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Environmental Impact Assessment of Thrissur-Vadanapally Road Project

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Abstract—Environmental impact assessment (EIA) for transportation projects has an integral role in environmental management schemes. All the road works and other transportation infrastructure development programs creates significant impact on various aspects of life. Impacts can be positive or negative. Here an EIA is conducted to study the socio-economic impacts and bio-physical impacts of widening of Thrissur - Vadanapally road project and evaluation of the same. The impact prediction is done by means of good fit models for the existing conditions. Gaussian air dispersion model, CRTN Model for traffic noise, Mass Balance and Streeter- Phelps Equation for water quality analysis were used. With the help of these models, the prediction is done accurately. The predicted impact includes the meteorological and climatic impacts, noise quality, water quality, air quality and social impacts. Water quality changes rises only when there is change in drainage pattern occurs. These change is modelled using the Streeter Phelps equation and the mass balance equations. Air quality modelling was done using the Gaussian dispersion model and the impact of traffic noise was done using the CRTN Models. The air and noise values at the present condition was greater than the prescribed norms of pollution control board. The air quality issues are predominant at distances nearer to the source, as the distance increases the effect of air pollution also decreases. Various mitigation measures are suggested for reducing the impacts predicted or to avoid the impact in each stage of construction.

Index Terms—Environmental impact assessment, impact modelling, impact prediction, mitigation measures.

I. INTRODUCTION

Recent environmental issues that has developed due to Urbanization with special effects on the environment has led to the process called Environmental Impact Assessment (EIA) which can be defined as “the need to identify and predict impacts on the environment and on man's wellbeing of legislative proposals, policies, programs, projects and procedures and to interpreter and communicate information about the impacts”. Since the introduction of EIA over 30 years ago, the possible profits has been widely recognized and it has been adopted and implemented in more than 100 countries by numerous aid and funding agencies .In essence, EIA is a process that assesses the impact of developments on the environment in an efficient, universal and multidisciplinary way taking into consideration all environmental components. EIA as a process involves a number of steps which are as follows: [3]

- Description of project
- Screening
- Scoping/consideration of alternatives
- Baseline studies public consultation and participation
- Impact prediction
- Preparation of Environmental Impact Statement(EIS)
- Decision making
- Post decision making and monitoring

A. Objectives

The main objective of the study is identified as to predict and evaluate impacts of a road project.

To achieve the main objective of predicting and evaluating the impacts of a road project involves following subtasks:

- Impact prediction using good fit models
- Suggesting mitigation measures for impacts predicted

II. LITERATURE REVIEW

Environmental impact assessment (EIA) is a planning tool for predicting the impacts on the environment from altering or building a new establishment. For the purposes of EIA, the meaning of environment incorporates physical, biological, cultural, economic and social factors. Over the last three decades, environmental impact assessment (EIA) or environmental assessment (EA) has become a major tool for effective environmental management. Over the years, the focus of EA has changed towards making it a useful tool for environmental sustainability, which can be very effectively put to use to ensure that all important factors are included and unnecessary factors are revealed and dropped. Generallyhighway projects are undertaken in order to improve the social and economic life of the people. But they may also have an adverse impact on the surrounding environment. Most affected people and property are those in the direct path of the road works. Damage to sensitive eco-systems, changes to drainage pattern and thereby groundwater, soil erosion, interference with animal and plant life, resettlement of people, demographic changes, loss of productive agricultural lands, , accelerated urbanization, disruption of local economic activities, and increase in air pollution are some of the impacts of highway projects. Highway development and construction should be planned with careful attention towards the environmental impacts.

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To reduce these adverse effects of highway development projects, EIA become essential. Identification and assessment of probable environmental impact should be a central part of the project cycle. It should begin early in the planning process to allow a full attention of alternatives and to avoid delays and concerns. [3] Various environmental components and impacts on them were identified at preconstruction, construction and operation phases of the project on the basis of valuation of planned project activities and analytical assessment of baseline environmental condition of the project impact zone.

A. Air Dispersion Model

Gaussian plume model uses a realistic description of dispersion, where it represents an analytical solution to the diffusion equation for idealized circumstances. The model assumes that the atmospheric turbulence is both stationary and homogeneous. In reality, none of these conditions is fully satisfied. However, Gaussian plume model has been successfully used for rural configurations. [1] The Gaussian dispersion equation can be written as:

$$C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left(\frac{-y^2}{2\sigma_y{}^2}\right)\left[exp\left(\frac{-(z-h)^2}{2\sigma_z{}^2}\right) + -z+h22\sigma z2\right] \quad (1)$$

Where C is the concentration, Q is the emission rate of the pollutant from the source, u is the wind speed which defines the direction x. y is the horizontal distance perpendicular to the wind direction, z is the vertical direction, H is the effective height of the plume (considering the additional height Δh to which the hot gases rise above the physical height of the source h); i.e., H = h + Δh, and $\sigma_y$and $\sigma_z$are the parameters of the normal distributions in y and z directions, usually called the dispersion coefficients in y and z directions respectively.

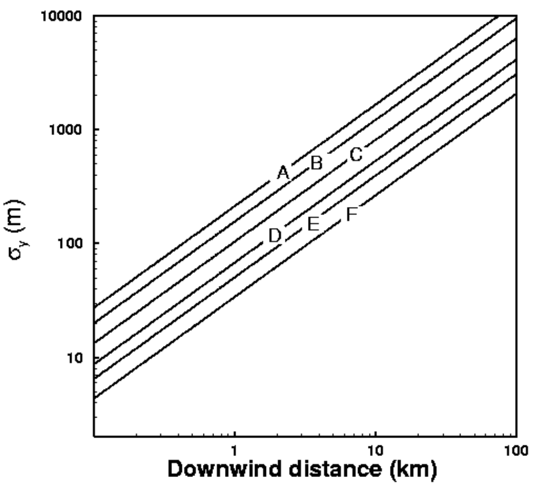

Fig.1. Pasquill-Gifford (P-G) curve for σ_y

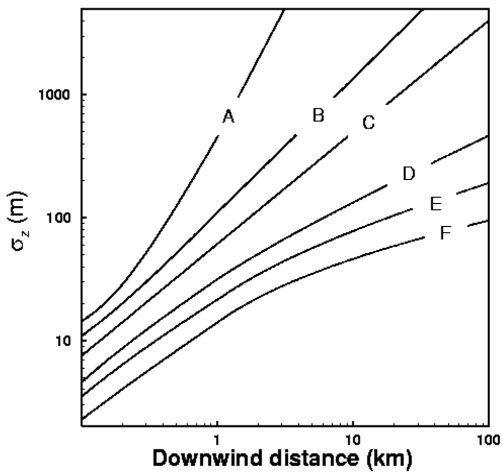

Fig.2. Pasquill-Gifford (P-G) curve for σ_z

Pasquill assigned a letter value to each of the curves ranging from A through F, where A represents highly turbulent conditions resulting in vigorous diffusion and F represents conditions with relatively little turbulence and weak diffusion. Furthermore, he specified practical criteria needed to identify the atmospheric conditions represented by each of the curves that were based on routine observations of wind speed, cloud cover and solar insolation. Gifford subsequently reformulated Pasquill's method of defining h and θ to produce the now well-known and widely used curves for σy and σz, given in figure 1 and 2. In the graphs each curve represents the following:

- A: strongly unstable
- B: moderately unstable
- C: slightly unstable
- D: neutral
- E: slightly stable
- F: moderately stable

B. CRTN Model for Traffic Noise

A motor traffic noise model based on the perpendicular propagation analysis technique (direction perpendicular to the center line of motorways carriageway) is found performed well in a statistical goodness-of-fit test against the field data. For each type of vehicle, regression analysis of noise level (dB A) on speed was carried out based on Logarithmic relationship. [4]

A traffic noise model was applied for the basic noise level study. The equation being used in practice for predicting the basic traffic noise is the calculation of road traffic noise (CRTN) model. The main equation for predicting the noise level is given by,

$$L = 10 \log Q + 33 \log (V+ 40 + 500 / V) + 10 \log (1 + 5P / V) - 26.6 \quad (2)$$

Where:
L= Predicted noise level in dB
Q= Traffic flow
P = Percentage of heavy vehicle;
V = Average speed of vehicles.

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C. Mass Balance and Streeter- Phelps Equation for Water Quality Modelling

The Streeter–Phelps equation is used in the study of water pollution as a water quality modelling tool. The model describes how dissolved oxygen (DO) decreases in a river or stream along a certain distance by degradation of biochemical oxygen demand (BOD). The equation is also known as the DO sag equation. [1]

$$D_t = \frac{K_D L}{K_R - K_D}[10^{-K_D t} - 10^{-K_R t}] + [D_0 10^{-K_R t}] \quad (3)$$

Where,

D_t = Dissolved oxygen (DO) deficit, mg/l

K_R = Re oxygenation coefficient

$= K_{R(20)}[1.016]^{T-20}$

$K_{R(20)}$ = Re oxygenation coefficient at 20°c, generally taken 0.15- 0.2

K_D = De oxygenation coefficient

$= K_{D(20)}[1.047]^{T-20}$

$K_{R(20)}$ = De oxygenation coefficient at 20°c, generally taken 0.1

L = Ultimate BOD of the mix at the point of discharge, mg/l

D_0 = Initial DO deficit, mg/l

When two streams or rivers merge or water is discharged to a stream it is possible to determine the BOD and DO after mixing assuming steady state conditions and instantaneous mixing. The two streams are considered as dilutions of each other thus the initial BOD of the mix,

$$C = \frac{C_S Q_S + C_R Q_S}{Q_S + Q_R} \quad (4)$$

Where,

C = Initial concentration of BOD in the river downstream of the mixing

C_S= BOD of the content of the merging river

C_R = Background BOD of the concentration in the river

Q_S = Flow in the merging river upstream from the mixing point

Q_R = Flow in the river upstream from the mixing point

III. PROJECT DESCRIPTION

The Project road Thrissur- Vadanapally is situated in the Thrissur district of Kerala State in the state highway 75 (SH-75). Thrissur- Vadanapally section of length 16.12 km which starts at Chungam Kanjani bus stop (Chain age –0+000) and ends at Eravu (Chain age – 8+980), the total length of the stretch being 8.980 km. The project road lies in the Thrissur District in Kerala and passes through Olarikkara - Elthuruth - Kannapuram -Manakody -Kunnathangadi -Arimbur - Kanjany -kandassankadavu- Vadanapally - Joins NH 17.

Various surveys have been carried out for the project road which include those for environmental and social impact. The studies were conducted during the feasibility study stage. The carriageway is throughout 10m for the project road, two lane divided carriage way with shoulders. The calculated traffic along the road way at present is 1547 vehicles/hour.

The improvement measures considered are

- To increase the carriageway width to 17m with more shoulders and to construct side drains with M15 concrete.
- Widening the existing roadway and land acquisition required for getting required width for the carriageway.

IV. DATA COLLECTION

Primary information regarding the road project like the alignment, cost were collected from the Public works department (PWD), Thrissur. Secondary information was collected from District Planning Maps and District Census Handbooks. Base line information were collected from Thrissur cooperation and Water quality testing laboratory, Thrissur.

The base traffic count was also determined using the video graphic survey technique. Composition of each vehicle in the traffic stream identified for finding out the air quality details. Environmental monitoring was done by determining of ambient air quality, water quality, and noise level at several locations along the planned alignment to get the baseline data of these parameters along the project area. The important sources of air pollution in the region are vehicular traffic and domestic fuel burning activities. Details of monitoring results are presented in Table I and II.

TABLE I: EMISSION RATE FOR DIFFERENT MODES

Mode	CO_2	CO	No_x	CH_4	SO_2	PM	HC	Total
Bicycle	0	0	0	0	0	0	0	0
Two wheeler	26.6	2.2	0.19	0.18	0.013	0.05	0.2	29.433
Three wheeler	60.3	5.1	1.28	0.18	0.029	0.2	0.14	67.229
Car	223.6	1.98	0.2	0.17	0.05	0.03	0.25	226.28
Bus	515.2	3.6	12	0.09	1.42	0.56	0.87	533.74
LMV	515.2	3.6	12	0.09	1.42	0.56	0.87	533.74
HMV	515.2	5.1	1.28	0.09	1.42	0.2	0.14	523.43

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TABLE II: EMISSION RATE

Mode	Speed of vehicle (m/s)	Emission at entry (Olarikkara) (g/s)	Emission at exit (Eravu)(g/s)
Bicycle	0	0	0
Two Wheeler	42	2468.547	1816.193
Three Wheeler	40	30.532	30.525
Car	45	1937.522	1903.58
Bus	40	533.739	462.571
LMV	50	445.951	280.488
HMV	35	583.754	583.754

Emissions from the vehicle at entry and exit depends on the number of vehicles and its speed. As the speed of the vehicles increases the emission rate decreases. Also emission rate depends on the road way characteristics.
Noise level monitoring was carried out at each location in a peak hour traffic time using sound level meter which measures the Sound Pressure Level (SPL) in dB. The calculated noise levels at locations in the project road are presented in Table III.The values are compared with the standards given by CPCB for various zones.

TABLE III: AMBIENT NOISE LEVEL ALONG THE PROJECT ROAD

Sl no	Place	Category of zone	Sound level(dB)	Applicable CPCB values at day time (dB)
1	Waiting Shed	Commercial cum Residential	70.5	55
2	Kalhara Apartments	Residential	60	55
3	Mother Hospital	Silent zone	70.5	50
4	Olarikkara Temple	Silent zone	70.5	50
5	Olarikkara Church	Silent zone and commercial zone	72.5	60
6	Elthuruth Junction	Commercial	69	65
7	Somany Fittings , Chettupuzha	Commercial	71.5	65
8	Saraswathi Vilasam School, Chettupuzha	Silent zone	69	50
9	St. Gemma's L. P School	Silent zone	72	50
10	Niya Collections , Kunnathangnadi	Commercial	73	65
11	Govt U. P. School Arimbur	Silent zone	69	50
12	Kerala Agro Industries Cooperation	Commercial	60	65
13	St Joseph's H.S. S Eravu	Silent zone	70	50
14	Karali Engineering Works	Commercial cum Residential	72	55

V. MODELLING OF POTENTIAL IMPACTS

A. Air Quality Impacts

Obtained emission rates are used for modelling in the Gaussian plume model. Defining the study area conditions the equation (1) reduces to equation (5),

$$C(x,0,0) = \frac{Q}{2\pi\sigma_y\sigma_z u} \quad (5)$$

Since the emission is at ground level, height of the plume H is taken as zero and the horizontal direction perpendicular to the direction of wind *y* and the vertical *z* is also taken as zero. The results of this study is tabulated in the table 3 and 4.The concentration are tabulated for each 110m *x* distance at the entry and exit points of the road stretch. Concentration of vehicular emission at various distances from the point of its origin was plotted.

TABLE IV: CONCENTRATION OF POLLUTANTS AT ENTRY POINT (OLARIKKARA)

Entry Q=5347.697*10^6 µg/s	
x (m)	C (µg/m^3)
100	14055067.35
210	7649016.245
320	3123348.3
430	2248810.776
540	1115481.536
650	937004.49
760	638866.698
870	449762.155
1000	267715.568

TABLE V: CONCENTRATION OF POLLUTANTS AT EXIT POINT (ERAVU)

Exit Q=5432.79*10^6 µg/s	
x (m)	C (µg/m^3)
100	14278712.75
210	7770728.028
320	3173047.278
430	2284594.04
540	1133231.171
650	951914.183
760	649032.398
870	456978.808
1000	271975.481

The concentration of the emission will be higher at its origin point. As the distance from the source increases its concentration level decreases and reduces up to a negligible level. This means that zones nearer to the road project suffer more than that at the far end. The vehicular emissions have adverse effect on human health as well as on the habitat. The effect of vehicular emissions on humans can be direct or indirect, it may include reduced visibility, highly dangerous cancers and death in rare cases while exposed to pollutants like carbon monoxide in large amount.

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The particulate emissions affect the respiratory and cardio vascular systems directly. The high concentration of suspended particulate matter and Sulphur dioxide may results in increased mortality, morbidity and impaired pulmonary function. At Olarikkara there we have sensitive areas like hospitals, religious places with the impact zones and also we have residential cum commercial zones. So special care should be taken for that zones. At the exit point of our project corridor, i.e. at Eravu, we have residential cum commercial zones with in the effected distance.

B. *Water Quality Impacts*

Water quality issues are considered only due to the drainage pattern. When it rains the rain water reaches the nearby water body i.e. to the Puzhakkal River nearer to the project corridor. The changes in the give water quality conditions are checked. The change in dissolved oxygen is only calculated using the Streeter–Phelps equation and mass balance equations. The present and predicted water quality changes are given in the table VI given below.

TABLE VI: WATER QUALITY OF PUZHAKKAL RIVER

Parameters observed	Present water quality	Predicted water quality change	Permissible limits IS 10500(2012)
Nitrate	2.340 mg/l	30 mg/l	45 mg/l
Iron	0.234 mg/l	0.8 mg/l	0.3 mg/l
Chloride	24.000mg/l	40.000mg/l	1000 mg/l
pH	6.3	6.4	6.5-8.5
COD	13.6 mg/l	47.16 mg/l	
BOD	8.5 mg/l	30 mg/l	
DO	5.2	4.8	

Using the mass balance equation initial BOD of the river-effluent mixture will be equal to 10 mg/l corresponding to a flow of 27 m^3/s for river water and 1.55 m^3/s drainage water. The ultimate BOD of the river is taken as 14.62 mg/l and it is assumed that river is flowing at a velocity of 0.2 m/s. Using the equation 3 and 4 the DO deficit was calculated for the entire river length i.e. for 30 Km. saturation DO is taken to be 7.6 mg/l corresponding to 5000mg/l chlorine at 30°c. The results are given in the table VII.

TABLE VII: DO DEFICIENCY AT PUZHAKKAL RIVER

Distance (Km)	Number of days	DO deficit (mg/l)
5	0.28	3.92
10	0.57	3.42
15	0.86	2.83
20	1.15	2.55
25	1.44	2.41
30	1.73	2.36

Due to the re-oxygenation process the DO deficit value decreases. The oxygen deficiency in the water will affect the biotic life present in the river.

C. *Noise Quality Impacts*

The major source of noise pollution is due to the noise generated from the vehicles. The noise level at the entry and exit points are calculated by considering the vehicular traffic present there using the equation 2

TABLE VIII: NOISE LEVEL DUE TO TRAFFIC

	At entry	At exit
Total number of vehicles	3362	2321
Percentage of heavy vehicles	2.85%	3.61%
Average speed of vehicles	42 Km/h	42 Km/h
Traffic flow	2241.33 veh/h	1547.33 veh/h
Noise level	72.01 dB	70.41 dB

The ambient noise level calculated is above the permissible limits i.e., greater than 55dB in the residential cum commercial areas. Also we have to take attention towards the sensitive areas like hospitals and religious places in the entry point. The increased noise level will effect badly on these areas.

VI. MITIGATION MEASURES

The increase in runoff due to widening of the roadway will not be noticeable. Puzhakkal River may show slight improvement in water quality after road upgrading due to reduced erosion from improved roadside shoulders.The water quality changes will be controlled, make softer or can be reduced by the execution of all applicable laws and protocols. While designing the side drains care has to be taken.The net air quality changes during the operational phase of the road is expected to be beneficial. Improvements in road surface condition and traffic capacity will lighten local congestion and improve traffic flow, thereby reducing engine idling. With improved vehicle performance on a better road surface, the air pollution should actually be reduced. Provision of labelled parking areas for auto rickshaws, cars etc. will improve the road safety conditions and reduced traffic congestion at the traffic corridor thereby positively contributing to air quality improvements. Smooth paved surfaces and adequate side drainage will considerably reduce human contact to air pollution, including both vehicular emissions and roadside dust. Narrowing construction activities at the road links to social working hours and employing noise controlled construction equipment of international standards will reduce noise impacts during the construction phase for the occupying population. These measures include:

- Source Control measures, i.e. all exhaust systems should be maintained properly with designed engine enclosures and silencers will be employed and routine maintenance for the equipment will be taken.

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- Site Controls measures, i.e. the stationary equipment will be placed as distant from sensitive receptors like hospitals, schools etc. as possible (i.e. aggregate crushers, etc.); disposal sites and haul routes will be selected to decrease disagreeable noise impacts; and covering mechanisms will be employed to control the dust while transporting the aggregates and other dust producing construction materials, where possible.
- Time and Activity Controls, i.e. construction activities will be organized such that people are least affected; working hours and working days will be restricted to less noise sensitive times as far as possible.
- Community Awareness, i.e. public notice of construction procedures will include noise concerns and methods to handle complaints should be included.

Estimated noise levels due to road use following which noise levels may exceed the ambient noise standards specified by the Noise Pollution (prevention and control) Rules 2000 of the Ministry of Environment and Forests, Government of India. Mitigation at these locations may include the placing of signs prohibiting the use of horns and, to the range possible, landscape planting to work as noise barriers. The effect of noise can be reduced significantly by the joined effect of sound isolating walls and green barriers. [6]

VII. CONCLUSIONS

The predicted impact includes the noise quality, water quality and air quality. Water quality changes rises only when there is change in drainage pattern occurs. These change is modelled using the Streeter Phelphs equation and the mass balance equations. Air quality modelling was done using the Gaussian dispersion model and the impact of traffic noise was done using the CRTN Models.

- The results shows that there will be reduction in water quality mainly at the point of discharge especially reduction in DO level and increased turbidity. The water quality issues raised in other stages of construction should be properly checked.
- The air and noise values at the present condition are greater than the prescribed norms of pollution control board. According to the project details, the improved road conditions reduces these air quality and noise quality issues as the riding characteristics get improved.

As a future work, more realistic models for modelling the environmental issues can be used. With the emergence of satellite remote sensing technology and Geographic Information Systems (GIS), research presents a new framework for the analysis phase of the Environmental Impact Assessment (EIA) for transportation projects based on the integration between remote sensing technology, geographic information systems, and spatial modeling.

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