Bauxite Mining: An Engineer's Perspectives

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The term bauxite ore is defined by Valeton (1972) as bauxites which are economically mineable at present or in the foreseeable future, containing not less than 40-50% Al_2O_3 and not more than 20% Fe_2O_3 and 3-5% combined silica. Most bauxite samples found in Kuantan area are within this definition as investigated by Rajah (1986). Indeed, as the Kuantan bauxite is characterised by a high ferric oxide content, it may be termed as ferruginous bauxite. It is conservatively estimated that the Kuantan deposit may contain approximately 70 million tons of crude, mainly low to medium ferruginous bauxite.

As reported in the Press, mining activity was carried out within 238 hectares in Felda involving 70 land titles without any Environmental Impact Assessments (EIA) since individually these were less than 250 ha 3 each. Before 15 January 2015, a full blown mining operation was going on in Bukit Goh near Gebeng, Kuantan, with crushers and excavators running 24 hours a day, seven days a week.

Haul trucks then carried the bauxite ore to Kuantan Port for storage before delivery to China. Between January and April, 2015, 4.6 million tonnes were exported to China. From April 2 to May 23, 2015, the Pahang authorities inspected 43,278 bauxite lorries (an average of 816 a day) which were using the roads in Kuantan.

The annual output of bauxite went up from slightly over 200,000 tonnes in 2013 to nearly 20 million tonnes last year. Malaysia is now the world's top producer, accounting for nearly half of the supply used in China's massive aluminium industry.

With this surge in activity and without the impacts prediction and mitigating measures as normally required in EIA, there were noticeable damages to the environment, namely physically, biologically and socio-economically. To address these issues, here are suggestions for consideration.

PHYSICAL ENVIRONMENT

Land-use Compatibility: For any activity to be carried out it must be compatible with present land use of the area. There should not be any conflict with the present land usage and in most cases, it is much easier if it is compatible but, if it is not, then mitigation measures must be carried out or the activity should not proceed at all.

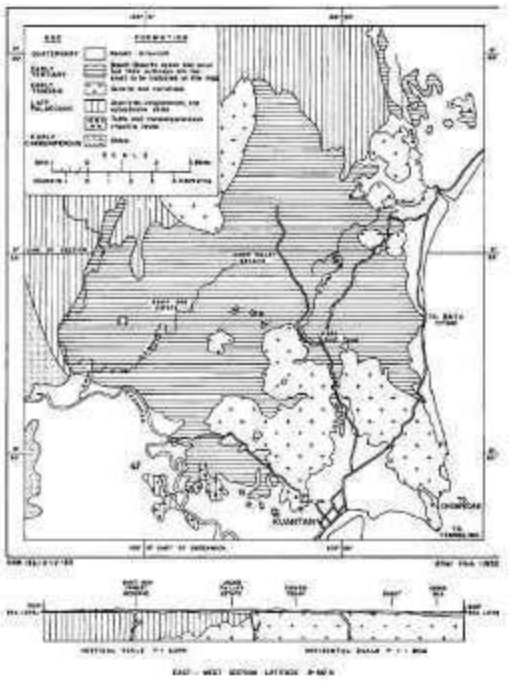

Fig.1: Geological map of the Kuantan area and cross-section of the Kuantan Basalt and Associated (Dolorite) DYKE (Rajah, 1986)

The land where the bauxite is found, is largely underlain by basalt. The present land-use is mainly oil palm and rubber plantations with primary and secondary forest in the northern part. The area of interest is clearly not in the forests away from populated settlements. Therefore, the activity should be done in phases and in a controlled fashion so as to not disrupt the present land-use pattern.

Hydrogeological: The analysis of the watershed affected by any activity has to be done, especially where the earth would be disturbed.

Activities like mining will normally result in an increase in runoff from the site. Prediction on the impact to the water courses can be made with respect to the changes in Water Quality Index (WQI) and mitigating measures have to be carried out. Some of the measures, with respect to mitigating the increase of suspended solids in the receiving streams, will be soil erosion and sediment control. The control is done through erosion and sediment control plans submitted by accredited Certified Professionals in Erosion and Sediment Control Plan (CPESC). Structural measures include source control (slope stabilisation), diverting the stream away from the disturbed areas, sediment fences and lastly, the sediment basin.

It is anticipated that suspended solids concentrations and hence turbidity of the water in the downstream rivers, would increase due to these earth disturbances. Use of unpaved roads, notably by heavy vehicles and during the rainy season, will lead to road damage and increased sediments in surface run-off. The extent of the increase will be influenced by the type of soiland weather conditions.

Monitoring of WQI will be carried out during pre-earthwork and earthwork and audited throughout. Any point and non-point sources of pollution must also be monitored so that these will not contribute to other parameters in the WQI such as BOD, COD, DO and ammoniacal nitrogen and phosphorus. The latter can lead to algal blooms in the receiving water body. The effluent from point sources must comply to whether it is above (Class A) or downstream (Class B) of the water intake point.

Air Quality: Similarly, the ambient air quality must be measured against Air Pollution Index and the parameters are measured before, during and post-operation. For this particular activity, Total Suspended Particulates (TSP) will be the concern because it can affect the API significantly. The other control is on dust emission from the movement of lorries and other vehicles.

The compliance and mitigation measures for physical environment can be simplified as follows:

ACTIVITIES & CONTROL MEASURES
Construction of drainage for all cut and fill slopes should be carried out immediately to prevent soil erosion and formation of deep gullies.
Surface and storm water runoff from the work sites should be channelled into proper drains and finally into the silt traps before it is discharged into waterways.
Silt traps must be constructed to maximise retention time and water discharge be directed through an overflow weir/perforated pipe and onto rock gabion to reduce any potential for erosion of the banks of the waterways.
Regularly spraying of water using water browsers shall be undertaken over the temporary access and logistics roads and other barren areas of the site. This should be carried out daily during the dry season.
Control of dust levels by watering, road maintenance and speed limits.

BIOLOGICAL (FLORA & FAUNA) ENVIRONMENT

The main vegetation communities include abandoned fruit orchards, rubber and oil palm plantation, bushlands and overgrown pasture for grazing livestock. The vegetation on the site is a result of anthropogenic influence and change in land use and land cover.

The tree data from secondary forest adjacent to the site can be analysed to determine the species diversity of the area. Diversity indices provide important information on the rarity and commonness of species in a community. The most common measurement is the Shannon Weiner diversity index which can be used to compare diversity between habitat types.

The comparison can be between different habitats or a comparison of one habitat over time.

Shannon Weiner diversity index (H') is calculated using the following equation:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

where s = the number of species

$$pi = n_i/N,$$

n_i=total number of individual the ith species, and
N=total number of individual of all species

Indices of biodiversity can be used to measure forest structure. Higher values of diversity index represent greater stability of community structure (Kohli *et al.*, 1996).

The compliance and mitigation measures for biological environment can be simplified as follows:

IMPROVEMENT AND MITIGATION MEASURES	
DURING MINING	**POST MINING OPERATION**
• Retain depression on site to capture runoff Retain existing well grown trees • Protect trees fromdamage • Erect fences and signs • Use silt fencing to avoid runoff • Maintain forested corridors	• Adopt "tree campus" concept • Replant similar trees • Introduce new trees • Quick revegetation of used/backfilled areas and soil • stockpiles with soil binding species • Establish tree buffer zone • Introduce enrichment planting programme • Implement afforestation programme • Retain, enhance and restore riparian habitats • Erect appropriate fences; continuous maintenance required • Continuously maintain the cleared zone outside the fence • Encourage local community participation
PRIOR TO MINING	
• Proper landscape design and habitat rehabilitation • Collaboration with potential stakeholder	

SOCIO-ECONOMIC SETTING

Land development and infrastructure. Any land development must comply with the National Land Code and an activity such as mining should be carried out when the land is designated for mining and not for agriculture or plantation use. There must be also a provision for investment in infrastructure so as not to burden the present road network. Traffic management must also be properly instituted.

The compliance and mitigation measures for socio-economic setting can be simplified as follows:

BEFORE OPERATION/ EXTRACTION	DURING AND POSTOPERATION
• Consultation on bauxite mining issues is important to reduce the negative social impacts of mining. • Local communities need to be empowered when decisions are made about natural resource management that affect them. • Invest in infrastructure development that benefits the communities. • Assessment of social impact and community engagement.	• Provision of compensation for those disadvantaged or displaced by the mining operation. • Fully integrated rehabilitation programme • Rehabilitation objectives must be clearly defined. • Standard rehabilitation procedures. • Monitorand report rehabilitation results. • Long-term or completion plan (self-sustaining system). • Considerable financial provision for rehabilitation. • Agreement on final land use with other stakeholders. • Vegetation salvaged for use before mining.

CONCLUSION

The ecological concerns should be given a practical shape in any ethical decision. This value-centred concern has the ultimate objective for the universal common good of all beings. On the basis of the principle, that the repelling of mischief is preferred to the acquisition of benefits, we can build the theory of abuse of rights governing the relations between neighbours. It provides that a person could be denied the exercise of a right if it causes excessive damage to others.

An activity or industry causing excessive environmental pollution, or other public damage might be stopped or curtailed even though this may cause economic loss to the owners of the business. A wrong must be redressed for the sake of justice, even though there may be economic benefits in the perpetuation of the wrong. The optimum point E, decided by people, is the choice for a balanced approach. Any activity which cannot be mitigated with minimum damage and at affordable cost, must not be allowed to proceed. ■

REFERENCES

[1] Kohli, R. K., Singh, H. P. and Rani, D. 1996. Status of floor vegetation under some monoculture and mix culture plantations in North India. Journal of Forest Research. 1: 205–209.

[2] Rajah, S.S., (1986).GEOSEA V, Proceedings \Vol.1,Geol. Soc. Malaysia,Bulletin 19, pp. 315-325.

[3] \Aleton, I., (1972).Bauxites. Elsevier Publishing House, Amsterdam, 226p.