16	1.1	41	20.2	18.9	15109	517	32.5	7	38	0.02
4	Kashitand Village	5	0.9	8	2.2	1.8	12474	100	2.3	2	13	0.02
5	Jaspur village	21	1.1	58	20.7	20.1	15329	550	32.3	9	48	0.03
6	Near DVC Water Tank (GH)	15	0.2	42	5.4	8.8	13529	324	11.4	5	170	0.07
7	Vrindavanpur Village	25	1.4	42	14.1	23.6	14129	358	29.1	17	109	0.07
8	Marama Aamdanga Village	23	0.6	25	8.7	10.4	13759	114	12.7	12	40	0.03
9	Gopalpura Village	21	1.4	30	8.1	4.6	13969	442	12.7	6	18	0.02
Canadian Soil Quality Guidelines (ppm or mg/kg)		**12**	**10**	**64**	**-**	**63**	**-**	**-**	**50**	**70**	**200**	**6.6**

Table 5.11

Microbiological Characteristic of Soil Samples

Sr. No.	Sampling Location	TVC ($\times 10^6$)	Fungi	Actinomy-cetes	Rhizo-bium	Azotobac-ter
			CFU/g of Soil ($\times 10^4$)			
1	Ratanpur Village	49.5	45.0	27.0	13.5	27.0
2	Barbindia Village	54.0	22.5	3.5	22.5	9.0
3	Tulsibhita Village	54.0	31.5	22.5	9.0	22.5
4	Kashitand Village	31.5	27.0	31.5	9.5	31.5
5	Jaspur village	58.5	40.5	27.0	13.5	22.5
6	Near DVC Water Tank (GH)	63.0	36.0	18.0	9.0	18.0
7	Vrindavanpur Village	63.0	40.5	22.5	18.0	18.0
8	Marama Aamdanga Village	85.5	31.5	13.5	9.0	9.0
9	Gopalpura Village	54.0	27.0	36.0	22.5	18.0

TVC – Total Viable Count; CFU – Colony Forming Unit

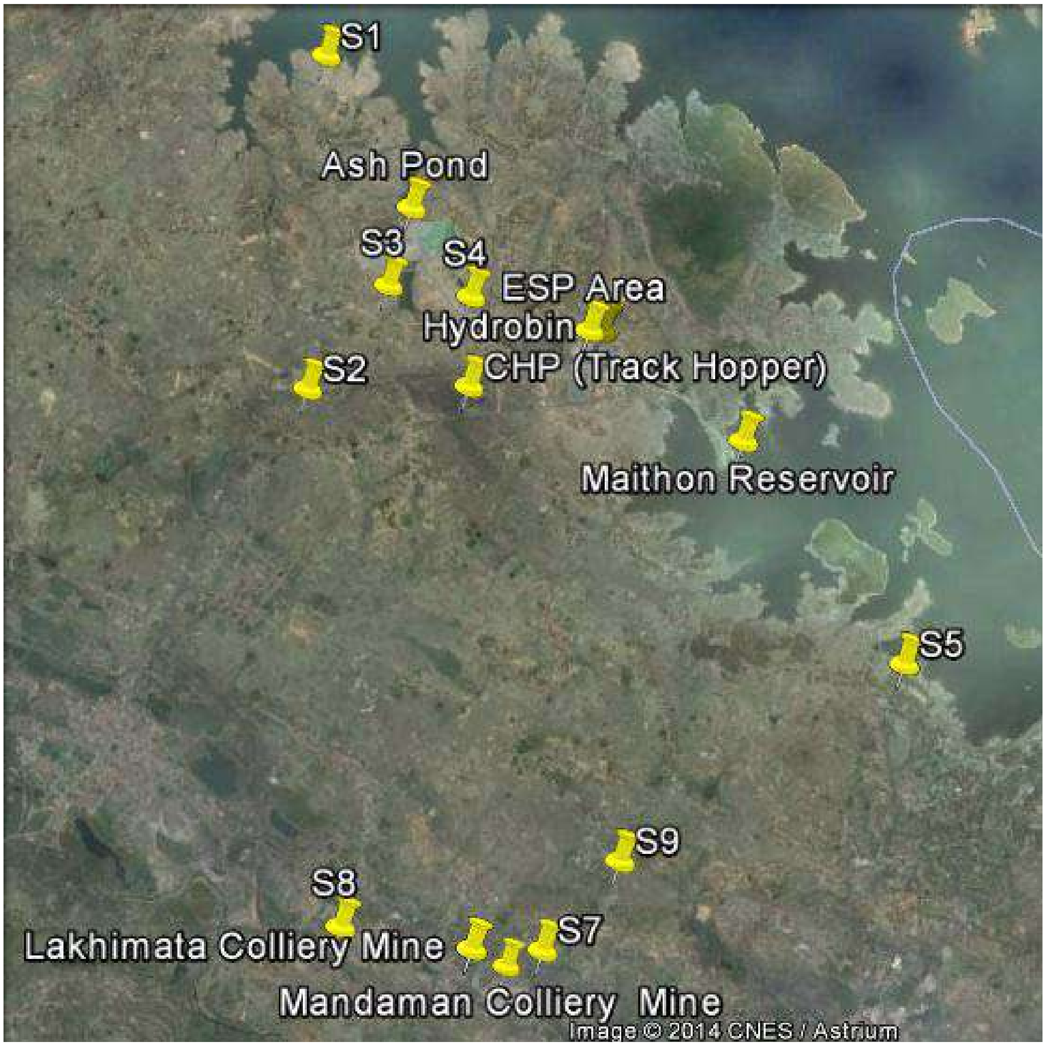

Fig. 5.1: Soil Sampling Locations in the Study Area

Exhibit 5.1: Photographs Showing Soil Sampling from Different Locations

Chapter 6

Effect of Fly Ash Filling in Abandoned Mines

Chapter 6

Effect of Fly Ash Filling in Abandoned Mines

6.1 Preamble

In order to assess the effect of flyash filling in abandoned mines on ground water quality, besides the present study, the following relevant studies conducted by Central Institute of Mining and Fuel Research (CIMFR), Dhanbad and National Institute of Hydrology (NIH), Roorkee are referred.

1. Study on Environmental Impact of Filling of Fly Ash by Maithon Right Bank Thermal Power Plant, CIMFR, January 2011
2. Advice on the Suitability of Underground working below Ash Filled Open Cast Mines at Mugma Area, ECL, CIMFR, January 2012
3. Hydrogeological Studies for Ash Pond of 2 x 525 MW Maithon Power Limited and an Abandoned Coal Mine, District Dhanbad, Jharkhand, NIH, Roorkee, July 2014

Findings of these studies are given in following section.

6.2 Findings of MPL Related Studies

6.2.1 Report entitled "Study on Environmental Impact of Filling of Fly Ash by Maithon Right Bank Thermal Power Plant"

The abovementioned report was prepared by CIMFR, Dhanbad in January 2011 and conclusions of the study are:

- The present study incorporates the characterization of coal flyash and leaching behaviour of flyash by flask and column method. It also includes water level monitoring of void area, its topographical features and physical condition for seeing the environmental impact of filling of flyash on ground water regime.
- The study reveals coal characterization, which shows that ash content in the three different Coal samples taken from Dahibadi colliery of

Eastern Coalfields Limited vary from 35.16% to 41.98%. Fixed Carbon was found between 44.63% and 53.13%, whereas calorific values for these samples varied from 3945.7 cal/g to 4804.4 cal/g. The average ash content in coal was found to be 38.32%.

- X-ray fluorescence analysis of Coal Samples show that the concentration of heavy metals like Zn, Co, Cr, Cu, Pb are found to be 50.0 ppm, 15.9 ppm, 144.9 ppm, 61.9 ppm, 58.0 ppm, respectively. Among the oxides of metals, SiO_2 is found to be 21.40% followed by Al_2O_3 and Fe_2O_3 as 3.64% and 1.70% respectively.

- The specific gravity of the bottom ash and pond ash is found to be 1.90 and 0.61 which are lighter than river sand (average sp. Gr. 2.61). All the above characteristics favour hydraulic transportation during filling. Bulk density of the ash sample is found to be 1.05 g/cc and 0.41 g/cc for bottom ash and fly ash respectively, which is also less than that of sand. Therefore, there will be substantial saving in energy during the flyash transportation upto the filling point.

- Heavy metals concentration in both bottom ash and pond ash samples are found more or less similar with few exception in pond ash like Ba and Cr, which are observed to be at high concentration i.e. 890.5 and 122.0 ppm. Other metals like Co, Ni, Pb and Zn are found in higher concentration in bottom ash.

- Oxides of metals in the bottom ash are found in higher percentage as compared to pond ash. High percentage of SiO_2 is found in bottom ash (33.57%) than pond ash (31.09%).

- Batch and column leaching experiment's results show that the concentration of Na, Ca and Mg decreases from 1 hr to 5 hr of leaching and again increases after 5 hr of shaking. There is no regular trend in leaching. Therefore, it needs a longer time for predicting leaching behaviour. Cations like NH_4^+ and K^+ start decreasing after 1 hr of shaking and increases after 3 hrs of shaking. Anions study shows that F^-, Cl^-, NO_3^-, PO_4^- and SO_4^- start leaching if the contact period increases after 5 hrs for bottom ash and after 7 hrs for pond ash. Concentration of fluoride in bottom ash are found to be varying between 4.81 to 14.45 ppm, and in pond ash it varies from 0.63 to 2.21 ppm, which is more than the prescribed limit of 1.5 ppm as per IS: 10,500. It may be due to addition of sodium fluoride in electrostatic precipitator of Bakreshwar Thermal Power Plant to capture more Flyash/Bottom ash in the form of bottom ash. The sample of flyash/bottom ash was collected from Bakreshwar Thermal Power Plant (W.B.). Therefore Maithon Power Limited should avoid using sodium fluoride as an adhesive agent in the electrostatic precipitator.

- Other parameters like Cl^-, PO_4^{---}, SO_4^{--}, NO_3^-, hardness and alkalinity are found below the prescribed permissible limit.
- The leaching of heavy metals increases from 1 hr contact period and continued to leach till seven hours and starts decreasing after seventh hour of contact period. An exception was observed for Arsenic which shows increased concentration even at twelve hour of contact period.
- For pond ash results show an increase in concentration after one hour of contact period for heavy metals like Fe, Co, Ni, Cd, Pb and Al with few exception like Cu and As. Decrease in metal concentration in the leachate are observed after 5 hours of contact period but it increases even after 12 hours of contact period. Iron is the most dominant metal among the heavy metals in bottom ash.
- Mine voids area specially in the case of Mandaman East/West, Lakhimata and Chapapur is of high percolation rate as on water is retaining at the bottom. Rajpura II area is full of water which shows that filling of flyash may be done without any pre-treatment. As all the fillings are surrounded area by many underground and opencast mines, it suffers from water scarcity. Water of each well gets dry in pre-monsoon season.
- Level of fluoride should be lower than the prescribed TLV of 1.5 mg/l otherwise the entire area may face the cases of fluorosis if leachate percolates to ground water system. Alternate technology may be adopted to capture flyash in electrostatic precipitator. Use of fluoride compound must be avoided.

– The concentration of the different parameters considered during the study i.e. pH, odour, conductivity, total hardness, dissolved solids, sulphate, chlorides, iron, copper, manganese, cadmium, arsenic, lead, zinc, chromium, aluminium and boron in the flyash/bottom ash leachates Maithon Power Limited (MPL) are within the acceptable limits. So, flyash can be used as mine filling material for the abandoned mines after using appropriate lining.

6.2.2 Report entitled "Advice on the Suitability of Underground working below Ash Filled Open Cast Mines at Mugma Area, ECL”

The abovementioned report was also prepared by CIMFR, Dhanbad in January 2012 and from the results of laboratory and field investigations, the following inferences were drawn.

- The coal ash and overburden are not going to pose any adverse environmental effect to the underground working which could be concluded from the leaching study
- As the percolation rate is above 10 cm/hr, it is expected that water will not accumulate at the filled mass and it will percolate out. This reduces the chances of liquefaction of the filled mass
- The numerical modelling study indicates the galleries are stable and having a safety factor more than 1 while extracting coal seams below the ash filled opencast mines
- Stooks of 2.5 m width and about 10 m length are proposed during deprillaring, those to be judiciously robbed while retreating
- It is necessary to monitor different rock mechanics parameter influencing the working by underground mining. It is recommended to use convergence indicators, TellTales and Load cells for monitoring the strata behaviour during development and depillaring
- The monitoring must be carried out regularly and proper care must be taken immediately in case the convergence value approaches the critical value and sudden excess load on support. It is recommended that the rock mechanic instrumentation and monitoring to be carried out under the guidance of a scientific agency

- The proposed support design guidelines provided must be followed, the bolts to grouted upto the mouth of the hole and tightened against the roof using bearing plates and nuts

6.2.3 Report entitled "Hydrogeological Studies for Ash Pond of 2 x 525 MW Maithon Power Limited and an Abandoned Coal Mine, District Dhanbad, Jharkhand"

The abovementioned report was prepared by National Institute of Hydrology (NIH), Roorkee in July 2014 and the summary of the work with conclusions from the investigations carried out are given below:

- Maithon Power Limited (MPL) is a joint venture company between the Tata Power Company Limited (TPC), Mumbai and Damodar Valley Corporation (DVC), Kolkata. MPL has set up a 1050 MW (2 x 525) Maithon Right Bank Thermal Power Project (MRBTPP) at the right bank of river Barakar in Dhanbad District of Jharkhand State in the eastern region of India
- Barakar River (with Maithon Reservoir) is flowing to the north and north eastern side of the ash pond area and Damodar river is flowing south of the abandoned mine area. In the areas under investigation only small 1^{st} to 3^{rd} order streams are present. Small tanks have also been constructed by the local people to fulfil the needs of the villages
- The climate of the study area is humid and tropical. It is characterised by a hot and dry summer from March to May, a monsoon or rainy season from June to September and a cool pleasant winter from October to February
- The average annual rainfall is 1368.0 mm and there are on the average, 97 rainy days in a year
- To study the hydrogeology of the area, a multi-disciplinary approach has been adopted integrating geological, isotopic and water quality approach
- The interaction of the ash pond water with groundwater has been determined by analysing the stable isotope of oxygen and hydrogen in the waters of the area. Investigations indicate that the groundwater surrounding the ash pond area is not contaminated from the ash pond

- Total 26 representative ground water samples from different drinking water sources located in the habitations, alongwith the location, situated in the buffer zone of abandoned mining areas and ash pond area have been collected during the June, 2014. The ground water samples were collected from the drinking water sources, which are extensive being used. One surface water sample from stilling pond and one from Maithon Reservoir were also collected
- Total 12 ground water samples from hand-pumps (IM-II) and open wells have been collected from 9 villages in the surrounding area of abandoned mine. The chemical constituents are within the permissible limits prescribed by BIS (2012) for various uses of water including drinking and other domestic supplies
- Total 14 ground water samples from hand-pumps (IM II) have been collected from 10 villages in the surrounding area of the ash pond. The chemical constituents are within the permissible limits prescribed by BIS (2012) for various uses of water including drinking and other domestic supplies
- Ash pond water has been found to have no interaction with local groundwater
- All the physico-chemical parameters of sample collected from Maithon Reservoir water are within the acceptable limit of drinking water
- Based on the hydrogeology investigations carried out around the abandoned mines area, no adverse impact on ground water quality has been observed
- The abandoned mine is located in the sediments of lower Gondwana sequence consisting of Talchirs and Barakars
- The ash pond is located on the basement rocks consisting of granitic gneisses and metasidements of Archean age. The rocks are compact and have no primary porosity
- Hydro geologically, the area is located in consolidated (Archean granitic-gneisses and meta sediments) and semi-consolidated formations (Gondwana formations)

- The maximum depth of dug well in granite gneiss and Gondwana is 17m and 25m respectively. The shallow aquifer in granite gneiss is less productive. Many dug wells and hand pumps get dried up during summer
- Ground water occurs under water table conditions in upper horizons of Barakar sandstone and granitic gneisses and is transmitted through bedding and joints of sandstone, interstitial opening of weathered material and joints and fractures of gneisses
- The depth to water table in abandoned mine area (Gondwanas) during pre-monsoon period ranging from 1.07 m to 12.55 m bgl, while it is 1.18 m to 9.88 m bgl in the ash pond area (granitic gneisses and meta-sediments)
- Groundwater flow direction in both the areas has been determined from the water level maps. Groundwater flow direction is towards Maithon Reservoir in the ash pond area and towards Damodar river in the abandoned mine area
- Most of the streams in the ash pond area were observed to be dry, indicating low hydraulic conductivity in the gneisses.
- The ground water movement mainly takes place through bedding planes and interstitial openings of sandstone, and joints and fractures of gneisses and meta sediments.
- The well yield of the wells in the abandoned mine area as well as in granitic-gneisses area of ash pond is very low and is generally <10 m^3/day
- Ground water development in the area is 52% indicating safe status with no declining trend of water levels either in pre or post monsoon period

Based on the hydrogeology study carried out around the abandoned mines area, it is observed that due to disposal of ash there is as such no impact on ground water quality. It is therefore recommended that the abandoned mines are suitable for backfilling by Ash.

Chapter 7

Conclusions and Recommendations

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7.1 Conclusions

7.1.1 Introduction

Maithon Power Limited (MPL) is a joint venture company between the Tata Power Company Limited (TPC), Mumbai and Damodar Valley Corporation (DVC), Kolkata. MPL has set up a 1050 MW (2 X 525 MW) Maithon Right Bank Thermal Power Project (MRBTPP) at the right bank of river Barakar in Dhanbad District of Jharkhand State (India).

Unit 1 & Unit 2 (525 MW each) started operation on Sept 1, 2011 and July 24, 2012, respectively. Total coal consumption (upto August 2014) was about 9.50 million tons, whereas total ash generation was about 4.14 million tons, which is about 43.6% of the total coal consumption. Out of the total ash generated, about 3.17 million tons (76.61%) has been disposed-off in abandoned mines, and about 0.95 million tons (22.86%) is disposed-off in Ash Pond. So far, only 21807 tons (0.53%) fly ash has been utilized for cement/brick manufacturing.

Disposal of large amount of flyash in abandoned mines and ash pond may adversely affect the surrounding environment. Therefore, the present study was undertaken to assess the effect of flyash disposal on environmemt, air, water and soil/agriculture. The salient findings/conclusions of the study are given in the following sections.

7.1.2 Fly Ash Characterization and Leaching Study

- The quality of various fly ash and mine overburden samples were thoroughly characterized with respect to various physical, chemical, structural and morphological properties and leaching patterns to assess their hazardous characteristics and potential to leach toxic metals. The results of elemental composition of various fly ash samples confirm that these fly ash samples are of F-grade class fly ash (as per ASTM C618).

- Particle size analysis was carried out to assess the possibility of re-suspension of fly ash in air during handling and transportation. The higher specific gravity and particle size indicate that the chances of re-suspension during handling and transportation of fly ash particles are relatively less

- All the flyash samples collected from different locations were having similar chemical composition. All the samples contain trace quantities of various toxic elements including As, Cr, Se, Pb, Hg, Ni etc.
- The powder XRD analysis confirmed the presence of silica (Quartz) and alumina (Mullite) along with some iron oxides and lime
- The morphology of fly ash particles determined using Scanning Electron Microscopy (SEM) revealed that the particles consisted of solid spheres
- The standard TCLP tests conducted to assess the potential of fly ash for leaching of toxic metals, revealed that many toxic metals leached from the fly ash and mine overburden samples, however the concentrations of various metals in all the samples were much below the regulatory limits of U.S. EPA.

7.1.3 Effect on Ambient Air Quality

- In order to assess the impact of fly ash disposal on ambient air quality of the area in and around the MPL Ash Pond and abandoned mines, air quality was monitored at six locations, continuously for 3 days at each location. The major air pollutants monitored were PM_{10}, $PM_{2.5}$, SO_2 and NO_2. Sampling was done on 24 hourly basis. Further, heavy metal and BaP content in PM_{10} samples were determined.
- 24 hrly average PM_{10} concentrations were found to exceed the permissible limit of 100 µg/m^3 on all the occasions (total 18 nos. sampling observations) except on 3 days. $PM_{2.5}$ concentration exceeded only on 4 occasions out of 18 sampling observations. High levels of particulate matter (mainly PM_{10}) are attributed to re-suspension of road dust and vehicle exhaust emissions from the movement of vehicles and other commercial/household activities occurring in the vicinity of each monitoring site.

- Concentrations of SO_2 and NO_2 were found well below the permissible limit of 80 µg/m^3 at all the locations.

- Lead content in particulate matter was found to be significantly high (upto 10 times) against the permissible limit of 1 µg/m^3. High level of Pb content in particulate matter may be due to air borne particles of soil, as evident from the analysis of soil samples, which also contain Pb.

- Analysis of ambient air quality study presents the general background status of ambient air quality in the region, caused by various anthropogenic activities. It presents cumulative effect of various activities/processes occurring in the region on any given day, and it is difficult to correlate with any specific activity of the region, including fly ash disposal from Maithon Power Ltd.

7.1.4 Effect on Water Quality

- From physico-chemical analysis of surface water and ground water samples; it may be concluded that most of the parameters are within permissible limits of stipulated standards, IS:2296-1982 with respect to Class C for surface water, and drinking water standards (IS:10500-2012) for groundwater.

- The ground water samples around the MPL fly ash pond showed high concentration of some of the heavy metals, which could be attributed to possible ash pond supernatant finding way into groundwater in addition to the geogenic conditions. Ground water samples around the abandoned mine site area also showed higher heavy metals concentration, which may be attributed to possible leaching from the abandoned coal mine site dumped with mine overburden, the activity prevalent in the area earlier in addition to the geogenic conditions.

7.1.5 Effect on Soil Quality and Agriculture

- Analysis of various physical, chemical, nutrients and microbiological parameters of soil samples collected from agricultural field of the nearby villages to the MPL Ash Pond and abandoned mines indicate that the soils are in general normal and representative of the region, and do not reflect any adverse impact of fly ash disposal on the quality of soil, and hence on the agriculture practices. However, for better agricultural productivity, the soils need to be supplemented with cations (mainly Ca^{+2} & Mg^{+2}), organic manure and nutrients/fertilizers (N,P,K).

7.1.6 Effect of Fly Ash Filling in Abandoned Mines

In order to assess the effect of flyash filling in abandoned mines on ground water quality, besides the present study, the following relevant studies conducted by Central Institute of Mining and Fuel Research (CIMFR), Dhanbad and National Institute of Hydrology (NIH), Roorkee are referred.

1. Study on Environmental Impact of Filling of Fly Ash by Maithon Right Bank Thermal Power Plant, CIMFR, January 2011
2. Advice on the Suitability of Underground working below Ash Filled Open Cast Mines at Mugma Area, ECL, CIMFR, January 2012
3. Hydrogeological Studies for Ash Pond of 2 x 525 MW Maithon Power Limited and an Abandoned Coal Mine, District Dhanbad, Jharkhand, NIH, Roorkee, July 2014

The following conclusions can be drawn from the above studies:

- **CIMFR Study (2011):** The concentration of the different parameters considered during the study i.e. pH, odour, conductivity, total hardness, dissolved solids, sulphate, chlorides, iron, copper, manganese, cadmium, arsenic, lead, zinc, chromium, aluminium and boron in the flyash/bottom ash leachates Maithon Power Limited (MPL) are within the acceptable limits. So, flyash can be used as mine filling material for the abandoned mines after using appropriate lining.
- **CIMFR Study (2012):** The coal ash and overburden are not going to pose any adverse environmental effect to the underground working which could be concluded from the leaching study.
- **NIH Study (2014):** Based on the hydrogeology study carried out around the abandoned mines area, it is observed that due to disposal of ash there is as such no impact on ground water quality. It is, therefore, recommended that the abandoned mines are suitable for backfilling by Ash.

7.2 Recommendations

7.2.1 Fly Ash Related

As per the reported literature and various regulatory norms, fly ash is not considered as hazardous waste. However, considering the findings of the numerous previous studies and also the results of present study, particularly the potential of fly ash for leaching of toxic metals, it is recommended that:

- Detailed geochemical and hydrogeological studies may be undertaken in order to ascertain the long-term impacts of disposal of fly ash in abandoned mine pits. The study may address determination of quality and location of groundwater, groundwater flow paths, the potential for coal ash to leach toxic elements and to react with minerals or groundwater, etc.
- It is also recommended that long term monitoring plans including frequent sampling and analysis must be undertaken to check the movement of fly ash particles and leaching of metals and other toxic elements in and around fly ash disposal area.
- Appropriate measures must be implemented at disposal site to minimise the contact of fly ash and mine over burden with water to prevent entry of leachates in surface and ground water.

7.2.2 Air Quality Related

- A comprehensive study involving emission inventory, air quality modeling, source apportionment leading to delineation of air environment management plan for different sources of air pollution in the region (such as industries, mines, vehicular and other miscellaneous activities) may be undertaken in due course of time to contain air pollution, particularly particulate matter within the permissible limits.

7.2.3 Water Quality Related

- Detailed studies viz. seasonal variation in the surface and groundwater quality and hydro-geological conditions around the MPL power plant; sources of wastewater generation, performance evaluation of effluent treatment facilities and characterization of water and wastewater used for ash slurry preparation at MPL

Power Plant are warranted to assess the impact on water environment due to the existing anthropogenic activities in the region.

7.2.4 Soil Quality / Agriculture Related

- It is suggested that the farmers of the region should take regular advice from local agriculture help centre, get analysis done for soil quality, assess the need for nutrients and other requirements, and then accordingly apply various fertilizers, to achieve better productivity from the agriculture fields.

7.2.5 Recommendations for M/s MPL

- The conditions laid down during environmental clearance of the power plant must be followed strictly, and implementation of such compliances should be reviewed annually by a third party.
- The recommendations/suggestions given in various related reports of CIMFR and NIH should be adopted, where ever possible.
- Utilization of fly ash should be ensured as per MoEF & CC guidelines.
- M/s MPL should build a strong environmental management group with proper laboratory facilities to take care of environmental issues related to the plant, and should target for continual improvement.

M/s MPL should prepare environmental sustainability report of the power plant every year. The report should incorporate the performance of the plant with respect to the power generation vis-à-vis consumption of various resources (such as coal, water etc.) and discharges with best environmental practices adopted by the industry, and should aim at achieving the sustainability in the context of surrounding region.