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Environmental issues to be addressed in Indian alumina refineries and their possible solutions

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ABSTRACT

India is endowed with a vast bauxite reserve totalling 3037 million tons, more than 87% of which is deemed fit for the production of metallurgical grade alumina by the Bayer's process. In spite of having such a vast bauxite reserve, the country's alumina production is very meagre and poised for augmentation in the near future. Also, the existing alumina plants except for Nalco, which has been set-up in the eighties, all the other existing plants are quite old and require modernisation and capacity expansion. With further additional capacities, may it be new green field plants or brown field expansions, there would be an increasing concern mainly for bauxite residue disposal, the working environment and nearby surroundings. The working environment in the alumina plant is critical due to the handling of corrosive chemicals, toxic fumes, air borne emissions, noise hazards and require necessary safety monitoring system. Based on plant operation experience and critical literature survey it is thought that the environmental measures possible under the Indian conditions would match even the best available in the alumina industry abroad, so that there will be a very little negative impact. This paper attempts to bring out the possible areas of concern with measures available and comparison of those with the best possible under the Indian conditions. The overall assessment of impact on the environment including the social, cultural and economic would be highly beneficial to the project planners, local community and the country in general.

Keywords : Environmental issues, Alumina refineries, Bayer's process, Bauxite residue disposal.

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INTRODUCTION

The process of industrialisation is always accompanied with damage to the environment and ecological system. There is not a single human activity, whether it is individual or collective, that does not degrade the environment. Only the degree of degradation differs. The environmentalist through out the world have propagated the doctrine "Prevent pollution in the first place, however, where it is not possible to do so for want of technology, equipments etc., try to minimise the damage by recovering the valuables from the waste to the maximum extent possible".

With the advent of increasing knowledge in Science and Technology, the degradation has been brought to the minimum possible so that continuous development of the human race (may be at the cost of other species) is possible. Except for the human related issues such as resettlement and rehabilitation, socio-cultural development, socio-economic considerations etc., almost all the technical and scientific ambiguities that might arise because of the setting up of a mineral process industry say alumina plant, have been taken care of by advanced fool proof systems. The consideration in all these were to reduce the impact on the environment to the minimum, rather than trying to eliminate it completely which is an impossible task. Moreover, it has been felt prudent and considerably less expensive to initiate actions in the planning stages itself so that negative environmental impacts, if any, can be taken care of and costly, time consuming and irreparable damages can be avoided. Hence in order to avoid erosion of the benefits, the operation is intended to provide the community in particular and the country in general, sound and cost effective environmental management. This has become the order of the day with cost and social conscious organisations.

BAYER PROCESS

The processing of bauxite to alumina is carried out by the Bayer process which is a hydrometallurgical extractive process involving the use of caustic soda as solvent for alumina dissolution from bauxite depending on quality and mineralogy at elevated temperatures and pressures with desired economic yield. The digested slurry is diluted with washer overflow and sent to mud settlers using starch/synthetic flocculants. The settler overflow aluminate liquor is filtered in Kelly filters and after cooling in heat exchangers the cooled liquor is sent for decomposition of aluminate liquor at lower temperatures using seeded crystal growth technique. The precipitated hydrate is filtered after classification to recover the product alumina hydrate. While the underflow mud is sent for counter-current washing circuit to recover adhered caustic soda and subsequently causticised with lime to recover bound soda. The causticised mud is filtered in rotary drum

filters and disposed either in cake form or pumped in slurry form to sealed impoundment for safe and stable storage.

The potential environmental impacts in Bayer processing are physical and natural. The air borne pollutants such as dust, noxious chemicals etc., may deteriorate the air, land and water quality. The air pollutants in the refinery are bauxite dust, lime dust, alumina fines, by-products like vanadium salts and red mud dust arising from dry disposal of bauxite residue. The potential problem in external environment arise from disposal, storage/impoundment of bauxite residue. The solid waste management, land disturbance, change in eco-system, aesthetic aspect as visual dissenity and other impacts are socio cultural and economic.

Red mud disposal and storage is crucial and important. Based on the plant operational experiences and due theoretical environmental approaches practised abroad the possible environmental issues that might arise in setting up/operation of an alumina plant of economic size (1 million tpy capacity) together with the best possible options available for tackling the same in Indian context are given in Table 1.

WORKING ENVIRONMENT AND SAFETY ASPECTS IN ALUMINA REFINERY

The potential problems of working environment are caused by handling of corrosive chemicals such as caustic soda, acids, fumes and toxic materials. The provision for the following is necessary:

- The safe storage and transportation and handling of chemicals
- Appropriate safety equipments and apparels
- Establishing of standards for safe periods of exposure to toxic chemicals, heat and noise
- Safety regulations to be established for moving machinery and equipments.
- Periodic monitoring of emissions and availability of appropriate control system
- Reporting accidents and health clinic management
- The elements of industrial hygiene and safety monitoring system which applies to chemical process industries manufacturing acid and alkali need to be established. The units for noise and heat control will be implemented.

Table 1 : Critical analysis of environmental situation in alumina refinery

ENVIRONMENT PROBLEMS	BEST POSSIBLE SOLUTIONS	BEST POSSIBLE SOLUTIONS UNDER INDIAN CONTEXT
Air Emissions		
Dust from unloading station, crushing of bauxite and lime stone (this problem is confined to the plant premises only).	Unloading station, crushing and grinding areas must be fully secured with provision for dust extraction and collection. Also water spraying provision are installed.	Efficient dust extraction system for bauxite, lime and alumina loading/unloading stations are to be provided. Efficient dust extraction system in the crusher area is to be provided. Covered storage of secondary crusher material is to be made.
Caustic fumes from the process (this problem is confined to the plant premises only)	Closed tanks especially those which have caustic liquor at higher temperatures.	All tanks provided are to have covers. Where ever there is a possibility of caustic fumes emission (from the dilution tank) flash condensers are to be provided with proper vapour vents.
Heat from the coolers.	Proper sized fans are installed so that the cooling air is not heated to much above the ambient temperature.	With the help of most efficient and advanced cooling towers there would not be any large quantity of heat dissipation at one place.
Flue gases from the calciners.	Fuel oil consumption is kept to the minimum. Sulphur content of the fuel oil is kept as low as possible. ESP's and/or multi cyclones are provided. The stack height are such that the diffusion of the pollutants is controlled and also minimum possible. Green belt around the factory presmises are established so as to mitigate the impact of dust.	Fuel oil consumption to be around 80 kgs/Mt. alumina as prevailing with the most advanced gas suspension calciners. The calciners must have a full package of control and monitoring equipments so that the prescribed norms can be easily achieved and bettered with respect to particulate emissions. Green belt around the factory premises must be provided depending upon the site topography. Desulphurisation plant is to be provided if the sulphur - dioxide emission is higher than the norms.
Flue gases from the steam plant	High combustion efficiency > 90-95%, low fuel usage. Provide ESP's for particulate	Lowest coal requirement/steam consumption must be possible with the prevailing technology.

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	control.	ESP's are to be provided in the steam plant. High combustion efficiency of around 85-90% with coal as the primary fuel must be achieved. Possibilities for obtaining good quality coal or using good alternate fuels are to be explored. Green belt around the plant would be useful in curtailing the effect to smaller distance.
Steam vent	Proper pressure controller and improved steam consumption system to avoid the venting and stoppage of steam.	Microprocessor based control steam controllers can be provided with planned & scheduled plant stoppages.
Liquid effluents		
Through open drains	No water is discharged to the nullahs/rivers without treatment.	Zero discharge concept is to be adhered. In case of emergencies and/or disasters, provisions for neutralisation and discharge, is to be made under careful monitoring.
Through seepages in the plant and processing area.	To seal the caustic liquor seepages in processing area by providing compact floor foundations with sealant. To construct parapet walls with steel angles and underground drain channels to waste liquor tanks with recycle facilities to the process.	No seepage is to be allowed by providing proper foundation and precautions to be taken during construction. Effort should be made to reduce/eliminate instances of liquor spillage onto the floor. Test bore holes to monitor the caustic seepage at various places inside the plant should be made and systematic monitoring must be carried out.
Through seepages in red mud impoundment.	The proper clay lining to be provided to reduce the soil permeability to minimum. The liquor collection system to be provided underneath the soil bed as an additional precaution depending on site condition. With the provision of polyethylene liners in pond the seepage should be	Cell wise construction of red mud pond is to be preferred. The type of sealing made must be a combination of clay compaction and PVC linears of appropriate thickness such that seepage is negligible. The seepage limits practically reported in slurry impoundment is in the

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	around 0.5 m^3/hect./day with Na_2O content less than 0.8%.	range of 3-9 m^3/hect./day with out PVC sealant but can be reduced to the norm of 0.5m^3/hect/day with appropriate strength liners. The systematic water monitoring in underground borewells (preferably 400-500 meters between monitoring points) would enable to adopt viable and effective course of action in case of any untoward incidents (such as failure of the PVC lining). The above monitoring would provide sufficient time to install recovery bores, together with open drains and/or impermeable grout curtains to cut off the flow of contaminated water and return it to the safe residue pond area which is not leaking. Separate ponds provided for alkaline water (run off as well as pond overflow) are to be provided with PVC liners and proper drainage net with pumping facilities, so that all foreseeable due precautions are taken to reduce the seepage from the ponds to a minimum.
Through overflow from red mud pond or run off pond.	Additional pumping provisions for any untoward condition, such as cloud burst, heavy rainfall etc., from one pond to the other has been prodivded so as to manage the problem efficiently. To provide run off water pond with process recycle pumping facilities and acid neutralisation plant.	In case of any natural calamity, overflow/breakage of the bunds of the red mud pond, the overflow liquor should be pumped to the surge pond or be taken back to the refinery. In case of cloud burst etc., the dilution of the alkaline water would be to a maximum extent that the pH of the liquor cannot be more than 8.
Solid wastes		
Bauxite rejects in grinding	To be transported to the red mud pond or used for land	To be transported to the pond/bauxite yard selectively.

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Lime grits and rejects	To be used for land filling and temporary walk ways & used for soling prior to road construction.	Can be either transported to the pond or used for land filling in the plant or township approach roads.
Red mud	Securely stored as dry mud. Sprinklers are provided for abetting dusts in dry season. Research efforts to utilise bulk of the mud are being made. Revegetation of the area are being attempted. In dry disposal on land, the limit for seepage of water 3-9 m^3/hec./ day to maintain surface permeability of 10^{-7} cm/sec. with Na_2O content less than 0.8-1% without PVC sealants.	Dry mud disposal is to be planned. The mud surface should be dried hard enough to enable working with mechanical equipments. Dust abatement in the dry season with the help of sprinklers is to be provided. Revegetation is to be planned from the initial years itself. Research for bulk utilisation of the red mud is to be persuaded vigorously under a time bound program.
Ash	Ash disposal in slurry form in fully secured ponds is being practised. Spraying facilities in ash ponds for reducing the air borne particulate during dry seasons are to be provided.	Ash disposal only in dry form is to be made. Spriklers to be provided for reducing the dust from the pond in dry seasons. Utilisation aspects should be explored. The bulk use can be in the form of fly ash addition in brick manufacturing.
Noise		
Crushing and grinding (problem would be within the plant area only).	Safety equipments are provided to the workers. Minimisation of noise less than 60 db level to be maintained by proper and periodical maintenace of the communition equipments and steam & condensate system.	The noise level should be as low as possible as prescribed in equipment design. Where it is above acceptable norms (> 66 db) plant operators should be provided with necessary ear plugs. Plant availability factor must be maximised by adopting superior maintenance schedule. Steam header condensate line leakage to be rectified (selection of high life wire woven gaskets).
Compressor house (problem would be within the plant area only).	Safety equipments have been provided to the workers. Minimisation of noise less than 60 db by proper and periodical maintenacne of the equipments.	The noise level should be as low as possible. Where it is above acceptable norms (>60 db) plant operators should be provided with necessary safety equip-

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		ments like ear plugs. Low noise equipments with silencers are to be selected.
Blow down in steam plant (problem would be within the plant area only	Safety equipments provided to the workers. Operations are co-ordinated so as to reduce the frequency of blowdown by proper and periodical maintenance of the equipments.	The noise level at the plant boundary should not be more than 45-60 db. However, during blow downs more than 60 db even for very short periods is very common.
Digestor area steam header	The leakages should be minimised by maintaining the constant opening of steam valves through controllers.	Steam traps should be opened with slow and steady manual opening of steam inlets adhering to proper maintenance and process control.

CONCLUSIONS

From the above analysis of the possible areas of concern and the best possible solution under Indian conditions in relation to the best available in the world, it is evident that the enforcement authorities are required to make not only the proposed new alumina plants adhere to the above facilities even from the start-up but also make the old plants stick to a time bound schedule for providing the above facilities. This will not only clean up the environment in the nearest vicinity of the plant but also send the right signals to the local population and others that the producer of alumina are very much concerned about the environment. This will help the Indian alumina industry to state unequivocally the precautionary approach of the industry and its concern for the environmental issues. These are much more than the best being followed in the industry anywhere in the world. Added to this the proper approach in the area of worker's health, safety, rehabilitation and resettlement would enable to declare that the industry is in pursuit of excellence in the area of community service and environmental protection.

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