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A Case Study On The Environment Management System of Bauxite Mine

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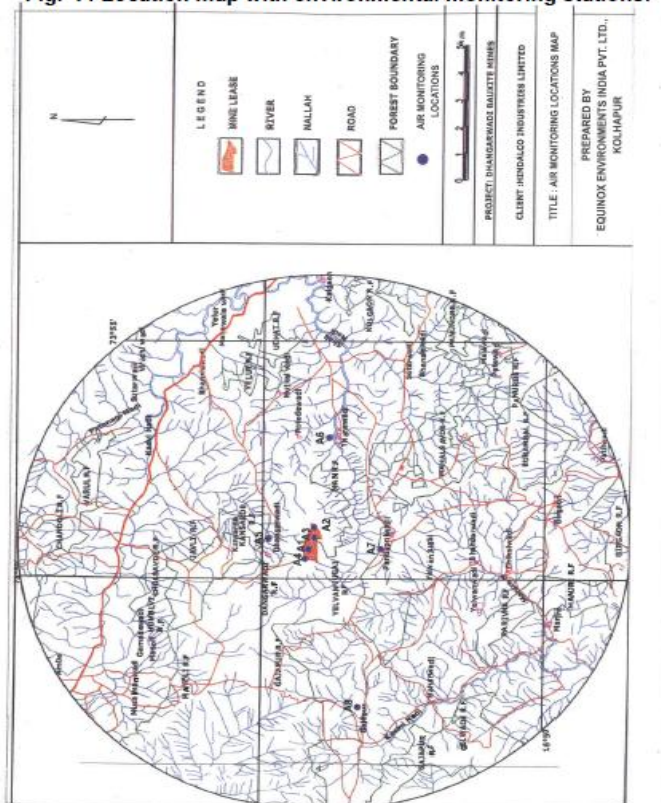
Abstract: Western Ghats consist of high-rising hill ranges with extensive plateaus and are dissected by narrow valleys. Trellis drainage pattern is seen on the flat top and dendritic drainage on hill slopes. Several first-order streams of seasonal nature originate at higher elevations, and streams become perennial at lower elevations. The Western Ghats have a very high biological diversity. The Western Ghats also hosts economically site-specific recoverable ore mineralization like bauxite, iron ore, manganese, and several other minor minerals. The present study is restricted to the reclamation and rehabilitation of the bauxite mined-out area of the Dhangarwadi mines of Hindalco Company as part of the Progressive Mine Closure Plan. Hindalco Company has taken all possible precautions and protection measures for the conservation of natural resources and the environment by planning, implementing, and post-monitoring in the light of a sustainable development framework.

Key Words : Mining, Environment Quality, Plantation, Reclamation & Rehabilitation

Introduction:

Hindalco Industries is one of the leading producers of aluminum in the country. The Company's business involves bauxite mining to alumina refining. Alumina metal conversion, sheet, extrusion, and foil manufacturing are spread all over the country. The Company operates several bauxite mines in Maharashtra, Orissa, Chhattisgarh, and Jharkhand to feed the Alumina Plants located in Belgaum, Renukoot, and Muri. Hindalco is a Public Limited Company. Governmental Maharashtra has sanctioned a mining lease for the production of bauxite over an area of 41.80 Ha. for 30 years, at village Dhangarwadi ($16^{\circ}54'23.91742''$ N & $73^{\circ}51'08.21277''$ E), Taluka Shahuwadi of Kolhapur district of Maharashtra. The total mineralized area is 32.3 Ha. out of a total leased area of 41.80 Ha. The location Plan of the study area is given in Figure No. 1.

Fig.- 1 : Location map with environmental monitoring stations.



The Company has obtained Environmental Clearance from the MoEF for producing 6,00,000 TPA of bauxite and Consent to Operate from the Maharashtra Pollution Control Board. The mining

operations at Dhangarwadi bauxite mine started with infrastructure development from 2009 -2010, but the actual production of bauxite started in March 2012, and mining operations were suspended in 2019.

India is home to 1,531 operating mines, including open cast and underground mines that produces 95 minerals – 4 fuel-related minerals, 10 metallic minerals, 23 non-metallic minerals, 3 atomic minerals, and 55 minor minerals (including building and other materials, and the recently notified 31 additional minerals). The area occupied by mining in India is just less than 2%. Area occupied. The space occupied by major and minor minerals is approximately 60% and 40 %, respectively. Mining is one of the core sectors that drive growth in an economy. Not only does it contribute to GDP, it also acts as a catalyst for the growth of other core industries like power, steel, cement, etc., which, in turn, are critical for the overall development of the economy. Analysis has shown that every one per cent increment in the growth rate of mining and quarrying results in 1.2 – 1.4% increment in the growth rate of industrial production and, correspondingly, an approximate increment of 0.3 percent in the growth rate of India's GDP (FICCI, 2013).

Mining activities bring changes in the natural topography, which results in restrictions on the possibilities of using the land for other purposes, changes in the hydrogeological conditions with consequences for both groundwater and surface water, and changes in the geotechnical conditions of the rock .At the same time, Illegal small-scale mining in surrounding mines leads to increased erosion and loss of viability for agricultural purposes, among other uses; increased clearing of vegetation for mining areas has adversely altered the hydrological regimes (Albert K. Mensah et al.2015). Vegetation is important in protecting the soil surface from erosion and allowing the accumulation of fine particles (Tordoff et al. 2000; Conesa et al. 2007b). They can reverse the degradation process by stabilizing soils through development of extensive root systems. The plants accumulate these nutrients and redeposit them on the soil surface in organic matter from which nutrients are much more readily available by microbial breakdown (Conesa et al. 2007a; Mendez and Maier 2008a).

The mining disrupts the aesthetics of the landscape along with it disrupts soil components such as soil horizons and structure, soil microbe populations, and nutrient cycles that are crucial for sustaining a healthy ecosystem and hence results in the destruction of existing vegetation and soil profile (Kundu and Ghose, 1997). The overburden dumps include adverse factors such as elevated bioavailability of metals, elevated sand content; lack of moisture; increased compaction; and relatively low organic matter content. Acidic dumps may release salt or contain sulphidic material, which can generate acid-mine drainage (Ghose 2005). The effects of mine wastes can be multiple, such as soil erosion, air and water pollution, toxicity, geo-environmental disasters, loss of biodiversity, and ultimately loss of economic wealth (Wong 2003; Sheoran et al. 2008). In mined areas, the overburden dumps exhibit a completely modified ecological system, and the mine spoil lacks most of the physical, chemical, nutritional, and biological characteristics of normal soils. Eco-restoration is a complex and long-term process and requires a fundamental understanding of ecosystem structure and function, including the process of primary as well as secondary succession (Connell and Slatyer 1977; Thomson et al. 1984; Gibson et al.1985). Land reclamation in India has traditionally been associated with the reclamation of saline and sodic agricultural soils . However, within the last few decades, there have been numerous attempts to restore lands disturbed by mining to an acceptable or useful vegetative condition.

Materials and Method:

The Company has obtained necessary legal permission to produce bauxite for its captive consumption from the Ministry of Government of Maharashtra and the Government of India. Mine is well explored to understand deposit qualitatively and quantitatively with its shape to design mine planning. Opencast mine planning is carried out to exploit shallow, occurring ore deposits. Traditional cross-sectional and slice methods are adopted for mine planning. The mining Plan (MP) for the year-wise development & production of bauxite and the Progressive Mine Closure Plan (PMCP) prepared by the Company was approved by the Indian Bureau of Mines. The

Company implemented the approved plan in terms of production, reclamation & rehabilitation of the mined out pit. The environmental monitoring every quarter with respect to the quality of water, groundwater fluctuation, noise, air, and soil in the core zone and buffer zone of 10km. radius around the mine through Green Envirosafe Engineers & Consultants Pvt. Ltd. Pune. Year-wise plantation in the mined-out pit was carried out by using local plant species.

Result and Discussion:

Dhangarwadi plateau shows two types of bauxite deposits viz

1. Blanket deposit: The bauxite deposit is a blanket-type residual deposit formed by in-situ residual weathering of alumina-rich basaltic rocks, typically under tropical/sub-tropical climatic conditions. The blanket deposit is confined between 1010 M to 1020 M. MSL. The thickness of the blanket deposit type of bauxite varies between 6 to 8m.

2. Float Type of deposit: Geological Survey of India and the Directorate of Geology and Mining reported that float boulders are eroded from the main plateau and moved to variable distances due to rainwater. We confirm and propose that boulders are not eroded from the main plateau due to rainwater, but there is a retrenching of the plateau due to differential weathering of hard capping and soft clay at the bottom. Lithomarge clay has been eroded easily and faster, leaving behind upper hard capping as support less which subsequently collapsed. This phenomenon continued over time, leaving behind continuous and systematic boulder formations along the slope in the entire lithomarge clay profile. The thickness of float varies between less than 0.5m to 3m. In addition to many other features, the absence of erosional features in the boulders and recovery of boulders as estimated all along the contours, strongly supports retrenching plateau rather than the erosion of boulders from the plateau.

Environment Management:

The Company has Environment Management System in line with ISO14001 implemented and monitored effectively. Policy reiterates the Company's commitment to conserve resources, reduce fugitive emissions, perform more than statutory conditions in mitigating operational impacts on the environment and create awareness about environment management among employees and the surrounding community.

Top Soil Management:

The Bauxite plateau is a barren land devoid of trees except seasonal flowering plants i.e, angiosperms. The topsoil generated (if any) is properly collected at the development stage and immediately used for spreading over the backfilled mined-out area before carrying afforestation.

Air Quality Management:

Drilling operations are being carried out with the support of a mist water jet (wet drilling) to avoid airborne dust. Water is sprinkled in and around working faces and also on haul roads within mine using 2 Nos. of water tankers. The mobile screening plants' feed points and discharge ends are provided with sprinklers to reduce dust suppression. Workers exposed to dust areas were provided with dust trap PPEs. The Air quality testing was carried out during the summer, post-monsoon, and winter seasons of every year by monitoring eight locations and analyzing for PM10, PM2.5, SOx, and NOx levels as per statutory requirements. The data for the summer season 2019 is presented in this paper. The ambient air Quality in the core and buffer zone is given in Table no. 1.

Table No. 1 : Quality of ambient air in the core and buffer zone

Zone	Location	Particulate matter Microgram/cu.m				Gases Microgram/cu.m			
		PM10 (size <10 micron m)		PM2.5 (size <10 micron m)		SO ₂		NO _x	
Season summer 2019		Min	Max	Min	Max	Min	Max	Min	Max
Core Zone	A1. Mine Pit area	46.2	70.1	13.7	23.1	13.5	20.0	23.1	28.9
	A2. Near dump	47.6	71.1	13.7	22.7	12.1	17.3	15.2	22.0
	A3.Haulage Road	55.4	70.4	15.5	21.3	12.4	18.5	15.0	27.0
	A4. Near office	59.9	70.5	18.5	23.1	12.4	19.5	18.0	21.6
Buffer Zone	A5. Dhangarwadi	49.5	65.4	13.9	21.8	12.8	16.4	18.2	22.0
	A6. Thanewadi	45.7	66.1	12.7	21.3	11.9	18.7	15.4	22.7
	A7. Pandapnwadi	49.8	67.4	14.5	21.5	12.2	21.4	16.5	21.9
	A8. Gajapur	50.8	64.7	16.7	21.7	12.5	20.4	15.0	22.0

There are four AAQ monitoring stations in the core zone (A1 to A4) and four in the buffer zone (A5 to A8). The location of the sampling stations is given in Figure No. 1.

The maximum value of PM10 in the core zone during the working mine was in the range of 70.19 to 71.1 microgram / cu.m against recommended standard of 100 microgram / cu.m and PM2.5 was 21.3 to 23.1 microgram / cu.m. against recommended standard of 60 microgram / cu.m . Similarly, in the buffer zone PM10 was in the range of 45. to 50.8 microgram / cu.m and PM2.5 in the range of 11.9 to 12.8 microgram / cu.m.

The maximum value of SO₂ in the core zone during the working mine was in the range of 17.3 to 19.5 microgram / cu.m. whereas in the buffer zone, SO₂ level ranged from a 16.4-2microgram / cu.m to 12.7 – microgram / cu.m. In both cases, SO₂ values are within the permissible limit of 80 microgram / cu.m.

The maximum value of NO_x in the core zone and buffer during the working mine was in the range of 21.6 to 28.9 microgram / cu.m and 21.9-22.7 microgram / cu.m, respectively. In both cases, NO_x values are within the permissible limit of 80 microgram / cu.m.

The values obtained were compared with the revised Ambient Air Quality Standard given by the Ministry of Environment and Forests (2009).

The Ambient Air Quality (AAQ) during the mining operations was maintained within the permissible limit due to the proper arrangement of the dust suppression system, proper maintenance of the gradient of the hauling road, regular maintenance of mining equipment and also coverage of all ore transporting trucks with tarpaulin at the loading point itself to avoid spillage or ore on the road . The Company has dedicated water tankers for dust suppression all along the loading point. Due to this, the SPM levels in the working area and the buffer zone, are maintained within the permissible limit. There is hardly any impact of mining activities on the AAQ. The proper gradient of the hauling road is maintained with dust suppression to suppress the dust generated during the production and movement of bauxite transporting trucks. The mobile crusher inbuilt dust suppression system.

Noise monitoring data for the summer season of 2019 carried from 6 am to 10 pm is given in the following Table No. 2.

Table No. 2 :Noise Monitoring data in the core and buffer zone

Location	Av.Value Leq10	Av.Value Leq50	Av. Value Leq 90
N1. Mine Pit area	54.1	60.8	62.1
N2. Near dump site	53.4	58.1	60.9
N3. Near Haulage Road	56.0	60.8	63.0
N4. Near office	54.4	58.6	59.9
N5. Dhangarwadi	40.6	45.7	48.5
N6. Thanewadi	40.2	45.0	48.5
N7. Pandapnwadi	41.0	46.4	48.8
N8. Gajapur	42.0	46.6	49.6

Noise values obtained in the core and buffer zone are compared with the noise level standard prescribed by Noise pollution (Regulation and Control) (Amendment) Rules 2000 and are found to be within the limit of 75 dB(A) Leq. Blasting was carried out by using Nonel technology to reduce ground vibration and noise pollution. Drillers are provided with ear muffs and a mist water jet (wet drilling). Adequate Personal Protective Equipment (PPEs) is provided to employees working in the mines. The Mining Machineries are periodically maintained in good condition.

Water Management:

There are no major perennial and seasonal water sources in the lease area. There is no possibility of encountering a groundwater table in mine workings as the ultimate depth of mining is within 10-12m, and the groundwater table is below 35 to 45m in the mine lease area i.e, contact zone of lithomarge clay and basalt. Hence, water management is restricted only to surface water during rainy seasons.

Mine area receives heavy rainfall during monsoon season, and mining stops during monsoon season almost for four months, from June to September. Due to torrential rains controlled by SW monsoon, all the nallahs / streams originating from the hill slopes get flooded. During the last four years variation in rainfall was 2133 mm, 3032mm ,4590 mm and 5481mm (2018). During the last four years, minimum rainfall was 2133 mm, and maximum rainfall was 5481mm. with an average of 3809.66mm.. Almost 2000 m garland drain is constructed all along the lower side of the lease area, and a series of silt check dams are also constructed in the valley portion to arrest the erosion of silt from mine runoff water during the rainy season. Water quality is monitored to test the efficiency of the garland and check dams.

The quality of Mine pit water is described in the following paragraph:

The pH of the water varies between 7.05 to 7.25, and the permissible limit is 6.6 to 7.5

Dissolved Oxygen (DO) which is temperature dependent varies between 6.0 to 6.7 mg/l. Desirable limit is 5.00 mg/l for the survival of aquatic life and Biochemical Oxygen Demand : 3.2 to 4.01 mg/l.

Total hardness of water was found to be in the range of 71.48 to 95.47 mg/l. By and large, water is soft to moderately hard. The chloride of the water sample collected in the study area was found to be in the range of 17 mg/l to 27.0 mg/l. The IS 20500 standard for chloride is 250 mg/l.

The iron content of the water was found to be in the range of 0.07 mg/l to 0.6 mg/l. As per IS 10500 standard for drinking water, the desirable limit is 0.3 mg/l, and the maximum permissible limit is 1.0 mg/l.

Being an open-cast mine and high rainfall area, the Total Suspended Solids (TSS) is a major cause of concern. The company has taken care to construct check bunds, and garland drains in the

working area so that erosion of silt can be minimized. The TSS of mine water sample analyzed during the rainy season showed values in the range of 50.61 to 56.4 mg/l. The maximum permissible limit is 100 mg/l. and turbidity is 0.2 to 0.54 NTU. (< 5NTU).

All the heavy metals are either below the detection limit or much less than the permissible limit.

There is no hazardous waste to be discharged from the mine. During the rainy season, runoff water from the mine is channelized to flow through the garland drains into silt check dams and then flow into the nearby streams. Rainwater flowing through the mine is neutral.

Mining operations are suspended during the rainy seasons. The rainwater accumulated during the rain in the mined-out pits gets infiltrated into the lithomarge and there is no need for pumping of mine water for the production of bauxite. The company has constructed garland drains of 2000 m and a series of check dams to arrest silt from the rainwater flowing out of the mine during the rainy season. Water quality parameters are within the permissible limit. Mining operations suspended from 1st June to the end of September every year to minimize the adverse effect during the rainy season and also due to the high moisture content in the bauxite. The mine water requirement is around 90 cu.m. per day which is partly met by rainwater harvesting and partly drawn from the bore well.

Waste Management:

Overburden/Associated waste rocks generation in the mine is mainly the top soil cover over the ore up to 1m thick and associated soil with float ore zone, which is 2-3m thick. No external dumps are in the mine, as the waste generated in the mine is completely used for concurrent backfilling of the mined-out pits.

Hazardous Waste: As the mine is being operated by deploying contractual machineries, no garages and maintenance are required in the mine. The hazardous waste generated in the mine is restricted only to electronic waste. Contractual machineries are maintained in workshops in nearby villages. Even though there is little scope of provisions for hazardous waste, the mine has obtained authorization under the provision for collecting, storing, handling and disposing off through authorized vendors.

Reclamation and Rehabilitation of Mined out area: The Company has adopted three restorations models for the reclamation of mined out area

1. Grassland
2. Plantation by using local species
3. Water bodies (Only for insitu mined out area)

The grasses commonly used are *Cyperus rotundus*, *Cynodon dactyl*, *Jasminum malabaricum*, *Pteris acurina* and *Cyperus bulbosus*. Name of local plants used for the reclamation of mined out pit is given in table No. 3.

Table No. 3 : Name of local plants used for the reclamation of mined out pit

Sr. No.	Common Local Name	Botanical Name
1	Bakul	Mimusops elengi
2	Bahunian	Bauhinia
3	Chiku	Manikara zapota
4	Chery	Prunus avium
5	Peru	Psidium guajava
6	Gholi	Portulaca oleracea
7	Hadaka	Sesbania grandiflora
8	Umbar	Fucus glomerata

9	Bava	Cassia fistula
10	Anjan	Memecylonumbellatum
11	Govonda	ButeaMonosperma
12	Apata	Bauhinia racemosa
13	Limbu	Citrus limon
14	Kokam	Garciniaindica
15	Kanchan	Bauhinia variegata
16	Shiras	AlbiziaLebbeck
17	Kashid	SennaSiamea
18	Gulmohar	Delonixregia
19	Pishali	Kalanchoepinnata
20	Bhoma	Glochidionellipticum
21	Kumbha	Careyaarborea
22	Hirda	Terminaliachebula
23	Karanj	Ongamiaglabra
24	Gilshidi	Gliricidia
25	Silver Oak	Grevillearobusta
26	Kanchan	Bauhinia variegata
27	Platopharm	Peltophorum
28	Fanas	ArtocarpusHeterophyllus

Year-wise, the overburden generated is simultaneously backfilled into the mined-out pit ,levelled, and then Plantation of local species is carried out as a part of the Progressive Mine Closure Plan. The total Mining Lease (ML) area is 41.8 ha. out of which the Mineralized area is 32.0 ha. The actual mined-out area is 30.0 ha, and the area developed for mining is 2.0 ha. Year wise reclaimed and rehabilitated area by Plantation of 61,700 saplings over an area of 28.0 ha . @ of 2200 saplings per ha. For Plantation, Pits are dug at a spacing of 2 m x 2 m (density of 2500 trees/ha). The pit size is 2 ft x 2 ft x 1.5 ft deep for tree species and 1 ft x 1 ft x 1 ft for shrub species

Post-plantation care included regular watering, weeding, and the addition of vermicomposting. The survival rate is almost 80% to 90%. About 0.1 ha of the mined-out area has been converted into a water body. A safety zone of 7.5m with fencing is maintained all along the lease boundary to prevent the erosion of mined-out material, protection of pits, and also to maintain the original plant diversity of small flowering plants. The total bauxite profile at the Dhangarwadi bauxite mine is only about 10m, including 4 to 5m of lateritic overburden and about 6m of bauxite. The entire lateritic overburden is backfilled into the mined-out area. After mining and backfilling, the elevation difference between the original topography and the altered topography is only about 5m.

Corporate Social Responsibility (CSR) : The Company has contributed significantly towards community development on year on year basis as a part of Corporate Social Responsibility activity. Details are given in the following paragraphs :

Spreading awareness among villages to encourage formal education for children.Special literacy drive for women & girls. The company endeavours to spark the desire for learning & knowledge at every stage through formal schools, Balwadis, for elementary education.

The company carries out the CSR activities like the construction/renovation of the school building and providing school uniforms & books. Organizing a career counselling program, supporting the school by providing computers for e-learning projects, and awarding scholarships to meritorious students. The company provides free medical services to needy people through our Mines dispensary. The company provides ambulances to the villagers for medical emergencies. The company regularly conducts health check-up camps and distributes free medicines. The company has formed Self-Help Group (SHG) at nearby villages and provides vocational training to the SHG women. Now, these SHG women actively participate & running Milk co-op dairy, Mushroom

cultivation, handicraft, Embossing, etc. The company is continually providing safe drinking water to the nearby hamlets and coordinating animal husbandry and cattle vaccination programs. The company has constructed roads, gutters, and latrines, installed street lights, pick up shed, community halls & houses, repairing the tribal community.

Conclusion: The Dhangarwadi Bauxite mine has adopted opencast mining operations as the bauxite profile is only about 6m thick. There are no external dumps as the entire overburden is backfilled into the mined-out area. The total mineralized area is 32.3 Ha. out of a total leased area of 41.80 Ha. Mined out area reclaimed is 28.0 ha with a total plantation of 61,700 local plants with a survival rate of 80% to 90% and also 0.1 ha of a water body. The Company has implemented an effective Environment Management Plan to maintain the quality of ambient air, noise, and water within the permissible limit. The efficiency of silt Check dams and garland drains is checked periodically with regular desilting.

Fencing of the entire mining lease area and water body is carried out and maintained 7.5 m safety zone as per the Mines Safety Act. The Company has significantly contributed towards community development in the nearby villages as part of its Corporate Social Responsibility (CSR) and contribution to the District Mineral Foundation (DMF) . Though the mining operations are suspended, the process of reclamation and rehabilitation remaining mined area and Plantation as a part of gap filling in the existing Plantation of the mined-out area is in progress to achieve a 100% survival rate. The Company has implemented an effective Environment Management Plan to ensure the least adverse environmental impact.

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