CHAPTER 11

ENVIRONMENTAL ASPECTS OF BAUXITE MINING AND ALUMINIUM PLANTS

11.1 INTRODUCTION

In India, Bauxite is mined by opencast method. Dust is generated as a result of drilling, blasting, loading, tra--nsportation operations, crushing and grinding of the ore. Freshly extracted bauxite ore is known to be chemically active and is easily attacked by atmospheric oxygen, heat, moisture and micro-organism. Rain water draining through ore piles turns acidic and dissolves metals which may eventually affect both ground water and surface water bodies.

Environmental pollution is also caused by Fluoride emi-ssion from aluminium smelters, emission of coal dust from steam generators, alumina dust from calcining plant, sulphur dioxide emission from refinery and red mud generated during alumina refining. Careful monitoring of the quality of air and ground water as well as surface water resources are therefore necessary in and around mining areas.[1]

11.2 POLLUTION CONTROL MEASURES ADOPTED BY THE PRODUCERS OF BAUXITE AND ALUMINIUM

11.2.1 HINDALCO

HINDALCO has installed full fledged treatment plant to bring down toxic contents in the effluents to the standards laid down by Pollution Control Board before discharge. Red Mud is dumped in the form of dry cakes within the premises. Measures are in progress to make use of red mud for the manufacture of bricks and also as a raw material in the cement industry. A co-mputerised firing system has been installed to control the oil quantity which checks the emissions. Efficient electrostatic precipitators have been provided on the Gas Suspension Calciner and on the process steam boilers to control alumina dust and fly ash.[1]

11.2.2 NALCO

Panchpatmali Bauxite Mine

In Panchpatmali Mine following measures have been taken in the Environmental Management Plan[2].

(i) In trench method of mining, as recommended by M/s. Aluminium Pechiney (A P), France, trenches for mining operations are worked so as to keep the floor level in transverse direction with a self-draining slope in the longitudinal direction.

(ii) Peripheral garland drains and catch drains have been developed beyond the mining area to avoid surface run off water entering into the mined out area and diverting to natural streams.

(iii) Peripheral barrier of more than 15 m width and 1.5 km length is left all around the area covered under the mining activities, where plantation has been started after treating with top soil.

The ground barrier ensures safety of men and machinery. This also prevents run off of muddy water from the mines. With the afforestation programmes taken up, this zone will act as a barrier for dust and noise from the mines to surrounding areas.

(iv) After the total excavation of bauxite, backfilling will be done suitably for rehabilitation of mined out areas and restoration of natural landscape. Reshaping of mined areas to blend with surrounding landscape will be done. Total area covered by quarrys and dumps are 60 hect. and 70 hect. respectively. By 31st March'91, 2 hect. area has been reclaimed.

(v) Adequate dust suppression measures adopted in dust-prone areas such as drilling, loading points, haul roads and crushing area etc.

It has been estimated by the company that present rate of expenditure towards environmental management and monitoring is about Rs. 6 per tonnes of bauxite produced, which includes interest and depreciation component of equipment and structure

apportioned to environmental applications. The direct expenditure however is about Rs. 2.50 per tonne of bauxite.

(vi) Extensive plantation covering mostly fruit trees, timberwood trees and fire woods has been taken up in the 225 hects. area out of 642 hects of free land available within 732 hect. of forest land acquired. The details of land use and trees planted are given in Annexure-I.[12] Type of plantation taken up in Bauxite mines in India, generally are given in Annexure-II.

(vii) Necessary investigation have been carried out for identifying the source of water for the Perrennial springs (which is at a depth more than 150 m below the bauxite zone) and effect of blasting at different horizons.[2]

Alumina Refinery[3]

(viii) - Provision of Electrostatic Precipitator to arrest particulate matter in Steam Generation Plant.
- Tall stack of 120 metres for venting out Flue Gas.
- Adequate number of stages for washing of red mud to reduce the soda content in red mud to the lowest possible limit.
- Lining in red mud pond to prevent permeating of soda impregnated water.
- Electrostatic Precipitator to extract fine alumina dust from the calciner exhaust stack.
- Bag-house type dust collectors to trap dust from alumina transport areas.
- Waste water treatment plant for treatment of process and sewerage water.
- Efficient equipment design for minimising noise pollution.

Smelter[3]

(ix) - Availability of large buffer zone in the most frequent wind direction.
- Provision of hoods on all pots and exhaust through dry scrubber using alumina injection for hydrogen fluoride emission.
- Provision of central automatic feeding of pots.
- Provision of hoods and bag filters for control of dust emission.
- Provision of gas collection system with high efficiency.
- Provision of sewerage and process water treatment plants.
- Recycling of process water to minimise discharge.

11.2.3 INDAL

From the last decade and a half, OB disposal is being done in specially identified 'no ore zone'. The top soil, and morrum/laterite are dumped separately. The mined out areas are back filled and covered with soil and massive afforestation is practised over the area.

Ripper dozers are being used to eliminate blasting and blast-induced vibration with a view to maintain a balanced eco-system, and minimum noise pollution.[13]

Nagrataswadi Mine[4]

Steps have been taken for back filling of mined out areas. Afforestation programme has been taken up in the mine. Nearly 2.5 lakh plants of different species like eucalyptus, subabul, babul, casurina, jamun etc. have been planted.

The persons operating heavy earth moving machinery and in crusher area, who are exposed to high noise levels have been provided with earmuffs.

Floating bed wet scrubbers are to be installed for treating smelter fumes. Liquid effluents are treated to bring down the toxic contents to permissible limits before discharge.[5]

Kasarsada Mine

Overburden has been back filled in the mined out areas, to restore the original profile and utilise the area for afforestation. So far about 1.2 lakh trees of different species have been planted.

Bagru and Bhusar Mine

Afforestation has been carried out over 3.9 % of the total lease area (181.61 ha). About 1,24000 trees have been planted, further 50,000 trees were proposed to be planted during 1991-92.[6]

11.2.4 BALCO

Measures undertaken to control environmental pollution due to mining are :-

i) Reclamation of the excavated area is taken up immediately after the bauxite extraction, and it is considered co-objective of mining venture.

ii) Top soil is preserved and utilised for covering the restored area after mining.

iii) Mining is not carried out on the steep slopes and a reasonably wide insitu barrier is left out for the prevention of soil erosion in the process of mining.

iv) Afforestation is carried out on the regenerated land and species of trees which have proved successful are planted in grid pattern. It is reported that a thicker forest has since been developed in the mined out area and density of trees in the afforested land is now 8 times higher than the original forest. The density of afforestation is about 2000 saplings per hectare.

v) Barrier at the periphery of plateau and garland shaped drainages have been constructed at plateau top to prevent any run off of laterites and soil to slopes and valleys.

vi) The study of physical and chemical characteristics of laterites and bauxite indicates total absence of toxic hazardous elements in it, which may dissolve or contaminate surface or ground water[7].

Gandamardan area

BALCO had great hopes on developing a large bauxite mine in the Gandamardhan area in Orissa. However the mining project ran into rough weather following strong protests from the local tribal inhabitants and environmentalists, who were very much against the clearing of the forest herbs & bushes. Balco finally abundoned the project[8].

Smelter

A wet scrubbing system has been provided at the smelters to treat smelter fumes. For checking alumina dust the rotary kilns have electrostatic precipitators. Liquid effluents are treated to bring down the toxic contents to the standards laid down by the pollution control board[1].

11.2.5 MALCO

The smelting plant at MALCO has got wet scrubbing system for treating the smelter fumes. Rotary kilns in alumina plant have electrostatic precipitator for arresting alumina dust. Part of red mud is being used as a raw material for cement industry. Liquid effluents are treated to bring down the toxic

contents to the standards laid down by Pollution Control Board before discharge[1].

11.3 RED MUDS

Bauxite residue popularly known as 'Red Mud' (RM) is a waste product of alumina industry. About 1-2 tonne of RM is generated for every tonne of alumina, when bauxites are treated by Bayer's process.

Composition of RM generated in Indian Alumina plants is given below :

CHEMICAL COMPOSITION OF RM

	Constituents approximate %						
	Fe_2O_3	Al_2O_3	TiO_2	SiO_2	Na_2O	CaO	LOI
BALCO	24-26	22-25	16-19	7-9	5-7	3-6	11-12
HINDALCO	35-38	18-20	19-20	7-8	5-6	1-2	10-11
INDAL	18-21	30-40	17-19	6-8	4-5	1-3	10-12
MALCO	50-56	14-18	2-4	6-9	1-2	-	5-10
NALCO	60-70	12-18	4-8	12-16	3-10	4-18	10-14

Other than the above oxides as major constituents minor constituents are oxides of vanadium, gallium, calcium, magnesium etc. RM has a coarse fraction (sand) and a fine fraction consisting of iron oxides, sodium aluminium silicates, titanium oxide, etc. The insoluble residue from the alumina rich caustic liquor is pumped as a slurry to tanks and from there to storage areas, called as red mud ponds. Environmental problems associated with RM are that these RM ponds can be aesthetically unpleasant, generate dust, pose hazards of contamination of ground water through seepage and of surface water by overflow. The disposal sites can fill up soon and alternative sites are required for the RM disposal. The residual alkali content of the mud is not conducive to agricultural use of the land.

Finding avenues of uses of red mud may solve the problems of its disposal. So far, however only minor uses are identified like manufacturing of clay bricks, roofings sheets etc.

There is also scope of extraction of valuable elements e.g. vanadium, gallium, titanium etc. from the Red Muds. Research efforts and economic studies are under progress in this direction.

DISPOSAL SYSTEM

There is need of a proper RM disposal system in view of problems of seepage and large areas required for storage ponds. RM disposal problem has been reduced in the new Giulini Dry Stacking system (FRG). The system is described below :-

a) After 2-3 washing steps, the slurry is filtered on rotary vacuum drum filters. The solid content in filter cake is 55-60% by weight, while Na_2O content is 1-5% by weight.

b) Filter cake is mechanically stirred and the resulting slurry is pumped into the pond.

c) After a few days it hardens and after some weeks even heavy caterpillar vehicles can traverse over it. The water is unable to penetrate into the hardened residue.

Advantages claimed for the new disposal system are Land area requirement is drastically reduced, as dam height can be increased upto 30-40m. There is no seepage danger and also reclamation is easier.

ALCOA in Australia have incorporated a base drainage layer in the disposal ponds. First only a sandbed was laid but due to the very low strength of the fine grade material, recovery of liquid via sand layer was very slow. Therefore, subsequently a network of perforated pipes have been installed into the dump sand layer.[9]

BALCO

At BALCO in India, Red Mud is first subjected to a series of counter-current washing which reduces its caustic content to 2-3 gm/litre from the initial 65-70 gm/litre. The mud is then conveyed to a distant closed-pond, where it settles and liquor standing at the top recycled in the process. It has been claimed that with this closed circuit, no waste product goes to the adjoining land/water systems. However, the closed circuit cannot be effective in preventing seepage

through the base of the disposal pond unless precautions are taken to seal off seepage by providing layers of compacted clay, soil over the basin surface.

HINDALCO

At HINDALCO, the red mud disposal system is based on filtered mud process. In this system, the mud is filtered in vacuum drum filters. At a consistency of 70 % solids, in almost a semi-dry and impermeable cake form, it is carried by dumpers to the red mud disposal area. This cake dries in a week's time and can be dozed for making further space for dumping. This is a good system environmentally, as small area will be required and there is no problem of seepage. The dried mud will also have much high resistance to chemical leaching.

NALCO

The Alumina plant of NALCO at Damanjodi (capacity of the plant 0.8 Mt. per annum) generates 2,350 tonnes of red mud per day which is disposed of in the Red mud pond by adopting wet disposal system. The NALCO experience however reveals that this wet disposal system is not the right solution for Damanjodi area having higher precipitation (2150 mm per year) and low rate of evaporation (650 mm per year).

Negative aspects of wet disposal system are found to be high investment costs of building dams with low rate of caustic recovery and creating large volume of pollutted water with likelihood of overflow and seepage.

In view of these difficulties, dry disposal system for red mud either by filteration or through deep thickening is envisaged by NALCO, as a long range solution of the problem. Dry disposal system can reduce the soda loss and also eliminate pollution hazards. The land already acquired by NALCO for the ponds, it is understood, will be more than sufficient for additional 50 years life even after full expansion. Further the dry mud can be utilised for manufacturing bricks, PVC pipes, roof sheets, etc.[11]

11.4 FLOURIDE EMMISSIONS[10]

Aluminium is manufactured worldwide through a reduction smelting operation using one of the following three processes :

a. Horizontal Stud Soderburg - (HSS)
b. Vertical Stud Soderburg - (VSS)
c. Prebaked Anode Type, either centre worked or side worked.

All smelters no matter of what type it is, emit flourides, gaseous and particulate, through primary and secondary sources. As increased fluoride content in the bones degrades the bone structure, hence fluoride emission from smelters is a matter of concern.

Primary Emission is stack emission and may vary in the region of 12-18 kg. fluoride/t Aluminium produced. The Secondary Emission is a fugitive emission, taking place through superstructure and roofs where quantity may vary from 2-4 kg fluoride/ton Aluminium produced. Typically, the total fluoride emission (primary and secondary) levels for different systems will be as under (in kg/t of Al produced) :

Prebaked Anode	: 15-17
Horizontal Stud Soderburg	: 20-22
Vertical Stud Soderburg	: 20-22

Fluorides being harmful to vegetation, health and environment in general, an effort has been made worldwide to control the emission of fluorides (gaseous and particulate) into the atmosphere within acceptable limits. The primary emissions are controlled by installation of suitable scrubbing system for fluorides and the secondary emissions are controlled by proper designing of the superstructure and suction flows to meet the requirement and follow a specific operation and maintenance schedule. The secondary emissions have a comparatively lesser impact.

Control of emission :

Three systems available for control of emission of fluorides are :

- Wet Scrubbers
- Wet ESP
- Dry Scrubbing

There are many advantages that the dry scrubbing offers over the wet methods of scrubbing. These are tabulated as follows :

	Dry scrubbing	Wet system
1. Estimated power consumption	X	1.5 X KW
2. Running Cost recovered through fluorides	75 %	NIL
3. Process Water Quantity required	Nil	300 m^3/day
4. Consumption of chemicals for process	Nil	Chemicals required for both Wet Scrubbing and Effluent Treatment
5. Secondary Waste	No problems of liquid Effluent generated and thus no separate effluent	CaF_2 is deposited as Sludge from Effluent Treatment Plant, which requires further handling/disposal. CaF_2 is toxic and requires cafe in disposing.
6. Scrubber Emission Level	Guaranteed 1 Kg. Fluorides per t.Al. Thus better system from environmental point of view.	Outlet primary emission is higher
7. Retrofitting	In case of HSS installations if option of converting to Prebaked Anode System is desired PRACTICALLY NO CHANGE is needed in installing dry scrubbing.	Wet Scrubbing System may have to REPLACED by entirely NEW system. ADDITIONAL EXPENDITURE.
8.	Dry system ensures, very long life due to absence of corrosion problems.	Corrosion problem exists due to liquid system, hence, comparatively lesser life and more maintenance.

The Dry Scrubber system consists of suitable numbers of dry scrubber-cum-bag filter modules designed for a particular application. The modules are supported on common support structure which is strengthened adequately. The clean gas outlet from the bag filter is connected to centrifugal blowers provided for individual module. The fan outlet terminates with vertical stack designed to meet the pollution control requirements with regard to fluoride emission.

The removal of fluorides in the scrubber-cum-bag filter is achieved in the following ways :

a) Injecting raw Alumina in the branch duct feeding the dirty gas into each scrubber compartment just near the entry, such that gases will mix thoroughly and react with Alumina during transport and entry into the scrubber.

b) A perforated grid plate of suitable size is provided just above the conical gas entry into the scrubber covering the entire cross section of the scrubber. A layer of suitable thickness of raw Alumina spread on the grid plate, scrubs and reacts with pot gases when it passes through this layer and enters the bag filter.

c) The bag filter which is directly above the perforated grid plate has requisite numbers of suitable length filter bags suspended vertically in each module. These bags which are precoated with raw alumina, react and absorb fluorides as the gases pass through them.

The installation of dry scrubbing system reduces emission of particulates and improve the quality of ambient air in general.

Dry scrubbing methods of emission control are very efficient in recovering gaseous as well as particulate fluorides and nuisance dust particulates. Dry scrubbling plants cost almost same as wet scrubbing systems including cryolite/aluminium fluoride recovery plants but they are superior in fluorine collection efficiency and operating cost.

Various Emission Standards for Aluminium Plants are indicated in Annexure-III. Flouride control systems in various Aluminium smelters in India are as shown in Annexure-IV.

Annexure - I

BREAK UP OF 732 HECTS FOREST LAND FOR PLANTATION PROGRAMME AT MINES[12]

Sl. No.	Specification of area	Area of surface right (in hects)	Space available for plantation (in hects)	Plantation done upto 1990-91 (in hects)	Plantation to be covered by 1995-96 (in hects)
(1)	(2)	(3)	(4)	(5)	(6)
	FOREST LAND OF PANCHPATMALI HILL				
1.	Access road (from Damanjodi) Corridor of 50 mt. width	20	15	12	03
2.	Conveyor Corridor (200 mt. width)	132	90	75	15
3.	Mining area (25 years)	450	450	80	100
4.	Explosive Magazine and miscellaneous area	66	50	25	25
5.	Mining Complex and auxiliary facilities	53	33	30	03
6.	Approach road from Kakiriguma base camp	06	01	--	--
7.	Water supply and Power line	05	03	03	--
	Total :(A)	732	642	225	146

Annexure-II

TYPE OF PLANTATION TAKEN UP AT BAUXITE MINES OF NALCO

Sl. No.	Area	Type of Plantation (Local names)	Remarks.
1.	Back filled	(a) Fruit Trees i) Bananna ii) Jack fruit iii) Cashew iv) Rose apple (b) Timber Wood i) Sisoo ii) Bombhari (c) Fire Wood i) Mohia ii) Accasia	a) All the plants are of economic importance. b) The plants are growing well finding disintigrated soil mass for easy root penetration.
2.	Perepherial barrier	Fire Wood i) Accassia ii) Casia iii) Casuarina iv) Silver Oak	Species selected are of fast growing type with thin leaves for effective screening of dust, noise and vibration.
3.	OB Dumps/Soil Dumps.	a) Soil Conservation Plant i) Lemon grass ii) Sisal iii) Bamboo b) Fire Wood trees i) Silver Oak ii) Accasia iii) Eucalyptuss iv) Subabul c) Fruit Trees i) Mango ii) Jack fruit d) Local Medicinal Plants i) Anola ii) Bahada	i) Soil Conservation plants have been selected as to preventsoil erroson against formation of gullies. ii) Medicinal & Fire Wood species selected as they have got very fast growing nature, with good canopy spreading to prevent rain drops splashing on the loose soil particles.

ANNEXURE-III

EMISSION STANDARDS FOR ALUMINIUM PLANTS

Plant	Type of Emissions	Standard	Remarks
I. India	As per Central Pollution Control Board		
Alumina	Particulate	250 mg/Nm^3	
Smelter	Fluorides	1 kg/tonne of Al	
	Particulate	150 mg/Nm^3	
Power Plant	Particulate	150 mg/Nm^3	For 200 MW & above.
	SO_2 (Through stack height)	220 metres	for 200 MW to below 500 MW
		275 metres	For 500 MW and above.
II. Other Countries			
U.S.A. (Federal)	Fluoride	1 kg/ton of Al	For VSS & HSS
		0.95 " "	For PB
U.S.A. (Oregon)	"	0.5 " "	Yearly average
		0.65 " "	Monthly average
Norway	"	0.95 " "	Maximum for new plants
Japan	"	3.0 " "	Stack emission
		1.0 " "	Room emission
France	"	0.95 " "	For pot room
		0.05 " "	For Bake room
Germany	"	1.0 " "	Pot gases
		0.8 " "	Ventilation gases

ANNEXURE-IV

FLOURIDE CONTROL SYSTEM IN VARIOUS ALUMINIUM SMELTERS IN INDIA

Name of Industry	Location	Installed capacity Tonnes per year	Fluoride control system
1. Hindustan Aluminium Co. (HINDALCO)	Renukoot	120,000	50 pots with Dry scrubbing
2. Indian Aluminium Co. (INDAL)	a) Alwaye b) Hirakud c) Belgaum	20,000 24,000 73,000	No system
3. Madras Aluminium Co. (MALCO)	Mettur	25,000	Wet scrubbing
4. Bharat Aluminium Co. (BALCO)	Korba	100,000	ESP+Wet Scrubber
5. National Aluminium Co. (NALCO)	Angul	218,000	Dry Scrubbing.
	TOTAL	580,000	

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