

ENVIRONMENTAL IMPACT ASSESSMENT OF LIMESTONE MINING PROJECT

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ABSTRACT

An Environmental Impact Assessment study was undertaken for the proposed limestone mining project of Lum Mawshun Minerals Private Limited, Meghalaya at Nongtra village of Meghalaya. The study examined thoroughly various technical aspects of the mining project for a realistic assessment of its likely impact on the environment and people of the project area. Baseline data of the project area such as, climate, topography, geology, soil, hydrology, landuse, vegetation, flora, fauna, socio-economic condition of the people and the problems faced by them, meteorology, air quality, and water quality of the streams and rivers flowing in the project area were collected. Positive and negative impacts of the mining operation were critically examined. Expected level of pollution and changes in air quality, hydrology, hydrogeology, water quality, noise and vibration levels due to mining were predicted. Impacts of storing and various hazardous materials as well as deposition of mining wastes were also assessed. Social and economic impacts of the project were critically analysed. Extensive interaction with the affected populations and traditional institutions such as village durbars was undertaken in order to address adequately the local problems likely to arise out of the mining project.

Although the impact of the project on the environment was considered minimum and no serious consequences was visualised, an environmental management plan was prescribed to compensate the impact. Besides, mitigation measures for each of the above aspects were suggested to reduce the impact of mining operation on the surrounding environment. Associated occupational health and safety measures required to be taken were also outlined. The environmental management plan induced various activities like, reclamation of mined areas, establishment of a green belt, conservation of a biodiversity-rich pocket identified within the mining area and compensatory afforestation.

INTRODUCTION

Some of the environmental concerns pertaining to the mining of limestone are : i) surface and ground water pollution ii) solid waste management iii) land degradation iv) air pollution v) noise and vibration vi) subsidence and land slide vii) displacement of human settlements viii) impact of mining on the hydrology and water regime ix) leaching of toxic elements from waste dump. In view of the above environmental implications, the Ministry of Environment & Forests, Govt. of India has placed the mining of limestone under Schedule I of the Environmental Impact Assessment Notification, 1994. It is mandatory to undertake a EIA study to identify all the environmental concerns related to the project so that the required mitigation measures are incorporated during the planning and implementation phases of the mining operation (Anonymous 1981, 1994). The EIA intends to analyse and assess all the environmental implications of the project and suggest various remedial/mitigation measures to minimise/neutralise the impact of mining on the environment.

The present paper describes the methods and findings of an Environmental Impact Assessment study carried out for a limestone mining project in Meghalaya. Based on the findings, the study recommends various mitigation measures and a comprehensive environmental management plan to minimize the environmental impact of the mining operation.

STUDY SITE

The EIA was conducted in the proposed limestone mining site of Lum Mawshun Mineral Pvt. Ltd. (LMMP), Meghalaya, located in Phlangkaruh area. The site is situated on the western side of Umiarn river at an aerial distance of about 2 km from the river bank immediately to the north of Shella - Hat Mawden - Balat border road section which runs along Indo-Bangladesh border. The area is located between the latitudes 25° 11' 18" and 25° 11' 55" N and longitudes 91° 37' 57" E (approximately). The mining site can be reached via Cherrapunjee, which is 55 km away from the site. The other alternative approach to the area by road from Shillong is via Mawsynram. The important settlements within the 10 km radius of the proposed mining site are, Shella bazar, Pyrkan, and Phlangkaruh village. An area of 100 ha has been acquired by the LMMP on lease basis for mining. There is no archeological or historical site within 10 km radius of the mining site.

CLIMATE

The project site is situated at an altitude of 180 m asl. The maximum and minimum temperature vary between 25-30°C and 13-25°C, respectively. Winter (December to February) is moderate. During rest of the year the weather remains hot and humid. The relative humidity at 6 am varies between 83 and 98%. The area receives an average annual rainfall of 4456 mm, most of which occurs during the monsoon season (May-September). The wind direction during January to March is south-easterly, while from April to December the direction is north-easterly. The wind varies between 15-30 km/hour.

REASONS FOR SELECTING THE SITE FOR MINING

The site was selected for commercial mining due to the following reasons:

- i) The site had commercially viable limestone deposit and the decision to carry out mining was taken after thorough consultation with the concerned village durbar, the custodian of the land. The land was left unused covered with degraded forests and, therefore, the site was preferred by the durbar to lease out the same to LMMPL for mining.
- ii) Other factors responsible for selecting the proposed site are: availability of water source, away from the human habitation, closer to the Islam Cement Limited Plant site at Chhatak, easy accessibility by road, less vegetation clearing and minimum damage to the rich biodiversity as the area was at the outskirts of the forest.
- iii) As per the data obtained from the chemical analysis of bore hole logs, the average core quality of the limestone obtained from the project site is as follows: CaO - 51.9%, MgO - 1.08%, SiO₂ - 1.96%, Al₂O₃ - 1.05% and Fe₂O₃ - 0.60%. The overall quality of the lime stone is considered to be good.

DESIGN OF THE LIMESTONE MINING PROJECT FOR WHICH EIA WAS CONDUCTED

The process of limestone mining consists of the following steps : (i) Drilling to place of explosives; (ii) Exploding mines; (iii) Crushing and screening to get proper size; (iv) Transporting and loading into the tram cars of the rope-way. The open cast method of mining by deep hole blasting was to be adopted and limestones were planned to be excavated with the help of heavy earth moving machineries. The blast holes were of 11 m depth and 115 mm dia. The holes will be in two rows. In the first row, the burden will be 5 m and spacing 6 m. The second row will be 4 m from the first row and spacing of holes will be 6 m. Blasting will be done once in a week. The charge shall be made up of 40% slurry explosive at bottom charge and 60% ANFO (Ammonium Nitrate Fuel Oil) explosive as top charge. The powder factor as commonly adopted for limestone will be 0.35 kg/m³. Thus the charge per hole will be 80 -90 kg and explosive required per week 2940 kg of which 1176 kg will be slurry explosive and 1764 kg will be ANFO. In a typical blast, the charge in each hole will be initiated by detonating fuse connected to a trunk line with one trunk line for each row. Each trunk line will be connected to separate millisecond delay detonators of connected to an exploder. To minimize vibration, delay detonators will be used whilst throw of material will be controlled by using inclined blast holes 60° to 70° from horizontal. As very few detonators and no nitro-compound explosive shall be used, there will be less noise.

The projected average production of the mine is 2450-3000 tonnes per day. On this scale of production, the quantity of waste to be handled will be about 540 tonnes per day. The mine would be designed to have a capacity to handle about 3500 tonnes of Limestone and waste per day. Year-wise limestone production is given in Table - I.

TABLE - I.

YEAR-WISE LIMESTONE PRODUCTION FOR THE FIRST FIVE YEARS

Year	Limestone (tonnes)	production (volume m ³)	Waste (tonnes)
I	160,000	400,000	32400
II	320,000	800,000	64800
III	320,000	800,000	64800
IV	320,000	800,000	64800
V	320,000	800,000	64800

METHODS

The EIA study was conducted through extensive field visits, Interaction with the villagers, and collection and analysis of soil, air, water and vegetation samples. The baseline data for the study was collected from the area encompassing Phlangkaruh and Nongtrai villages and their surroundings extending over 10 km radius of the project site. The entire study area was about 315 sq. km and about 60 hamlets and villages were scattered over this area.

Soil Analysis

In order to get an over all picture of soil characteristics, samples were collected from crevices, hill slopes and foot-hills of the project area. These were analysed for a few important physico-chemical properties following standard analytical methods (Allen et al. 1974).

Faunal Inventory

List of avifauna was prepared by observing the birds by a binocular during the morning (7-9 am) and in the evening (4-6 pm) from a view point located 200 m uphill from the mining site and also on the basis of published literature.

Measurement of Air, Temperature, Relative Humidity and Wind Speed

A wet and dry bulb thermometer was used for recording of ambient temperature and humidity at hourly interval collected for 24 hours during March and April, 1997. Wind speed and direction were monitored using automatic cup-counter anemometer with wind vane facility. The equipment was placed at a height of 3 meters from the ground level and the data were recorded for 24 hours at 1 hour interval. A precision Barometer was used to observe the changes in the atmospheric pressure during ambient air sampling.

Ambient Air Sampling and Analytical Procedure

The Shella Bazar was chosen as a buffer zone for ambient air quality monitoring as this is the nearest populated and the biggest commercial centre situated in the South-East direction of the proposed mining site at a distance of about 2 km. The other station was at the proposed mining site in Phlangkarush village for determining concentrations of SPM, SO₂ and NO_x. The ambient air quality samples were collected in the months of March and April, 1997 as per the norms fixed by the Central Pollution Control Board, New Delhi. The sampling was performed for 24 hours in a manner that 3 sets of 8 hourly samples covering day and night periods could be collected for SPM. Six sets of 4 hourly samples were collected simultaneously for SO₂ and NO_x.

At both the stations, 24 hours sampling period was covered with 3 consecutive 8 hourly sets described as (12 am - 08 pm, 08 pm - 04 am, and 04 am - 12 am Shifts) for SPM and 6 consecutive 4 hourly samples

(12 am - 04 pm, 04 pm - 08 pm, 08 pm - 12 pm, 12 pm - 04 am, 04 am - 08 am, 08 am - 12 am) for SO_2 and NO_x .

Suspended Particulate Matter (SPM)

The ambient air sampling was done using High Volume Sampler (HVS, Envirotech APM 410). The sampler draws ambient air through pre-weighted glass fibre filters of 20x24 cm size at a flow rate ranging from 1.1 to 1.6 Cum per minute. The samplers are provided with specific angled housing which ensures pre-separation of suspended particles larger than 100 microns diameter before ambient air samples comes in contact with the filter surface. EPM 2000 glass fibre of Whatman make were used for sampling. The HVS were operated continuously for 24 hours and 3 sets of 8 hour samples were collected for SPM by changing the filter papers in each shift of 8 hours. The flow rates were measured at the beginning and in the end of each set of sample. The volume of air sampled was calculated from average flow rates during the sampling period. The SPM concentrations were calculated from the mass of the dust collected and the volume of air sampled. The results are presented in $\mu\text{g}/\text{Nm}^3$.

Sulphur Dioxide (SO_2)

The improved West and Gaeke Method as recommended by the Central Pollution Control Board, New Delhi was adopted for sampling and analysis of SO_2 concentration in the ambient air. The ambient air was drawn at a controlled rate of 1 litre per minute (LPM) through 0.1 M sodium tetrachloromercurate solution in impingers. The sample was collected for a period of 4 hours. SO_2 in the ambient air sample was absorbed in the absorbing solution. The procedure results in formation of dichlorosulfitomercurate complex. After sampling, the sample solution was first treated with sulphuric acid solution to destroy the nitrite anion formed due to absorption of the oxides of nitrogen present in the atmosphere, then it is treated with formaldehyde and specially purified pararosaniline hydrochloride. Pararosaniline, formaldehyde and bisulfite anion react to form an intensely coloured pararosaniline methyl sulfonic acid. The absorbance of this solution was measured at 575 nm wavelength with the help of UV-Visible Spectrophotometer (HITACHI U2000) and the results are presented in $\mu\text{g}/\text{Nm}^3$.

Oxides of Nitrogen (NO_x)

Jacob & Hochheiser modified (Sodium Arsenite) Method was employed for the sampling and analysis of the ambient NO_x concentration. The ambient air was sampled at a controlled rate of 1 LPM through Sodium hydroxide Sodium Arsenite solution in an impinger. The air was sampled continuously for 24 hours and 6 sets of 4 hourly samples were collected. During the sampling ambient NO_x was converted into Sodium nitrite. After sampling, the absorbing solution is treated with solutions of hydrogen peroxide, sulphanilamide, and NEDA (N-1 Naphthylethylene diamine dihydrochloride). The absorbance of nitrite ion in the solution thus formed was measured with the help of UV-Visible Spectrophotometer (HITACHI U2000) and the results are presented in $\mu\text{g}/\text{Nm}^3$.

Water Sampling and analytical methods

Water sampling of the two rivers was done in the months of March and April, 1997. Water temperature, pH, conductivity were recorded on the spot using a Water Analysis Kit. Dissolved oxygen was fixed on the spot. The samples were preserved as per the requirement of testing of the specific parameters. The analysis of the collected water samples was performed according to the Standard Methods for Examination of Water and Wastewater (APHA, 1985).

RESULTS

BASELINE DATA

Soil

The entire hill slope is practically devoid of soil having typical karst topography. The soil in the crevices is sandy clay loam in texture, whereas on the hill-slopes and foot-hills, it is sandy loam. The soil reaction is

near neutral to alkaline with pH ranging from 6.93 to 7.86. The soil accumulated in rock crevices is rich in organic carbon, organic matter, total nitrogen and available phosphorus. Cation exchange capacity of soil is fairly high (Table II).

TABLE - II

PHYSICO-CHEMICAL PROPERTIES OF SOIL AT THE PROJECT SITE

Parameters	Crevices	Hill Slope	Foothill	Mean
Texture				
Clay(%)	17.46 ± 0.83	11.20 ± 0.70	7.6 ± 0.69	12.09 ± 2.87
Silt(%)	14.82 ± 0.58	8.84 ± 0.70	17.81 ± 0.00	13.82 ± 2.63
Sand(%)	67.72 ± 0.65	79.95 ± 1.22	73.86 ± 0.00	73.84 ± 3.53
Textural Class	SCL	SL	SI	SL
Moisture content (%)	30.72 ± 0.20	28.80 ± 0.02	27.34 ± 1.99	27.72 ± 1.99
pH	6.93 ± 0.03	7.086 ± 0.01	7.67 ± 0.02	7.48 ± 0.28
TKN (%)	3.48 ± 0.02	3.28 ± 0.03	1.96 ± 0.02	2.91 ± 0.47
Organic Carbon (%)	2.69 ± 0.02	2.58 ± 0.02	1.54 ± 0.02	2.27 ± 0.36
Available Phosphorus (%)	0.04 ± 0.0003	0.04 ± 0.001	0.04 ± 0.0003	0.42 ± 0.002
CEC (m.eqv. %)	14.56 ± 0.03	14.53 ± 0.02	14.82 ± 0.01	14.73 ± 0.010

+ = S.E.; CEC = Cation Exchange Capacity; SCL = Sandy clay loam; SL = Sandy loam; TKN = Total kjeldahl nitrogen.

Land Use

Landuse in and around Nongtraï village can be divided into two major categories: (i) land used for agricultural purposes, and (ii) land under forest cover. The details of landuse in the study area is presented in Table III.

TABLE - III

LANDUSE IN THE EIA STUDY AREA (BASED ON IRS - 1B DATA-DECEMBER, 1994).

Landuse	Area (sq. km)	Per cent of total area
Settlements	5.42	1.72
Agriculture	82.63	26.30
Grass/Shrub	14.61	4.65
Forest	188.33	59.95
Sandy river bed	1.82	0.58
Limestone	21.35	6.80
Total Area	314.16	100.0

Forest, covering about 60% of the total area within 10 km radius is the dominant land use of the area. Agriculture is the next important landuse in the area. Most agricultural lands are situated in the plain areas adjacent towards southern side of the project site near the Bangladesh border. Rice is the principal crop. On

hills the agricultural land is negligible. The principal land based economic activity of the people is plantation of betel nut, oranges and betel leaf. These plantations are interspersed with natural forests and provide a dense vegetal cover to the land. The open forest, covering the limestone area constitute about 7% area within 10 km radius of the proposed mining site.

ECOLOGICAL ASPECTS

The vegetation of the area is a tropical semi-evergreen forest composed of deciduous and evergreen tree elements. The plant species in the forest are distributed in three distinct layers, the top layer is composed of sparsely distributed tall trees, the middle layer composed of young trees forms a dense canopy at many places. This layer is characterised by the presence of large number of lianas, the third and lower layer is represented by shrubs and herbs. The shrubs are scattered and the herbaceous species are limited in number. The low number of herbs and their poor growth are mainly due to the lack of soil. Majority of the valuable timber trees have already been extracted from the mining site.

Plants are restricted to the crevices and on the gentle hill slopes where there is some soil. The distribution and occurrence of plants appear to be mainly dependent on the soil depth and its fertility. The site provides a wide variety of habitats ranging from deep gullies having thick deposit of moist and nutrient rich soil to dry and exposed rock surfaces without any soil cover. As a result, diverse kinds of plants, ranging from massive trees (d.b.h. of up to 235 cm) and lianas to xerophytic euphorbias were growing on the site. Woody plants growing on rocky substrata have developed interesting root and stems forms. High humidity during most part of the year are responsible for luxuriant growth of epiphytic orchids and ferns in the forest. Wild bananas were also present at many places, particularly where there was some deposition of soil. Small amount of humus rich soil accumulated in the fissures and depressions provided favourable sites for germination and establishment of a variety of plant species. The plants have adapted themselves in such a way that they are able to grow luxuriantly in very limited soil volume. Plant litter accumulated in the pockets provide necessary nutrients to plants by a faster rate of decay due to high temperature and rainfall. It appears that a closed nutrient cycling prevailing in the depressions favours the growths of trees. Presence of a good number of serophytic species in the vegetation indicates limited availability of soil water.

Frequency distribution of d.b.h classes reveals abundance of young trees in the project site. The average tree density in forest is 4 trees/m² and average basal cover is 185 sq. cm/m². The average d.b.h. of cut stumps is 83 cm (Table - IV).

TABLE - IV

AVERAGE DENSITY, BASAL COVER AND D.B.H. (DIAMETER AT BREAST HEIGHT) OF THE TREES PRESENT AT THE MINING SITE

Average tree density (No. of trees/m ²)	366.00
Average basal area (cm ² /m ²)	185.37
Average diameter of tree stumps (cm)	83.10

Flora

An inventory of flora of the project area prepared on the basis of field survey. The site is mostly covered with pole size trees, shrubs and herbs. However, some small patches of dense forests exists at a few places particularly near the cavern in the extreme southwest of the site where a large number of old trees and a wide variety of shrubs, herbs, epiphytes, pepper, canes, palms, medicinal plants and lianas are present. Such forest patches are dominated by trees like *Trema* sp., *Duabanga grandiflora*, *Firmiana* sp., *Ficus* spp. and different species of palms. Many economically important species such as *Albizia* spp., *Kydia calycina*, *Hibiscus macrophyllus*, *Anthocephalus chinensis*, *Duabanga grandiflora*, *Gmelina arborea*, *Teramelos nudiflora* were found at the project site.

Other important tree elements in the forests are *Castanopsis* spp, *Elaeocarpus* spp, *Ficus* spp, *Heritiera* sp, *Sterculia* sp, *Toona ciliata* and tree members of Rubiaceae. Luxuriant epiphytic growth of ferns and orchids

was seen at the site. The wood rotting fungus, particularly the members of Polyporaceae were common in the dense forest patches. The floristic data furnished in Table V clearly indicates that the forests at the study site is rich from the point of view of plant biodiversity.

TABLE - V
 FLORISTIC COMPOSITION OF VEGETATION AT THE MINING SITE

Vegetation component	Number of species
Tree	39
Evergreen	22
Deciduous	16
Shrubs	19
Herbs and under shrubs	10
Climbers and Lianas	24
Epiphytes	15
Rare and wild relatives of crop plants	14
Total	120

Fauna

Terrestrial Insects, arthropods, mammals, reptiles and amphibians were observed during weekly field trips undertaken for this purpose. Fishes and other aquatic fauna were recorded during the day time in the Phlangkaruh river.

Folklores related to animals were used as a key to identify the fauna of the area. The older folks and other knowledgeable persons of Nongtrai and Shella villages were also consulted for this purpose. For soil fauna, samples were collected from 5 km away from the mining area, and from four different depths, i.e. 0-5, 5-10 and 15-20 cm at the mining site. From these soil samples insects the arthropods were extracted using the common light extraction method. For collecting nocturnal insects, light traps were used, employing a petromax near the mining area. The traps were of white porcelain trays half filled with water and surface covered by kerosene. Four traps were set from 6 p.m. to 4 a.m. Summary of the observations are furnished in Table VI.

TABLE VI
 SUMMARY OF FAUNAL COMPOSITION OF THE EIA STUDY AREA

Class	Important Species
Mammals	Civet Cat Large black squirrel
Avifauna	44 species
Reptiles	Snakes Python (<i>Python molurus</i>) Lizards (<i>Lacertilla spp.</i>)
Snails and Fishes	Snail (<i>Limnea spp</i>) Fishes (<i>Garra gotyla, Neolissochelius, Hexagonolepis, Danio dangila, Channa spp.</i>)
Amphibians	<i>Limnonectus Limnocharis</i> Hyla spp <i>L. cyanaophlyctis</i> Rana spp.
Soil Insects	Insects 24 Species Spider mites Termites Ants

SOCIO-ECONOMIC CONDITIONS

Population Structure and Habitation

As the area of study falls under East Khasi Hills district, about 80 per cent population belong to Khasi tribe. The people settled on southern slope are called War Khasi. A segment of garo ethnic group and Bengali linguistic group migrated from Bangladesh form about 20 per cent of the total population. The immigrant people are engaged in mining and trades while indigenous War Khasis are engaged in agriculture. Besides agriculture, areca nut, betel leaf and orange gardening are parts of their economic activity. Khasi is the main language of the area.

The hamlets and villages are nucleated in pattern. There are about 63 villages within 10 km radius of the proposed mining site near Nongtraï area. The river Umiam divides study area into two halves. The eastern part falls under Shella-Bholaganj C.D. Block while the western part falls under Mawsynram C.D. Block. The average family member in a household varies widely in both C.D. Block. The population growth in the villages of Shella-Bholaganj C.D. Block during the last decade (1981 - 1991) was 1.77 per cent while the growth in Mawsynram C.D. Block was 6.05 per cent. This growth rate is far below the Meghalaya's average of 32.86 per cent. The total estimated population within 10 km radius of the mining site (only in Meghalaya side) is 16,487.

Social Setup of Nongtraï Village

Nongtraï is one of the mine villages of Shella confederacy. According to a census conducted during 1997 there were 106 households with a total population of 627 persons in Nongtraï. The average population distribut on comes to about 6-7 persons per household. The range varies from 3-8 per household.

Nongtraï is neither a mono-clan village nor any single clan could be identified as numerically dominant. Our respondents belonged to Khasi tribe but they had different religious affiliation; e.g. 50% Presbyterian, 30% Church of God, 10% Catholic and 10% indigenous Khasi faith.

About 15% of the population was below 14 years of age, 20% were between 15 to 25 years, 20% were between 26-45 years, 20% were within 46-65 years of age and the rest were above 65 years of age. More than 3/4th of the village population was young in age.

The literacy rate in the village is 75%. Two lower primary schools, one managed by the District Council and the other by Roman Catholic Church, and a Middle English school managed by the village have contributed to the high literacy rate of the village. Majority of school going students discontinue their studies after completing lower primary and middle level education due to lack of motivation and financial constraint. Even, under such constraints the village has produced graduates in different fields.

Majority of population depend on agriculture/horticulture. The produce include, betel nut, betel leaf, oranges, wild pepper, broom and bay leaf. Some household having private forest have entered in timber trade. A small number of persons are engaged in local trades. Only few persons are in Government services.

Administrative Set Up

The political administration of the village is directly linked to the Shella confederacy. The confederacy is headed by a Chief known as Wahadar. Under Wahadar there are village chiefs or Headmen. The headman is elected by the village council. The village council has two committees: (i) Special Affairs Committee relating to boundary disputes, and (ii) Local Affairs Committee relating to Government Schemes and methods of implementation. The members of both the committees are selected by the village council. The village council selects two prominent members as its representative to the Wahadar Durbar.

Problems

The problems faced by the villagers are stated below :

- i) There is no water supply for the village. This poses tremendous difficulty for domestic hygiene and sanitation.
- ii) The production of plantation crops has shown a declining trend during the last six years due to various crop diseases.

- iii) The price of the crop products is controlled by the market forces. As a result, the planters do not get remunerative prices of their produce.
- iv) Although the village is connected by road, there is lack of public transport facility.
- v) Availability of limestone within the village is seen as a potential source of income generation but due to lack of cooperation of the Shella village in allowing transportation passage for limestone, the residents of Nongtraï are facing hardships.
- vi) Medical and health care facilities are available through a Public Health Care Sub-Centre but it is not able to handle even common diseases such as fever, malaria, dysentery, and other related stomach ailments.

Economic Condition

In a household, normally all the members are not engaged in economically remunerative activities. The ratio of non-earning members to the earning members is a good measure of the degree of dependency in the family. The ratio varied between 1-3 in about 50% of the family in the villages. Dependency ratio was higher in the large families.

Employment

Agriculture and plantation labour, mine labour, porters and small trade are the major employment opportunities available for the villagers. The normal wage rate for unskilled male labour is Rs. 60-70 per day and for female labour Rs. 35-40 per day. The skilled labourers may get up to Rs. 90-100 for a day's work. The employment is available only for 8 to 9 months in a year.

Socio-economic Infrastructure

Health, education and sanitation are the major components of social infrastructure, whereas road, power and other civic facilities are the part of economic infrastructure. Most of these infrastructural facilities are not available to the villagers living near the project site. For example, Primary Health Centre is 4 km away from Shella Bazaar, and the nearest hospital is 55 km away from the Shella bazaar at Cherrapunjee. For drinking water most of the villages are solely dependent on natural sources. During dry season, people face acute shortage of water. Though most of the villages are electrified, the supply of power is very irregular. Shella Bazaar has a branch of State bank of India, a police thana, custom office, a veterinary centre and a post office.

Meteorological Data

The international border of Bangladesh is 2-5 km away in the southern direction from the mining site. The Chhatak District of Bangladesh being close to the proposed mining place, the weather conditions at Chhatak would be more similar to the weather of mining site. Therefore, meteorological data consisting of Ambient Temperatures, Relative Humidity, Average monthly Rainfall, Wind Speed and Wind Direction recorded by Envirocare (Pvt) Limited, Dhaka for preparation of Environmental Impact Assessment Report for Islam cement Limited have been considered.

The average monthly ambient temperature ranges from a minimum of 13.4°C in the month of January to a maximum of 32.8°C in the month of April. The average monthly relative humidity recorded at 6 P.M. ranged from of 51% in March to a 85% in September. The average relative humidity at 6 A.M. ranged from of 83% in March to 97% in July. The average annual rainfall was 4456 mm. Though there is some rainfall in every month, most of it occurs between May and September. The average wind speed is relatively high and it ranges from a minimum of 9.4 km/hour in the month of August to a maximum of 27.2 km/hour in the month of March. Wind blows in South-East direction during monsoon and in the North-East direction during winters. Some meteorological data recorded on hourly basis during the ambient air quality samplings in the months of March and April, 1997. The ambient air temperature in March, 1997 varied from a minimum of 13.0°C at 3.00 A.M. in the morning to a maximum of 34.0°C at 3.00 P.M. in the evening. The ambient air temperature recorded in April, 1997 varied from a minimum of 17.8°C at 3.00 A.M. in the morning to a maximum of 32.6°C at 1.00 P.M. in the afternoon.

The relative humidity in March, 1997 varied from 50% at 1.00 P.M. to 99% at 2.00 A.M. In April, 1997 the minimum relative humidity was 62% at 1.00 P.M. and maximum (96%) was at 3.00 A.M. The wind speed in March, 1997 varied from a minimum of 2.0 km/hour at 5.00 P.M. in the evening to a maximum of 28.9 km/hour at 2.00 A.M. The minimum wind speed recorded in April, 1997 was 2.88 km/hour at 9.00 A.M. and maximum 11.9 km/hour at 11.00 P.M. at night.

Air Quality

Data collected during dry months (March - April, 1997) for SPM, SO_2 and NO_2 were found to be well within the prescribed Ambient Air Quality Standards. These months represents the dry period of the year and the concentrations of SPM and the other gaseous pollutants were expected to be maximum during this period.

This place is located in the remotest part of Meghalaya and except a few small traditional lime kilns and scattered limestone quarries there is no industrial activity in this area. Therefore, it is highly unlikely to get any of air pollutants in the wet period of the year lasting for about 6-8 months in a year.

At mining site maximum SPM concentration of $50.3 \mu\text{g}/\text{Nm}^3$ for Shella bazaar was recorded during April, 1997 at 12 AM-08 PM shift and a minimum SPM of $32.3 \mu\text{g}/\text{Nm}^3$ here was recorded in 08 PM-04 AM shift in March, 1997. At the mining site maximum SPM concentrations for the proposed mining site was recorded in 12 AM-08 AM shift in March, 1997 and a minimum of $22.8 \mu\text{g}/\text{Nm}^3$ in 08 PM-04 AM shift in April, 1997.

The maximum SO_2 concentration of ($4.8 \mu\text{g}/\text{Nm}^3$) in Shella Bazaar was recorded in 12 AM-04 PM in April, 1997 and a minimum of BDL (Beyond Detectable Limits) was recorded mostly during the night shifts in March and April, 1997. The maximum SO_2 concentration at mining site was ($4.6 \mu\text{g}/\text{Nm}^3$) in March, 1997 in 08 AM-12 AM shift and a minimum of BDL in March, 1997 in 04 AM-08 AM shift of the same months.

At mining site maximum NO_2 concentration ($20.2 \mu\text{g}/\text{Nm}^3$) for Shella bazaar was recorded in March, 1997 in 04 PM-08 PM shift and a minimum of ($8.6 \mu\text{g}/\text{Nm}^3$) in the same month in 04 AM-08 AM shift. At mining site maximum NO_2 concentration ($28.2 \mu\text{g}/\text{Nm}^3$) was recorded in March in 04 AM-08 AM shift.

A few limestone quarries and traditional lime kilns operating in and around Shella Bazaar area are the main sources of air pollution in this area.

Water Quality

The main river close to the proposed mining site is the river Uiam which originates from Cherrapunjee plateau and after passing near Shella Bazaar area flows in the Bangladesh and joins there with the Surma river. The next important surface water body is the Phlangkaruh river, which originates from the foothills of the proposed mining site and joins river Uiam further downstream from Shella. The river Uiam is the main source of domestic water supply for the inhabitants of Shella Bazaar. The Phlangkaruh village having about 200 inhabitants is located in south on the bank of this river. These two water bodies were chosen for the study as they are likely to have maximum impact of the proposed mining activities. The water quality at both the stations did not change frequently.

Temperature

The temperature of river Uiam ranged from 21°C in March to 23°C in April, 1997. In Phlangkaruh it varied from 20°C in March to 22°C .

Turbidity

The turbidity of river Uiam ranged from 1.8 to 10.0 while that of Phlangkaruh ranged from 1.6 to 2.8 during March and April, 1997. The change in turbidity was mainly due to the rainfall.

Conductivity

The conductivity of river Uiam ranged from 43 to $49 \mu\text{mho cm}^{-2}$ and in river Phlangkaruh it varied from 47 to $172 \mu\text{mho cm}^{-2}$ during March and April, 1997.

pH

The pH of river Umiam ranged between 7.3 - 7.5. Water of Phlangkaruh river was more alkaline (pH 7.6 - 8.0) than the Umiam river.

Alkalinity

Alkalinity values of river Umiam ranged from 12.0 to 14.0 mg/l. In Phlangkaruh river it ranged from 40.0 to 64.0 mg/l.

Total Hardness (TH)

Total hardness value ranged from 38.0 to 46.0 mg/l in river Umiam and in Phlangkaruh river from 110.0 to 112.0 mg/l. Substantial difference in the TH values of Umiam and Phlangkaruh river may be because the later originates from the bed of the limestone deposits.

Chloride

The Chloride contents in both rivers varied between 5.0 to 6.0 mg/l.

Iron

The Iron concentration in river Umiam was 0.1 mg/l and in river Phlangkaruh it was 0.04 mg/l. It did not change during March and April, 1997.

Nitrite - Nitrogen

The Nitrite - Nitrogen could not be detected in these rivers.

Calcium

The calcium concentration ranged from 8.0 to 9.8 mg/l in river Umiam and 35.0 to 35.2 mg/l in of Phlangkaruh river.

Dissolved Oxygen (D.O.)

The D.O. concentration in both the rivers was quite high (9.0 mg/l).

Biochemical Oxygen Demand

The BOD concentrations in river Umiam ranged between 0.8 to 1.0 mg per litre. In case of phlangkaruh river it ranged between 0.7 to 0.8 mg per litre. The low values of BOD in these rivers is mainly because they do not receive any domestic waste water and solid waste.

Chemical Oxygen Demand

The COD values ranged from 2.3 to 2.4 mg per litre and from 1.8 to 2.1 mg per liter in case of Umiam and Phlangkaruh rivers respectively.

Total Coliform

Total Coliform bacteria in river Umiam ranged from 4 to 6 MPN/100 ml and in Phlangkaruh River the value was still lower. The quality of water is within the standards prescribed for the drinking purpose.

Faecal Coliform

Faecal coliform bacteria were not found in both the rivers. This indicates that these water bodies are not contaminated by sewage.

Noise Level

The site is located far from any human habitation or any activity centre and the prevailing noise level is extremely low. Therefore, it was not necessary to quantify the level of noise in the calm and quite environment of the proposed project area.

EXPECTED LEVEL OF POLLUTION DUE TO MINING

It is difficult to simulate the level of pollution caused by any project which is not yet established. One way of getting some idea about the expected level of pollution is to collect data from similar projects established in nearby areas. However, often the reliability of such data may be limited due to the difference in technology, quality of raw material, pollution abatement methods used and microclimate which may cause variance in the simulation exercise. Still in order to have a beard idea about expected level of pollution, data were collected from the Komra Limestone Mine, Ichhamati which is about 20 km away from the proposed site and is in operation for more than fifty years.

The data collected from the Komra Limestone Mine reveals that the levels of Suspended particulate matter (SPM) Sulphur dioxide (SO_2) and Nitrogen Oxides (NO_x) are well below the national standards for industrial and mixed areas, as laid down by Central Pollution Control Board, New Delhi under section 16(2)h of the Air (Prevention and Control of Pollution) Act 1981. The air quality standards as notified for the stone crushing units by the Government of India under the Environment (Protection) Amendment Rules 1993 states that "the SPM contribution value at a distance of 40 metres from a controlled, isolated as well as from a unit located in a cluster should be less than $600 \mu m^3/Nm^3$ ". Thus the level of SPM expected to be generated shall be below the prescribed limit.

The data on quality of water collected at three different points viz., adjacent to quarry, near pump house and near the junction and near the junction reveals that the water quality has not been adversely affected due to the mining of limestone at Komra. The levels of various parameters analysed are well within the national standards laid down by Central Pollution Control Board, New Delhi.

At present, the level of air pollutants was found to be well within the Ambient Air Quality Standards notified by the Central Pollution Control Board, New delhi. The mitigation measures recommended would minimise the impact of these emissions on the environment.

The limestone mining and its associated activities shall have the pollution impact on the hydro-environment and may lead to the changes in physical and hydro-chemical characteristics of the water. The Phlangkaruh river originates near the proposed mining site. The mining operations may substantially reduce the quantity of discharge water to this river and may possibly lead to the extinction of this water body. This will affect adversely the interests of about 200 people living in Phlangkaruh village. However, this needs a detailed investigation. The other important variations in the following chemical and bacteriological characteristics of these rivers may be caused due to the mining and its associated activities: i) Suspended Solids, ii) Total Dissolved Solids, iii) pH, iv) metals, v) DO, vi) COD, vii) BOD, viii) Total Coliform, ix) Faecal Coliform.

An expected noise level of 80 - 100 dBA during day time and 50 - 60 dBA during night time would be generated due to mining operations. Besides, high vibration may occur within 500 m diameter of the mine exploding point.

Although the mining waste will not have any toxic effect on the environment, its dumping area measuring about 200 m x 250 m i.e., 50,000 m^2 may affect the landscape structure of the area. Spread uniformly, the height of the loose dump may rise to about 2 m annually.

SOCIAL IMPACT

The impact of the project on socio-economic conditions of the people of surrounding villages was assessed through interaction with the villagers and interviewing village council members, village elders, youth and members of youth club, and the women. The members of the village council on one hand, were apprehensive of the adverse impacts of this project which it may produce on their social and political life and on the other hand, they also felt that the project will provide avenues for alternative income and employment generation.

ECONOMIC IMPACT

Monetary Benefits

The expected monetary benefit to different agencies from the export of limestone is given below :

Head	Rs./tonne limestone	Income Rs. lakh/annum
Cess to govt. of Meghalaya	5	38.75
Royalty to District Council	35	271.25
Central Sales Tax to Govt. of India	4	31.00
Royalty to Village Durbar	5	38.75
Metals and Minerals Corporation Ltd., Shillong	25	173.75

Employment Generation

The Project will generate direct employment for skilled and unskilled persons. The skilled manpower will include Managers, Engineers, Machine Operators etc.

Direct employment: 77 persons

Working days in year : 310

Employment generated : $77 \times 310 = 23970$ man days/annum

The total number of many-days employment that the project would generate indirectly would be more than the direct employment.

Foreign Exchange Earning

Since the project is an export oriented one, the Government of India will earn foreign exchange. The amount would depend on the quantity of limestone exported to Bangladesh.

Direct, Indirect and Induced Effects on the Economy

- (i) Social infrastructure development : It is expected that the project will help improve health and educational facilities, social and cultural upliftment of people living in areas surrounding the mining site.
- (ii) Economic infrastructural development : Construction of road, bridges, public buildings, residential accommodation, marketing facilities etc. may increase after commencement of the project.
- (iii) Gainful employment to local people.
- (iv) Development of agriculture, horticulture and services sector for the local economy.
- (v) Development of ancillary industries to cater various requirements, like power sector, engineering activities etc.

Development of one economic sector induces investment in other linked sectors directly and indirectly and enhances the process of economic growth in the region. Development/expansion of an economic sector generates employment, increases the income of the people, and improves their standard of living. This increases the demand for consumption goods. These in turn increases the output, employment, investment in the consumption good sector and lead the economy to a higher level of economic, but would also influence economy of neighbouring regions like Meghalaya and Bangladesh.

The project would likely to have direct economic impact on those sectors from which it is likely to draw its inputs. Power being a main input, Meghalaya State Electricity Board would have to increase its activity in the area, to develop necessary infrastructure and to ensure uninterrupted power supply at the project site. There is a proposal for establishing a market area near the project site. The project would enhance various productive economic activities in other sectors which directly supply inputs to this project.

Since cement is one of the key sectors which play a vital role in developing any economy, therefore, Bangladesh would get its output-led-forward spill over effect.

Besides both backward and forward direct linkage effects, the project will have indirect impacts on the economy of Meghalaya and Bangladesh.

The project would help in reducing the unemployment problem by generating employment opportunities for local people. The project is likely to generate secondary and tertiary employment along with the primary employment within the project. Most of labourer respondents of the area, complained that they do not get full-time employment through out the year. The proposed project would be in a position to provide full-time employment to the labourers throughout year. In the local labour market, wage rate is not fixed. When an organized sector like LMMPPL would offer employment to its labourers at a reasonable wage rate, it is likely that wages would increase and stabilize in other areas for the benefit of poor people of the area.

The gainful employment of the people may induce investment in other economic sectors and thereby increase the demand for goods of mass consumption. Due to increase in cash-flow, opportunities for self employment would increase in the area. This will further increase the trade and commerce activities and help in raising the overall living standard of the people of the region.

DISCUSSION

Impacts of the Project

The project is expected to contribute positively to the socio-economic development of the project area. Besides creation of basic infrastructure and employment opportunities, the project will have the following positive impacts on the locality: (i) Economic benefit to the village community, District Council, State and central Governments in the form of royalty, cess and other taxes; (ii) Improvement of trade relations with the neighbouring country; (iii) Community development works such as establishment of educational and health care facilities to be taken up by the company; (iv) Success of the project may encourage more investment/international collaborations in the region; (v) Increased economic activity due to forward and backward linkages of the project.

The following negative impacts are anticipated due to the mining project: (i) Construction and operation of rope way; Land acquisition (84 sq. m) for pillars and hazards of falling of limestone from the rope way baskets during transportation; Dust emission during transport; (ii) On-site storage of the uncrushed/crushed limestone causing undesirable change in the landscape; (iii) Emission of dust during mining, crushing and loading; (iv) Wastewater from mining and sewage discharge from housing colony; (v) Solid wastes up to 500 t per day; (vi) Removal of vegetation; (vii) Noise produced from blasting and operation of machines; (viii) Slurry due to spraying of water; (ix) contamination of river water and possible effect on human and aquatic life; (x) Influx of outsiders.

Mitigation Measures

The limestone deposits at the mining site are devoid of overburden and therefore, dust generation would be considerably less. Even then, the following mitigation and pollution control measures should be adopted so that air pollution levels may not alter baseline environmental characteristics in case of ambient air :

- (i) Black topping of all life haul and service roads.
- (ii) Water spraying before and after drilling and blasting operations and use of right system such as blasting by effective stemming using millisecond detonators.
- (iii) Proper deployment of heavy equipments and machineries to reduce gaseous emissions.
- (iv) Water spraying in haul roads, service roads, overburden (if any), coil dumps and the transfer points of limestone handling.
- (v) Provision of dust collectors at drills and at transfer points in limestone handling.
- (vi) Provision of green barriers.

Water shall be used for suppression of dust generated during blasting and other mining operations. Wastewater treatment facilities for settlement of suspended solids and separation of oil and grease from the effluents shall be provided at the mining site. Septic tanks and soak pits should be provided with each house of the residential quarters so that no additional provision shall be required for domestic effluent treatment.

Noise due to blasting should be reduced by using Delay Detonators. Secondary blasting to be reduced to the minimum by use of hydraulic rock-breakers. CT-series Cummins Engines are to be preferred for earth moving equipment. Efficient maintenance of silencers at all times is another measure to be adopted for keeping the level of noise to a minimum.

To minimize vibration, delay detonators should be used and throw of material should be controlled by using inclined blast holes. Inflammable materials like High Speed Diesel and Lubricants should be stored properly. During storage and use of explosive, the provisions of the Indian Explosive Act and Rules and also the provisions of the Mines Act and rigorously trained in handling of explosives and to follow the rules strictly. The storage place for fuel and lubricants should be provided with fire fighting equipments, materials and warning notices.

The waste material should be spread over the dump uniformly through leveling and consolidation so that the dump rises only about 1.5 m per annum. For safety and to check the flow of the material to the surroundings, the dump should be benched so that each bench is not more than 6 m height.

Occupational Health and Safety Measures

The surface limestone mining and its associated activities can result in air pollution which may have the following effects: (i) Dust particles below 10 micron size may cause pulmonary diseases like pneumoconiosis, silicosis etc. ; (ii) Suspended particulate matter along with the dust particles may reduce the visibility range;

In order to reduce the impact of noise from the quarrying equipments and blasts, the following mitigating measures should be undertaken: (i) Regulating spacing between noise sources and between operators; (ii) Providing ear defenders for the workers involved in blasting and working near pneumatic machines.

To prevent health hazards, dust suppression by wet spraying should be adopted. respirators, goggles and earplugs should be used by the concerned workers. First aid stations and ambulance to be maintained and first aid training programmes are to be organised.

Environmental Management Plan

Based on the findings, a comprehensive Environmental Management Plan was recommended which included the followings :

- (i) reclamation of mined areas through plantation of fast growing indigenous tree species such as, *Duabanga grandiflora*, *Erythrina stricta*, *E. indica*, *Holarrhena antidysenterica*, *Sterculia villosa*, *Dillenia indica*, *mmclina arborea*, *Toona ciliolata*, *zanthoxylum sp.*, *Albizia procera*, *Acacia mangium*, *Bauhinia purpurea*, *castanopsis* spp. etc.
- (ii) establishment of a green belt: An area of 100m width surrounding the whole 100 ha mining plot will be demarcated for undertaking aided natural regeneration of the existing species duly mixed with the dust tolerant fast growing tree species so tha a permanent green belt can be created. Currently, the proposed land has very sparse tree growth intercepted with blank areas. The proposed green belt will help reduce air and noise pollution arising from the mining operation.
- (iii) Conservation of a biodiversity-rich forest patch: The south-west corner of the proposed mining plot has a deep cavern where the depth of limestone deposit is very thin, but has a deep cavern where the depth of limestone deposit is very thin, but has high plant diversity. This would be helpful in conserving plant biodiversity on one hand and reduce pollution level on the other.
- (iv) Compensatory afforestation : Two barren plots of 200 ha area in Nongtraï and mawdet villages were recommended for afforestation using multipurpose tree species as a compensatory measure.
- (v) Environmental management and waste minimization cell: A high-level environment management cell and a waste minimization cell were recommended to look into all the environmental aspects of various mining activities and waste minimization process, respectively.
- (vi) Risk analysis and emergency preparedness plan and an environmental monitoring plan.

The anticipated environmental impact of the project was considered to be within the prescribed limits. With the adoption of various mitigation measures and environmental management plan, as discussed above,

the adverse environmental impact of the project can be kept at minimum. Therefore, the study recommended the implementation of the mining project after incorporating the suggested measures.

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