CHAPTER 5

IMPACT ANALYSIS AND MITIGATION MEASURES

5.1 GENERAL

The prime objective of this chapter is to understand the environmental impacts of heavy mineral sand mining and its consequences on the coastal stretch covering the core and buffer zone. The potential adverse impacts of mining on the land, water, air, average noise and societal system of the area are sought to be brought out in detail. The water system consists of surface and ground water domains. The land system consists of human settlements, existing land use patterns, fragile shoreline and eco-protective land cover. Air aspects include emissions due to transportation and mining Noise includes sound generated by the Mineral Separation Plant (MSP) and other mining and separation activities. All these are prone to multiple changes from time to time, in tune with the prevalent socio-economic scenario, systemic anomalies in the seasons and coastal dynamics and anthropogenic activities. The impact of mining on heavy mineral sand in all these environment have been evaluated and possible measures to mitigate their adverse impacts have been worked out.

The heavy mineral sand deposits of the coastal stretch of Kollam and Alappuzha districts are one of the richest in the world. These sands contain Illmenite, sillimanite, rutile, leucoxene, zircon and the highly radioactive monazite which were being mined and separated by the IREL & KMML during the last decades and value added by KMML during the last thirty odd years. This has been a source of sizeable revenue for the Govt., and due to pressure of land and CRZ restrictions for mining in the coastal stretch, the KMML and other industrial users have to find suitable locales for sustained retrieval of the strategic raw material without causing any environmental imbalance. It is therefore important to collect temporal data on the original land and water systems in the area from existing sources to assess the changes due to seasonal variations and anthropogenic influence. This includes collection of representative water and soil samples to assess from the designated block and its buffer impact peripheries. These data will be synthesized and collated to prepare spatial outputs and workable models vis-a- vis existing environment, to project EMPs. Impact assessment describes the beneficial and adverse effects of the 88.119 Ha mining project. For extracting heavy minerals, beach washing is collected using scrapers and inland mining conducted by using toyo pumps mounted on pontoons. The dredge unit is transported using trucks and assembled at the plot. The mined concentrate is transported to Mineral Separation plant (MSP) for separating the various minerals.

Two methods of mining are used:

- By collection of beach washing
- By dredge mining or using TOYO pumps/ Excavation by using excavators where dredge mining is not possible.

In beach washing collection, only sand that has been brought in by wave action is collected. The quantum sand available for collection has been assessed by National Center for Earth Science Studies, Trivandrum (NCESS) based on Sand Budgeting study. From September 2014, onwards the beach wash collection is being limited as per NCESS recommendation.

In case of inland mining, the pits are covered progressively by the tailings generated in the treatment plant.

The environmental impact assessment process ensures identifying the key developmental and operational activities/hazards resulting from the proposed mining & mineral processing. The proposed activity is purely a wet process and there is no significant impact on air except fugitive emissions due to material transport. Other significant impacts include socio-economic impacts and road traffic congestion. However considering various activity components, the impacts on the environment, either beneficial or deleterious due to the proposed mining activity are identified. The aspects on the environment that are likely to be disturbed or damaged due to the implementation of this project is represented with mitigation measures. The area has a reserve of 12,811,700 tons of beach sand deposit and the average grade is seen to be 27.81% of Heavy Mineral Content. Approximate quantity of sand mined so far is 1.14 million tons. So the balance quantity of geological reserve is 11.6 million tons. The mineral separation plant is located in the Mine lease area. No adverse impacts are anticipated due to MSP since the separation of minerals is done using the physical properties of minerals such as magnetic, conductivity, specific gravity. Equipment like magnetic separators, electrostatic separators are used for separation of individual minerals.

The mining methods practiced here are such that there will be minimal environmental impacts. Here there is no drilling or blasting. In Beach wash process, the accumulated ore is scraped from the surface. In dredge mining, the sand is loosened by the cutter head working inside the water in the dredge pond. There is no generation of dust or vibration in both these operations.

Mathematical models are used to quantitatively predict the impacts on air and noise quality. Air quality model was modelled using FDM pro™ (Fugitive Dust Emission Modelling System) and noise by hemispherical model.

Battelle environmental system is used for evaluation of various impacts of environmental pollution, ecology, human interest and Aesthetics.

The environmental impacts due to the mining can be summarised as follows:

Air quality

Noise

Topography and Land use

Water Environment

Ecology

Traffic

Socio-economic & Rehabilitation & Resettlement

5.2 Air environment

Beach sand extraction, upgradation and back filling do not cause appreciable rise in gaseous or particulate pollution level in ambient and work zone environment. Sand extraction process (dredging) is a wet primary process and back filled mass is moist in form and do not release dry dusts in mining area. Therefore the pollution in the proposed area will be insignificant. Ambient Air Quality monitored at Vellanathuruthu, KMML Guest house, MS Plant and IRE Guesthouse for PM_{10},SO_2 and NO_X are well within respective permissible limits. The meteorological data have been generated at 80 ha mining site during the study period on an hourly basis.

5.2.1 Modelling of Dust Emissions

A) Modeling of air emissions

The air pollutants of interest in this project are PM_{10}. The main sources are emissions during mining and transportation. Dust emission is not significant in dredge mining as the ore and rejects are in wet or slurry form. Road transportation of ore on the haul road is the only source of dust emission.

B) ***Fugitive Emissions Estimation***

Dust clouds due to the movement of trucks on roads can cause very significant transient dust nuisance. In this project, the transportation of mined material is through rural unpaved single lane road and concentrate is transported from MS plant to pigment plant is through bituminous topped public roads with six meters width. The average mined quantity of sand from Ponmana is 97,200 MT per year and Anchumanakkal beach washings 36,900MT per year respectively. The combined mining is 1,34,100 MT per year. The collection of mineral rich sand takes place during a span of 330 working days with the plant working for 9 hours, from 8am to 5pm. Thus the collection and extraction of mineral rich sand per day is 407 MT.

According to the project the requirement for the revision is done for the increase in mining capacity to 4,50,000 MT/year, considering the limitation set by NCESS, Trivandrum.

The material transported is heavy mineral rich beach sand, and its silt content is very low. Therefore dust raised from entrainment of spilled materials will be relatively less compared with the transportation of excavated soil or clay as commonly seen on roads in Kerala.

Table 5.1 Provide the estimated vehicle movement in terms of total traffic within mining site and the Road leading to the KMML plant for present and future condition.

Sl. No:	**Project time**	**Site**		**Number of trips**	**Total trips**	**Increase in traffic no:**
1	**Present condition**	From Ponmana and Anchumanakkal	With load	52	106	-
			Empty load	52		
		From MS Plant to pigment plant	With load	10	20	-
			Empty load	10		

2	**After Expansion**	From Ponmana and Anchumanakkal	With load	137	258	162
			Empty load	137		
		From MS Plant to pigment plant	Towards KMML	25	50	30
			From KMML	25		

Dust can be assessed using emission factor equation for both paved and unpaved roads. The emission factor equations are given below. The equation is according to AP 42 on emission factors of unpaved roads.

$$E = k\left(\frac{sL}{2}\right)^{0.65}\left(\frac{W}{3}\right)^{1.5}$$

Where:

E = Particulate emission factor (having units matching the units of k),

sL = Road surface silt loading (grams per square meter) (g/m^2)

W = average weight (tons) of the vehicles traveling the road

k = is the particle size multiplier as given in the table below

Size range	**Particle Size Multiplier k g/VKT**
PM- 2.5	0.66
PM-10	4.6
PM-15	5.5
PM-30	24

The equation given below for paved road is taken from the AP 42 for paved roads, neglecting correction factor for tire and break wear.

$$E = k(sL)^{0.91}(W)^{1.02}$$

Where,

E, sL and W are the same as above

The particle size multiplier k is as given in the table below

Size range	Particle Size Multiplier k g/VKT
PM- 2.5	0.15
PM-10	0.62
PM-15	0.77
PM-30	3.23

The silt loading, refers to mass of less than 75µm particles collected by brooming and vacuuming the road. This has not been measured. Silt loading is taken as 20 g/m^2 for the mining area and 10 g/m^2 for the road leading to KMML Plant.

Table 5.2: Estimated increase in emissions by emission factor method

Road Traffic	**Total no. of vehicles per day**	**Avg. vehicle weight (t)**	**Silt loading (g/m^2)**	**E = PM10 g/ VKT**	**Total emission g/km/s**
From ponmana and anchumanakkal combined	106	16	20	258	0.000317
After expansion	274	16	20	258	0.00082

From MS Plant to pigment plant	20	16	10	87	0.0000202
After expansion	50	16	10	87	0.00005046

Modeling of SPM due to dust emissions from traffic has been done using Gaussian Plume modeling method for which the general equation is given below. The Gaussian model is the most commonly used model for the air dispersion modelling. The Gaussian equation for point source emission is

$$C(x,y,z) = \frac{Q}{2\,\pi u \sigma y \sigma z}\left\{\exp 〚\left(\frac{-(z-h)^2}{2\sigma z^2}〛\right) + \exp\left(\frac{-(z+h)^2}{2\sigma z^2}\right)\right\}\left\{\exp 〚\left(\frac{-(y)^2}{2\sigma y^2}〛\right)\right\}$$

The Gaussian equation applicable for the line source is

$$C(x,y,z) = \frac{2q}{\sqrt{2}\pi u \sigma z}\left\{\exp 〚\left(\frac{-(H)^2}{2\sigma z^2}〛\right)\right\}$$

Where,

C (x,y,z)= Pollutant concentration as a function of downwind position (µg/m^3)

Q = Emission rate (g/s)

q = Emission rate (g/s/m)

u = Average wind speed (m/s)

σ_y,σ_z = Standard distribution of the concentration distributions in the Horizontal and vertical directions

z = Vertical distance from ground level, (m)

y = distance in horizontal direction (m)

H = Vertical distance from ground level, (m)

Dust emissions have been modeled using MOeF approved Envitrans FDMpro software.

It would suffice to calculate the increase in PM_{10} from increase in total emission calculated above, using the measured baseline values. The isopleth plots are obtained. The isopleth plot for the current mining capacity is shown in figure 5.1.

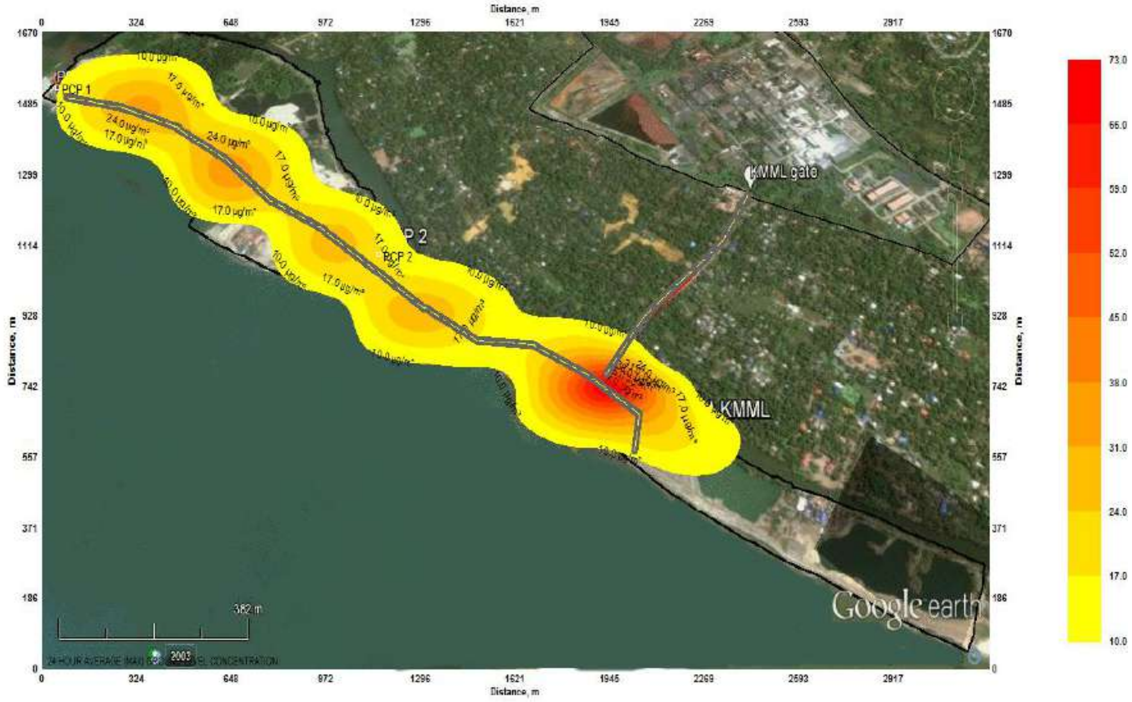

Fig 5.1 Isopleth plot for current mining capacity

The model shows the highest value near the conjunction of the two roads. The CPCB limit prescribed for PM_{10} is 100μg/m^3 for 24 hour. According to the data obtained, the PM_{10} is within prescribed limits for the current mining capacity. The figure 5.2 shows the isopleth plot for the mining capacity after expansion without applying the mitigation measures.

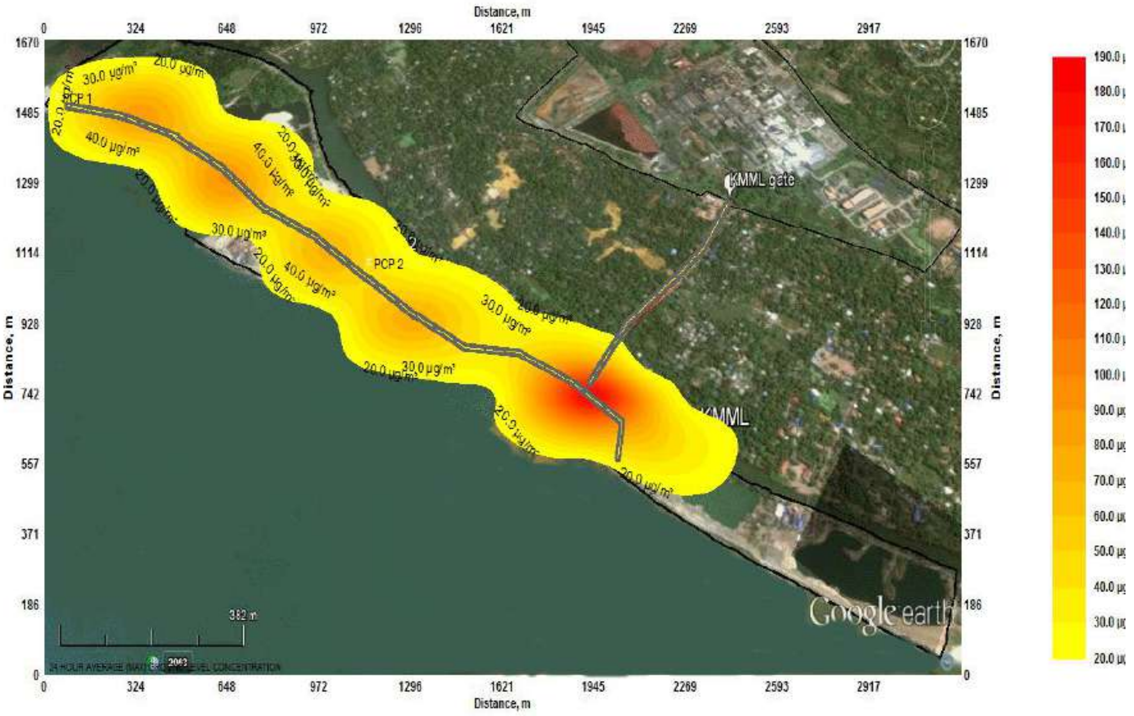

Figure 5.2 Isopleth plot for air quality after expansion without applying mitigation measures.

5.2.2 Mitigation Strategies

Existing level of air pollution in the proposed core zone area is below the permissible limits (National Ambient Air quality norms). The dredge is electric driven and therefore has no gas or dust emissions. The only source of air pollution is emissions during road transportation in haul roads of heavies from mine to MSP. No emissions are expected from the loaded heavies as they are covered and transported in moist form.

Air pollution can be totally avoided by using water transport through the TS Canal. The suggested method is the use of country boats which are the most environmentally friendly and having a very positive socio-economic impact.

The following measures are recommended to reduce pollution for road transport

- During the transportation from the segregated area, the material may be wetted thoroughly to avoid dispersion.
- The segregation area where the material is stored should be covered completely to avoid wind dispersion

- During transportation after the loading the vehicles should be secured with a covering over the loaded material to avoid spillage, which on drying may cause dispersion.
- Provision of water trough at the exits of roads for tyre washing is recommended at the exit of Chavara factory, for the return vehicles.
- Good preventive maintenance schedule for equipment & vehicles.
- It is suggested that the vehicles strictly follow the stipulations for their vehicular exhausts, both diesel and petrol vehicles
- The existing roads connecting MSP and TiO_2 plant should be, resurfaced and maintained in good condition. Trees should be planted on sides.
- All the areas from loading point to the segregation point should be concreted or tarred to avoid heavy dispersion of sand, which will lead to an increase in solid particulate matter.
- As per CPCB norms all the roads where vehicular transportation is being done should be kept wet.
- Ensure leak-proof transport equipment. Vehicles transporting the minerals shall be provided with tarpaulin cover
- Supply of face masks to workers and staff to prevent dust inhalation
- Overloading of transport equipment must be prevented.
- The 35% Calcium chloride solution can be sprayed on the roads to prevent the rise of dust particles into the atmosphere. This shall be done in the summer months when the soil is dry and subject to dispersion.

Gaseous pollutants in the exhaust fumes generated by the dozers and other machinery shall be minimised by ensuring vigorous maintenance and stringent overhaul schedules. The repair workshop and maintenance garage should be equipped with all necessary facilities.

The air quality drastically improves after applying mitigation measures and this has been modelled using Fugitive Dust Modelling Software, Envitrans mine FDMpro.

The isopleth plot showing the emission after the implementation of the mitigation measures is shown in figure 5.3. This shows that the pollution was reduced considerably after applying the mitigation measures.

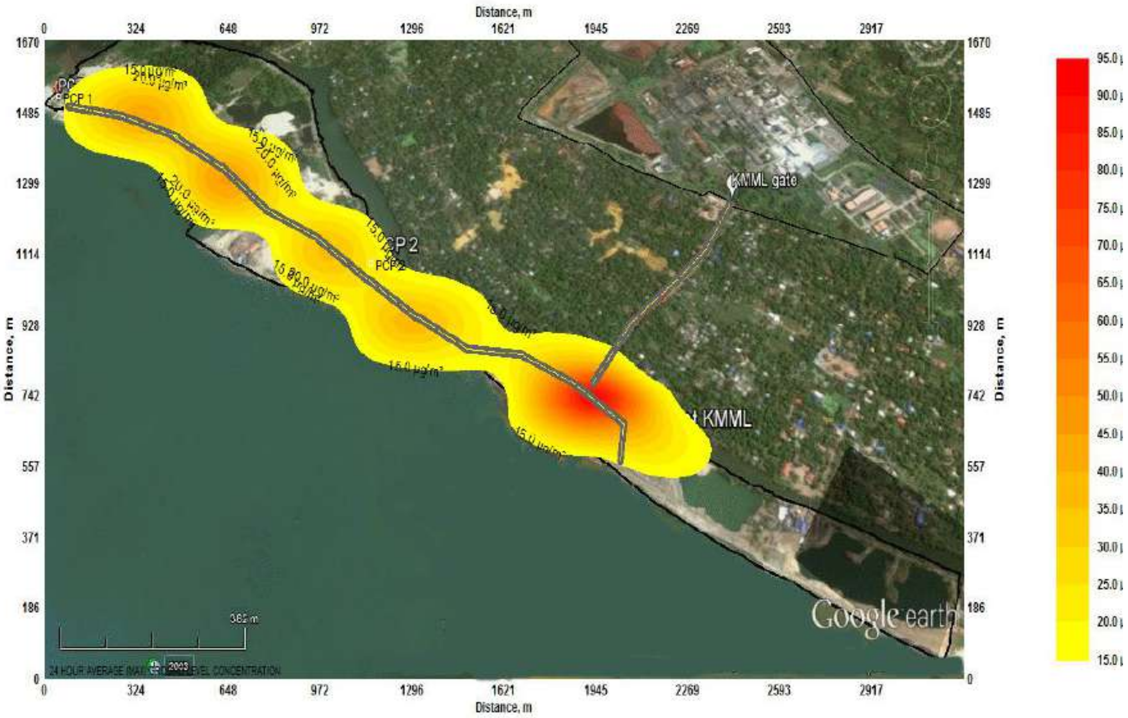

Fig 5.3 Isopleth plot for the emission after the implementation of the mitigation measures

5.3 Noise

Monitoring of sensitive areas has been done in and around the area. The noise was measured in different locations in and around the area of mine lease.

Table 5.3 the value of noise measured from different locations near KMML

Sl no:	Location of monitoring	Time of monitoring	Value recorded in dB
1	Near Administrative Office.	08.05am - 08.15am	60.2
2	Near Dispensary	08.30am - 08.40am	54.9
3	Near Workshop (Electrical and Mechanical)	08.55am - 09.05am	69.2
4	Location of monitoring: At Mining Area North side	09.20am - 09.30am	76.1
5	Location of monitoring: At Mining Area South side	09.45am - 09.55am	65.6
6	Near St. Andrew’s church and St. Andrew’s L.P School	10.15am - 10.25am	56.1
7	Near IRE mining office and Kerala Government Anganvadi (No. 116) Chavara	10.40am - 10.50am	52.5
8	Near Zircon recovery plant (In front of production department)	11.05am - 11.15am	64.9
9	Near Wet mill plant	11.40am - 11.45am	77.4
10	Near Govt. H.S.S Shankaramangalam, Chavara	13.40pm - 13.50pm	75.7
11	Nerar Kalpakaseriyil Abdul Rahman Kunju Memorial building, Kattakada.	14.15pm - 14.25pm	54.2
12	Near KMML guest house	16.30pm - 16.45pm	64.6
13	Near Zircon sillmanite recovery plant	11.55am -12.05pm	79.4
14	Near Rutile illmanite magnetic separation plant	12.20pm -12.30pm	82.4

15	Near Panamana Minnam Thottathil Sree Bhagavathi Temple	12.50pm - 13.00pm	52.4
16	Near Sreenarayana Guru Temple,Thevalkara	14.45pm - 14.55pm	49.1
17	Near Kunnel Junction,Thevalkara	15.20pm - 15.30pm	75.7
18	Near KMML Titanium Junction	16.00pm - 16.10pm	77.8

Table 5.4 Standards for noise calculation according to CPCB Norms

Acceptable Outdoor Noise Levels: Norms of Central Pollution Control Board			
Area Code	Category of Area	Limits in dB (A)	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Sensitive zone	55	45

5.3.1 Noise Modelling

The modelling of noise was carried out using the hemispherical model equation.

$L_W = L_p + [20 \times \log_{10} (r)] - 8$

Where,

Lw= Sound power level (dB),

Lp = Sound pressure level at a receiver

r = distance from source

The modelling of noise has been carried out using the hemispherical model equation. The Noise values have been calculated at a distance of 1m, 5m, 10m, 20m, and 40m respectively. The Table 5.5 shows the variation of noise from source with distance. This shows a logarithmic variation of noise. As the distance increases, the reduction in noise also reduces.

Table 5.5 Change of noise from source with distance

Location of monitoring	Value recorded in dB	Calculated values at distances					
		1m	5m	10m	20m	30m	40m
Noise from Machinery	92	84	70	64	57.9	54.4	51.9

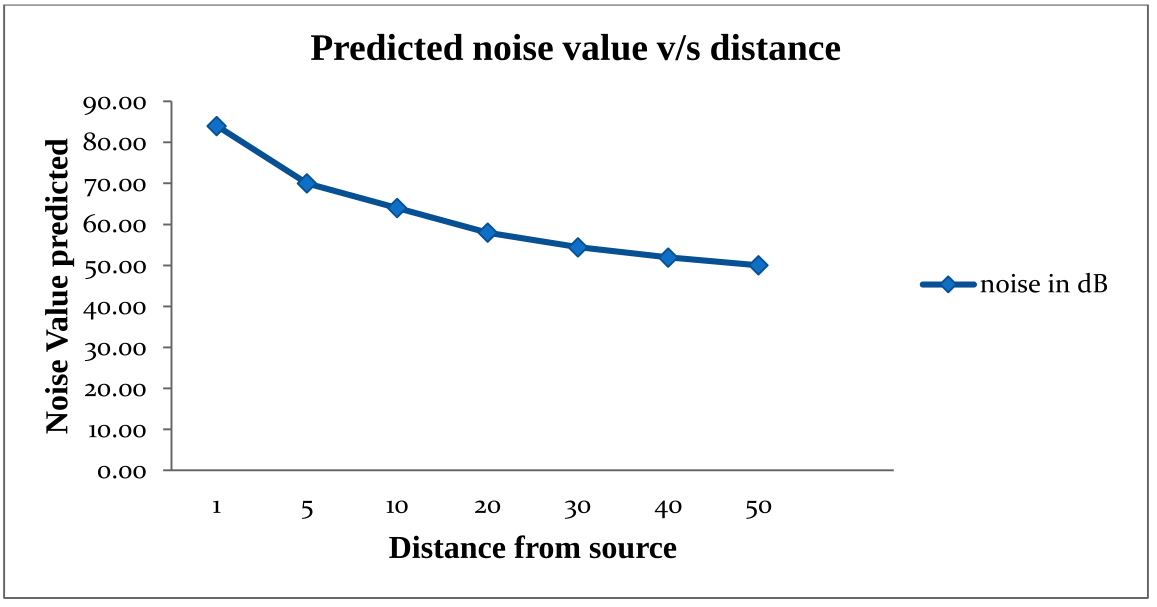

Fig 5.4 Plot for the change of noise wrt the distance

From this, it is understood that the noise levels does not cross the limits as prescribed by the standard limits by CPCB norms. The noise values are within limits. Figure 5.5 shows the outburst of the noise from the Mineral Separation Plant and the buffer zone is limited with 40 meters as the noise level does not cross beyond that limit. The nearest inhabitants (settlements) from the MSP is more than 250 meters and the temple located nearer to the plant is 340 meters away.

5.3.2 Mitigation Strategies

Personnel involved in work on inplant noise producing equipment are likely to be exposed to high level of noise. For such personnel, audiometric examination should be arranged at least once a year. The noise level should be monitored at these key locations once in a month and values to be recorded. The plant workers shall be provided with the noise protection ear phones or plugs.

5.4 Ground water quality: Studies by CGWB

In a study conducted by Central Ground water board, a well located at Chavara recorded an EC value of 1370 mS/cm at 25^0 C and chloride value of 298mg/l. However in the bore wells, the quality of water is generally good, mostly the Electrical conductivity (EC) in the range of 50 to 250 mS/cm at 25^0 C. The fluoride value is also within the permissible limits. The shallow phreatic aquifers in alluvium are developed through dug wells. Filter point wells are more economical where the saturated thickness of the shallow zone exceeds 5m. These are feasible in the coastal areas along Chavara and Karunagappally and the yield ranges from 20 to $60m^3$/day. In areas very near to the coast and tidal zones, the water samples have reported EC above 1000 µS/cm at 25 ^{0}C. Chloride in phreatic groundwater is below 60 mg/l in major part of the district. Higher values of chloride were observed as localized patches in the coastal plain in the close vicinity of the backwaters. The chloride content is observed as 298 mg/l in Chavara area.

Based on the sampling, hydrology survey and analysis the consultant has observed that about 74 Hectares of land lying on the western side of TiO_2 plant is being affected. The area falls outside the core zone . The impact is observed on the water resources. Potable water is supplied by KMML in the affected area

Tube well details constructed in 1992 at Chavara 8^0 58'; 76^0 32' 05'' D/9

Table: 5.6 Analytical data on samples from GWM wells in April 2006

Sl.no	Depth drilled	Depth constructed (m)	Static water level (m)	Aquifer	Discharge (lpm)
I	189.53	185	12.91	Warkallai	30
II	160.0	143	9.18	Ouilon	1.83

III`	101.45	48	2.89	Vaikkom	0.02

Table: 5.7 Data

Location	EC in (us/cm at25^{0}C)	Total hardness as CaCO3 (mg/l)	Ca (mg/l)``	Mg (mg/l)	Cl (mg/l)	F (mg/l)
Karunagappally	325	110	35	49	60	0.02
Chavara	1370	465	162	14	298	0.26

5.4.1 Ground water level trend:

Ground water level trends analysed through water level data of observation wells in Karunagapally block for 5 years (2006 to 2010) of 10 wells indicate that the fluctuation ranges from 0.02 to 2.37 meters during SW monsoon and from 0.62 to 2.97 meters during the North east monsoon. . The hydrological surveys and exploration for ground water carried out in Kollam district by the Central Ground Water Board(CGWB) to assess the capabilities of the aquifers, water quality and ground water potential. The stage of ground water development in Chavara Panchayat and Karunagappally Municipality were assessed as safe. However the prevalence of large scale pumping of wells along the western area have resulted in the depletion of the water table aquifers, as evidenced from the steep gradient of the water table contours.

5.4.2 Ground Water level and Flow Pattern

Ground water is influenced by the difference in hydraulic head produced by topographic relief and unconsolidated formations. The difference in hydraulic head due to topographic relief is the most significant driving force for ground water flow. The contours were generated with reference to water level RL's of wells which are measured during the field survey. The water level RL of well is calculated from the above table i.e., (Water level RL= Reduced level - (depth to water level from top of parapet - Height of parapet)).The details the wells taken into consideration for deciphering the ground water contours are provided in Annexure 8. The ground water contours were drawn for determining the ground water flow direction in the study area. Usually sandy layers facilitate the flow of water whereas clayey layer retards it. The Ground water contour map indicates that the ground water flow is predominantly towards western side. There are no significant impacts on the water resources due to MSP or due to mining

5.4.3 Impact on water quality

Physicochemical parameters determined on the 99 well water samples collected from the study area are tabulated in table 1 of annexure 8. Data generated was compared with the Indian Standards and specifications for Drinking Water (IS: 10500:2012) and World Health Organizations (WHO) drinking water limits. The analysis results were interpreted based on IS: 10500 (2012).

Iron content in the water samples before and after filtration are presented in table 2 of annexure 8. The table indicated that in most of the cases, the iron content is high in samples subjected to analysis without filtration. Above pH 4, iron compounds precipitate out from water. Majority of the water samples exhibited pH in the range above 4 and hence showed lower iron content values in the case of water samples after filtration. Thus tables 1 & 2 provides the data of all the physicochemical parameters analysed, while table 3 , annexure 8 provides the data on trace metals analysed with ICP-MS at University of Kerala, Kariavattom, Thiruvananthapuram.

5.4.4 Impact of inland mining on ground water conditions due to Saline Water Intrusion

Bicarbonate and carbonate ions are abundant in ground water but Chloride generally occurs in small amounts but is abundant in sea water. Salt water intrusion may be identified by the relative concentrations of some of the characteristic ions of sea water such as Cl^-, Na and Mg. The $Cl^- / (CO_3^{2-} + HCO_3^-)$ ratio is recommended as a criterion to evaluate salt water intrusion aspect. This ratio is considered to be indicative of ground water contamination by sea water

Table 5.8: Range of Cl-/ (CO_3 ^{2}- + HCO3-) Vs Saltwater contamination level

Range of Cl-/(CO32- + HCO3-)	**Remarks with reference to salt water contamination**	**Sample no's**
< 0.5 Normal ground water	(no salt water contamination)	
0.5 - 1.30	Slightly contaminated ground water	KMW1,KMW5,KMW13,KMW16 and KMW17
1.30 - 2.80	Moderately contaminated ground water	KMW3,KMW6,
2.80 - 6.60	Injuriously contaminated ground water	KMW11,KMW12
6.60 - 15.50	Highly contaminated ground water(near sea water)	
> 200.0	Sea water	KM2(Mine pit water sample at Koilthottam)

Above cited results show that the ground water in the study area is hard water with very high alkalinity. Since 9 no's of well water samples viz.KMW1, KMW3 ,KMW5, KMW6, KMW11, KMW12, KMW13, KMW16 and KMW17 showed $Cl^-/(CO_3^{2-} + HCO_3^-)$ ratio of ranging from 1.03 to 3.80, brackish / salt water intrusion is not ruled out. The contamination level in the water samples varied from slightly contaminated, moderately contaminated to injuriously contaminated ground water. Though the Cl^- concentrations of all the well water samples are within the permissible limit, overall water quality in the core zone is unfit for drinking purpose but can be used for domestic chores.

5.4.5 Sea erosion

The shoreline of Kerala has been subjected to severe coastal erosion in recent times. In the monsoons, two third of the shore line is vulnerable to dynamic changes**.** Beach erosion is a major environmental and public issue in the area and indeed throughout the Kerala coast. The mining and removal of sand will have a negative impact on coastal topography. Moreover, the dredging operation will not lead to any erosion at any point of time. However the beach washing collection might be a causative factor for sea erosion if carried out without any restraint in an unscientific manner. The NCESS had conducted a detailed sand budgeting study at the instance of KMML

The coastal protection measures undertaken include; Seawall construction and Groyns, by the state government and KMML in its mining areas. These measures are also being taken up by KMML over the stretches of mining areas every year for controlling erosion. But there is no evidence to state that beach sand mining is primarily the cause of sea erosion. Besides the dredging of sand from land area will not lead to any erosion.. However the mining operations in the very loose unconsolidated sand near sea may upset the stability of land area which is only about 1 to 2.5m m above msl.

Mitigation measures proposed are:

- Rip rap walls on the banks of the TS canal
- Construction of groyns for strengthening of existing seawalls and for a possible land reclamation. The figure 5.6 shows an example of formation of beach due to construction of groyns at Kayankulam Pozhi.

Fig 5.5 Beach formation due to construction of groyn.

- Sand dunes may be constructed and stabilized using vegetation.
- Geotechnical investigation study has already been conducted by IIT Madras on the area for construction of groynes etc….

Mitigation measures are further explained in detail in Environmental Management Plan chapter.

Fig 5.6 Study conducted by IIT Madras

5.5 Topography and Land use:

The Mining operations go in tandem with reclamation. About 75% of the raw sand will be deposited back to the mining area and will be used for reclamation of the mined out area. Original Topography of the beach sand mining extension area will change due to removal of 25% heavies. Since the land elevation is not more than 1 to 2.50 m above the high tide line and also since water table is not more than 1 to 2.00m belowground level a small change in topography will have significant impact. It is recommended that the back fill and tailing alone be used to bring the land to the original elevation and to leave the remaining areas as enlarged pond as wetland. The mining and recovery of heavy mineral will eliminate the radioactive mineral (monazite) present in the raw sand.

The T S canal area will be dredged with the concurrence of the Inland water authority as a part of development of NW 3. The rejects from the canal area will also be used to refill the mined out area. Deepening of the canal will facilitate the movement of larger boats / barges. Widening and deepening of the TS canal is being done by NWAI as part of rejuvenating the National Waterway III. The surplus rejects from the canal can be used to refill the land area mined and also for making sand dunes along the sea shore for coastal protection to make up the volume lost as heavies output.

As the back filling is integrated into the mining process, the excavated land will be subsequently reclaimed and the ground surface of the reclaimed land will be brought back to the contours matching with the surrounding topography. The mined out land will be converted to artificial sand dunes stabilised with vegetation and beaches. The land utilisation plan will be finalised in consultation with the elected local government bodies and the state government.

KMML will ensure that the infrastructure facilities extended to the rehabilitated/ relocated inhabitants will be maintained. No temple or any sensitive locations will be disturbed. The reclamation will improve the overall landscape considerably in a phased manner by green belt development, sand dunes and ponds for water conservation and ground water recharge, to improve the water quality / quantity. It will also be a sustainable source for water, availing infiltration of water where ever feasible. .

The mined out area will be converted to natural sand dunes, beaches, rather than homestead and non-remunerative coconut holdings.

This area is not a forest and there are no historical monuments in the lease area or near it. Overall landscape shall improve in a phased manner when greenbelt development, plantation cover, sand dunes, mangrove afforestation, wetlands etc stretches subsequent to backfilling / mining.

Green belt is recommended on the North of KMML Mine Lease area which will also strengthen the border between Vattakayal and the Arabian Sea. About 2400 square meters of coconut palms are recommended for plantation. Afforestation will be done to about 300m per year. Thick bushes shall be placed in areas with lean land width.

5.5.1 DRAINAGE

The deposit is totally isolated from the main land side by T.S canal. Seasonal/perennial streams join T.S canal at places instead of directly discharging into sea. The canal is connected with sea at two ends of the deposits. Natural Drainage of water from the project site is not at all a problem since the canal is just on the eastern side of the ML. Floating of the dredge on the canal water or sand extraction at the canal bed for some period will not have any appreciable impact on drainage. Thus beach sand mining will not have any impact on the network of backwater bodies including T.S canal.

5.6 IMPACT ON ECOLOGY

5.6.1 Fauna

No animals, included in Schedule I of Wildlife Protection Act 1972 were observed in the study area. No endangered or endemic animals were also observed during the ecological survey. Since continuous mining activities are going on in this area, there is no stability for the soil habitat in this area, which may be the reason for less soil organisms in this area. There are certain specific areas in the buffer zone where the soil has become polluted due to the leaching of iron oxide from KMML titanium plant.

5.6.1.1 Flora

At present, no endangered species or threatened species or plants included in the Schedule I of wild life protection act of 1972 was observed. There are no forest nor wild life sanctuary in the core or buffer zone. There are no significant impact on the ecology due to the mining or MSP plant.

5.6.2 IMPACTS ON SOIL AND AGRICULTURE

The core zone soil is basically sandy soil. The mining will involve extraction of this sandy soil, and dumping back the tailings in the mined out areas. Since the heavy mineral extraction is a simple physical process, the sand which is dumped back will not differ chemically from the pre-mining sand except that the heavy minerals are no longer present. The physical changes which will occur will be minor and will have no lasting impacts. Mining will involve cutting down of coconut trees leading to loss in coconut production. These trees if required can be replaced by new saplings of improved variety to improve the agricultural yield. The emission from MSP is too small to have any impact on the soil or agriculture production in the study area. Mitigation measures suggested in EMP section has to be implemented by KMML.

5.6.3 SOCIO- ECONOMIC IMPACTS

5.6.3.1 Mining Area

Most of the households have left the Mine lease area by accepting reasonable compensation as per the existing R&R policy of the government and the company. About 10 families resisted to vacate on the assumption that the value offered by the company is less. These families feel that that it is impossible to get suitable land with the money offered by the company.

During the pre-mining period, the majority of the people were engaged in fishing, daily wage labors and driving. After mining process has started, fishing sector in this area has declined, which caused a decrease in their daily income.

The income of the 10 families located in the ML area is less than Rs.20,000/- per annum. Though majority of the inhabitants have primary, upper primary or high school education, unemployment level is as high as 70%. Since there is no commercial or industrial activities in the immediate vicinity of the mine area, people find it difficult to get suitable employment. They cannot depend on their limited land holding for sustenance. The people in the ML area have limited occupational skill but majority of them are well versed in fishing

The inhabitants generally depend on piped water supply or water supplied through mobile tankers funded by KMML. The respondents have reported that the supply of water is insufficient and erratic. The tanker supply is not reliable since the same is organised at the convenience of the mine operator. Inadequate water supply is a major issue which has a direct bearing on the health and hygiene of the 10 families living in the mining area.

The stagnant water in the mine pits has become a breeding ground for mosquitoes, increasing the incidence of mosquito related diseases, skin ailments and allergic disorders. Sea erosion is another serious issue faced by the people in the ML area.

A revised R & R package has to be devised to vacate the remaining 10 families in the ML area. The amount of compensation should be reasonable so as to get land as per their occupational / job profile pattern. However as a part of land acquisition package employment has been provided for a member of the family from whom the land was purchased. In a way this has effected in reducing the socio economic impacts of the project as well as an upliftment of the surrounding community.

5.6.3.2 Buffer Zone

In Ponmana Panchayath three wards were taken for the study- Chittoor, Mekkad and Ponmana wards which are free from mining but fall within the neighbourhood and indirectly affected by mining.

Most of the wells have dried up or is contaminated mainly on the western and North Western side of the existing KMML plant. Management measures for controlling the ground water contamination are a must.

Frequent up and down movement of vehicles loaded with mineral concentrate (between KMML MSP and KMML Plant) are another area of concern which result in sand spills and dust pollution, traffic congestion and accidents in the village roads. Unavailability of potable water for drinking is another issue causing social unrest in this area. Water available in the existing wells in the area is brackish or contaminated due to the seepage from the titanium plant.

All these aspects adversely affect the people in the locality, specially their health and tranquil family life. It is a fact that the company is taking steps for reducing the pollution. Infact the respondents felt the company has undertaken some steps for reducing pollution which otherwise will have a direct bearing on the health and well-being of people in the area.

Majority of the respondents reported that their income from the traditional job of fishing is diminished. Though they are sparing more time compared to pre-mining period the income is less. So, in the formulation of the R&R, this fact may be given much priority which will reduce their anxiety as well as increase their standard of living.

A small portion of land in buffer zone are affected from the acidic leachate from the KMML Titanium dioxide plant. In the affected area land utilization for agricultural purpose is insignificant because of the loss in the fertility of the soil. They feel health issues are in the order of increasing trend if management measures are not taken.

Take over the land with proper value is the main demand in addition to the following points:

1. The waste material is a source of iron. KMML may engage a reputed industry for taking over the waste as a resource for producing steel.

2. Prevent Acid leak from storage pond by suitable technology/ or the leachate must be treated in the ETP before discharge.

3. The operation of acid regeneration plant should be raised to maximum to reduce acid purchase to subsequent treatment.

4. Look into option for alternate economic use of Iron oxide sludge by the company

5.6.3.3 ENVIRONMENTAL RADIOACTIVITY

The impact of mining project in terms of environmental radioactivity can only be considered positive. The beach sand, rich in monazite deposits is the cause of anomalous background radiation is mined and the beaches are refilled back through reclamation with sands free of radiation. The mining activity will reduce the existing levels of radiation and radioactivity. On the other hand it is expected to reduce the background radiation level of the mined and refilled areas and thus the proposed action is expected to have a net positive impact.

A) Risk hazard

KMML has adopted a mining method that has minimum of risks. The operations for beach mining are conducted on the ground and it involves manual loading of heavy mineral sands deposited by the wave action of the sea. Loading of sand on the trucks is done semi mechanically . In dredge mining, the dredge works in an artificial pond and the sand is dredged out from the pond. As the sand is collected by the cutter suction head, more and more sand will slip into the pond and will be collected by the cutter suction head. This will not pose any danger because the dredge is at a distance from any type of structure. Any other method like manual mining, drilling and blasting would have caused more dangers to man power and nearby structures. The mining methods deployed in KMML are predominantly wet process.

5.6.4 Recommendations to mitigate environmental risks

5.6.4.1 Post mining land use and reclamation

In general, mining in India is conducted in land that belongs to the Government. In the present instance almost all the land that is used for mining has been purchased by KMML from persons who have absolute (JENMAM) rights over the land. Hence after completion of the mining activity, KMML is free to utilise the mined out land as per the desire of KMML / government. Being a Government owned company, the utilisation of this land will be in line with Government directions. However, the decision will have to be in consideration of the following factors:

- The Mineral Separation Plant of the company is located in this block. The MS plant will be required to continue its operations for treating sand mined in other blocks.

- Beach washing Collection operations will continue because the reserves are being replenished by the sea and will not exhaust when the inland deposit is mined out. The MS plant will be required to process the Beach washing Collection product also.

In Beach washing Collection, there is no digging deep into the ground, only scraping the accumulated ore. In dredge mining, the sand is loosened by the cutter head working inside the water in the dredge pond. There is no generation of dust or vibration in both these operations.

The operations are closely supervised by a team of competent personnel qualified to perform these functions, by virtue of possessing the qualifications prescribed for the job under Mines Act 1952. They include Mines mates possessing statutory Mines Mates Certificate issued by Directorate General of Mines Safety (DGMS), Mines foreman with Foreman certificate, Assistant Managers and Mines Managers with Mine Managers Certificate issued by DGMS.

Total number of persons holding Certificates of competency from DGMS is shown in table 5.9 . All the Registers required under Mines Act 1952, Mines Rules 1955 and Metalliferous Mines Regulations 1961 are maintained here.

Additionally, the company has been working to improve the safety in mining by working with DGMS and the workers unions. The company also has workmen inspectors and they submit monthly reports on operational safety.

One possible environmental impact is the dust that could be raised during truck transport of the ore and the rejects. To avoid dust generation, all haul roads are sprayed with water. option of mitigation of dust in haul roads is to spray 35% $CaCl_2$, which is effective for mitigation of dust emissions. NIIST along with Pollution control board has proved this method in a large clay mine in Trivandrum, as a feasible and cost effective solution. The treatment applied is effective for 10 to 14 days in summer period for controlling of dust emissions.

TABLE 5.9 NUMBER OF PERSONS HOLDING CERTIFICATES OF COMPETENCY FROM DGMS

S. NO	TYPE OF CERTIFICATE	NUMBER OF HOLDERS
1	Mines mate	3
2	Mines Foreman	1
3	Second Class Mines Manager	4
4	First Class Mines Manager	3
5	Approved Electrical Supervisor	1
6	Approved Mechanical Engineer	1

5.7 EVALUATION BY BATTELLE ENVIRONMENTAL EVALUATION SYSTEM (BEES)

The first step in this process is the identification of impacts which are likely to occur as a result of this mining project. Environmental impact assessment process begins by identifying the impacts due to mining and evaluation of impact with management plan conferred to the activities of the mining site and a quantitative evaluation of different impacts. Based on the analysis no major environmental impacts were observed except Socio-economic impact and minor impacts on traffic, air quality and land use are anticipated. The probable impacts on the environment, community, economy etc. are identified. Wherever possible, interrelationship and combined effects are identified. The following proposed activity / parameters have been identified for prediction of impacts due to the proposed plant.

For this project seven environmental parameters have been identified as the significant ones for evaluation of impacts (Table 5.11). Battelle Environmental Evaluation system (BEES) is the methodology used for evaluation of impacts. The parameters have been assigned with parameter importance unit (PIU) based on the type of project. The objective measurement of the environmental qualities prior to and after the implementation of the project, with and without EMP and change in Environmental Impact Unit (EIU) are then presented into a subjective interpretation of Environmental quality based on a scale of 1.0 for good quality and 0.0 for poor quality (EQ).

Environnemental Impact unit (EIU) = (EQ) * (PIU)

Where, EIU= Environmental Impact Unit for the parameter

EQ = Environmental quality scale factor for the parameter

PIU= Parameter Importance units for the parameter

Table 5.10 : Values of environmental quality (EQ) factor		
Sl no:	Values on scale	Environmental Quality
1	0.1	Unacceptable
2	0.2	Very Worst
3	0.3	Worst
4	0.4	Very Bad
5	0.5	Bad
6	0.6	Medium
7	0.7	Good
8	0.8	Very Good
9	0.9	Best
10	1	Excellent

This method evaluates the expected future condition of the environmental quality both "With" and "Without" the project. A difference in Environmental Impact Units (EIU) between these two conditions constitutes either an adverse impact, which corresponds to a loss in EIU or a beneficial impact, which corresponds to a gain in EIU. The identified parameters have been classified into four major categories i.e. Environmental Pollution, Ecological Environment, Aesthetics & Human Interest.

In the present study, environmental pollution is the most affected among the other factors and hence it is given a PIU value of 450 and the next affected parameter is human interest and so a PIU value of 400 is adopted in this case. There are no significant impacts on ecological environment. There are only minor impacts on the aesthetics of the area. A PIU value of 150 is adopted for aesthetics.

Table 5.11 : Checklist of anticipated impacts due to the proposed Project

Sl.no.	Proposed activity/Parameter	IMPACTS		
		Negative	No impact	Positive
1	AIR QUALITY			
	i) KMML Mineral Separation Plant plant emissions		**	
	ii) Fugitive emissions due to loading / unloading / traffic	**		
2	LAND Environment			
	Land cover			**
	Beach erosion	**		
	Agriculture	**		
3	ECOLOGY			
	i) Terrestrial	**		
	ii) Aquatic	**		
	iii) Forestry – No forest land		**	
	iv) Wild life- No wild life		**	
	v) Fisheries	**		
4	WATER QUALITY			
	Lake / Sea area	**		
5	NOISE ENVIRONMENT	**		

6	SOCIO-ECONOMIC			
	i) Change in social status			**
	ii) Change in economic status			**
	iii)Employment generation			**
	iv) Traffic	**		
	v) Medical facilities			**
	vi) Infrastructural facilities			**
7	Radiation			**

5.7.1 Environmental Pollution

No major environmental pollution is anticipated during mining as this is carried out in wet condition except traffic and fugitive emission due to transportation of concentrate. Suitable control measures are suggested in the EMP to keep the dust emission levels within the prevalent norms. No ground water is tapped.

Noise, air and water pollution shall be mitigated by curbing emissions at the source and other management measures as suggested in EMP. Water sprinkling during construction and greenbelt / dunes proposed during post operational phase will take care of fugitive emissions. In summer months chemical stabilisation shall be adopted for curbing emission on the roads inside the ML area .The dunes proposed on the ML area will also give protection against sea erosion. In addition groyns are proposed to curtail sea erosion. To eliminate traffic related issues, the consultant recommends transportation of mineral to KMML from the mining area through barges or country boats.

Table 5.12: Environmental Pollution (450)						
Parameters	PIU	Existing EIU (EQ*PIU)	After project			
			EIU with EMP	Change in EIU with EMP	EIU without EMP	Change in EIU without EMP
Water	100	20	40	20	25	-5
Air	200	160	160	10	40	-110
Noise	50	25	20	-5	13	-12
Landuse pattern	100	40	50	10	16	-24
Total	**450**	**255**	**270**	**35**	**94**	**-151**

5.7.2 Ecological Environment

No rare or endangered species exists and species found here are found in other parts of the core area or buffer zone and likewise, there is no National park or wildlife sanctuary in the core area. The project site consists of loose unconsolidated sandy soil with sparse vegetation. Mangroves are found to exist as per CRZ mapping. There are a few patches of mangroves on the banks of Vattakayal, the area of which is not large enough to map them in the scale used. The dredged area will be filled by MRP rejects and well planned reclamation programme will ensure improved land use pattern, improved crop yield, aesthetics and overall improvement.

5.7.3 Human interest

The following sections give the socio-economic impacts (on population growth, density, aesthetics, standards of living, infrastructure etc.) likely as a result of the project.

During the mining phase:

- short - term as well as long term employment opportunities

- improvement in socioeconomic status, communications and transportation sectors
- local, long-term betterment of human welfare will take place;
- Medical and drinking water supply facilities will improve the health of the people who are directly or indirectly connected with the project.

Table 5.13: Human interest (400)						
Parameters	**PIU**	**Existing EIU (EQ*PIU)**	**After project**			
			EIU with EMP	**Change in EIU with EMP**	**EIU without EMP**	**Change in EIU without EMP**
Economy output	60	18	30	12	12	-6
Employment	70	21	42	21	15	-6
Human welfare schemes	60	24	36	12	16	-8
Overall development	80	24	36	12	16	-8
Traffic	65	30	20	-10	13	-17
Radiation	65	13	45	32	26	13
TOTAL	**400**	**130**	**209**	**79**	**98**	**-32**

7.4 Aesthetics

Table 5.14 : Aesthetics (150)						
Parameters	Weight (PIU)	Existing (EIU)	After project			
			EIU with EMP	Change in EIU with EMP	EIU without EMP	Change in EIU without EMP
Topography	60	18	36	18	15	-3
Vegetation	90	30	58	28	23	-7
Total	**150**	**48**	**94**	**46**	**38**	**-10**

The development of green belt, creation of sand dunes and wet land, construction of rip rap along the banks of canal and enhancement of mangroves would augment diversity of vegetation and aesthetics. The proposed project hence promotes overall positive impact aesthetically converting the unplanned land into planned systematic plantation for green belt development, sand dunes, added wetland for improved aquatic ecology etc.

5.7.5 Impact identification summary

Based on the above aspects, the observations in impact identification have been summarized below for the proposed mining activity. Due to the use of state of art technology in the mining process as well as pollution control equipments, the emission levels will be within permissible limit. Due to the above, the air quality would not be affected significantly. Health and welfare services are the major areas to experience impact due to the additional employment potential and the resultant social and cultural development.

Table 5.15: Summary of Evaluation of Impacts				
Sl.no.	Category	Weight (PIU)	Change in EIU	
			Without EMP	With EMP
1	Environmental Pollution	450	-151	35
2	Human interest	400	-32	79
3	Aesthetics	150	-10	46
	Total	**1000**	**-193**	**160**

Table 5.16: Impact identification matrix during Mining operation

Identification Matrix for Operation Phase **P** - permanent impact **T** - Temporary impact ***Environmental parameters***	Commissioning of mining equipments	Water Requirement	Effluent Discharge	Gaseous Emissions	Fugitive Emission due to traffic	Solid Waste Disposal	Dredged Material storage	Raw material Handling	Spills and Leaks	Shut down/ Start offs	Equipment failure	Traffic	Transport of workers	Movement of vehicles	Medical and other needs	Educational needs	Recreational needs	Immigration	Power needs
Land use	**T**				P		T	T			T	P		**P**					
River water Resources														P					

Identification Matrix for Operation Phase **P - **permanent impact **T - **Temporary impact ***Environmental parameters***	Commissioning of mining equipments	Water Requirement	Effluent Discharge	Gaseous Emissions	Fugitive Emission due to traffic	Solid Waste Disposal	Raw Material storage	Raw material Handling	Spills and Leaks	Shut down/ Start offs	Equipment failure	Traffic	Transport of workers	Movement of vehicles	Medical and other needs	Educational needs	Recreational needs	Immigration	Power needs
Animal Life																		T	
Groundwater Resources		**T**								T	T								
Odour Problem																			

Identification Matrix for Operation Phase **P** - permanent impact **T** - Temporary impact ***Environmental parameters***	Commissioning of mining equipment	Water Requirement	Effluent Discharge	Gaseous Emissions	Fugitive Emission due to traffic	Solid Waste Disposal	Raw Material storage	Raw material Handling	Spills and Leaks	Shut down/ Start offs	Equipment failure	Traffic	Transport of workers	Movement of vehicles	Medical and other needs	Educational needs	Recreational needs	Immigration	Power needs
Air Quality	**T**				**P**				**p**	**T**	**T**	**P**		**p**					
Solid Waste	**T**					**T**	T	T	T										
Noise	**T**							T		**T**	**T**	P	T	P					

Identification Matrix for Operation Phase **P** - permanent impact **T** - Temporary impact ***Environmental parameters***	Commissioning of mining equipments	Water Requirement	Effluent Discharge	Gaseous Emissions	Fugitive Emission	Solid Waste Disposal	Raw Material storage	Raw material Handling	Spills and Leaks	Shut down/ Start offs	Equipment failure	Traffic	Transport of workers	Movement of vehicles	Medical and other needs	Educational needs	Recreational needs	Immigration	Power needs
Human Settlement	T											T		T					P
Employment	**P**														**P**	**P**	**P**	P	
Infrastructure	**p**																	P	P
Culture	P															P	P	P	

Water Supply	P	P												P					P
Power situation	P																		P
Health facilities	P	P		T	T				T			T		P	P			P	
R&R	**T**														**P**	**P**	**P**		
Ecology	T	P			**P**				P					P					P

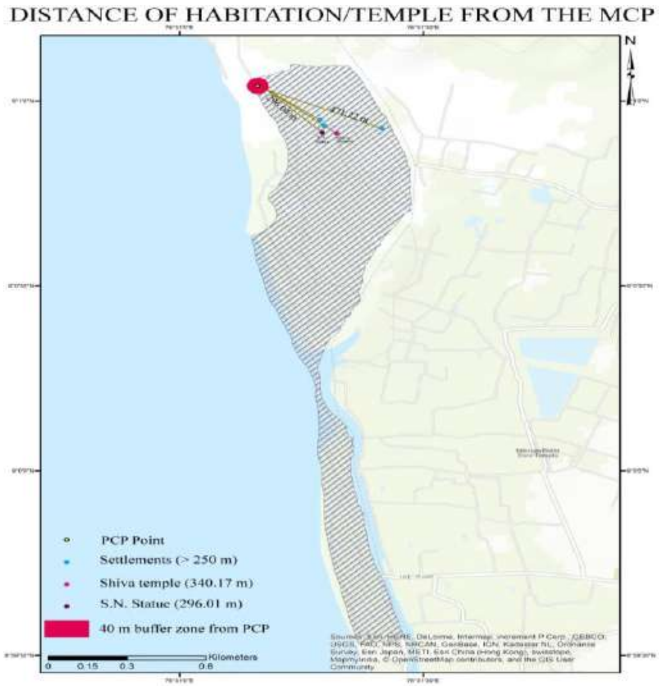

Fig 5.8 Distance of the buffer zone from the nearby habitation

Fig 5.7 Proposed road widening map between MSP and TiO2

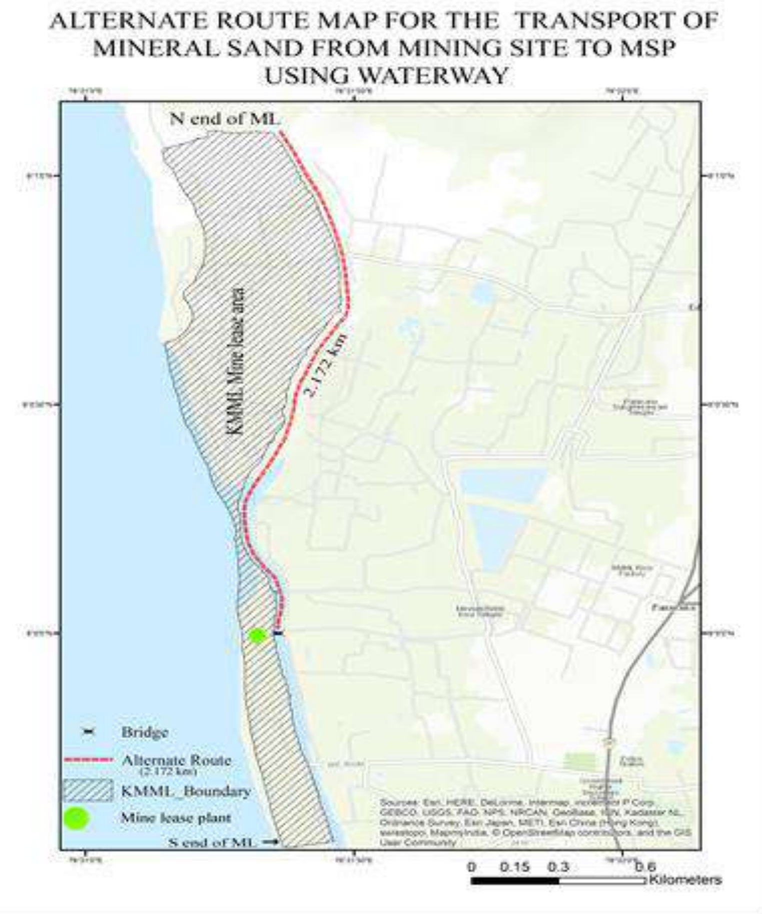

Fig 5.9 Proposed water transport route.