GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS

Sustainable Strategies to Minimise Vehicular Pollutant Concentrations - A case of Vijayawada City

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12th Urban Mobility India Conference & Expo 2019

Need for the study

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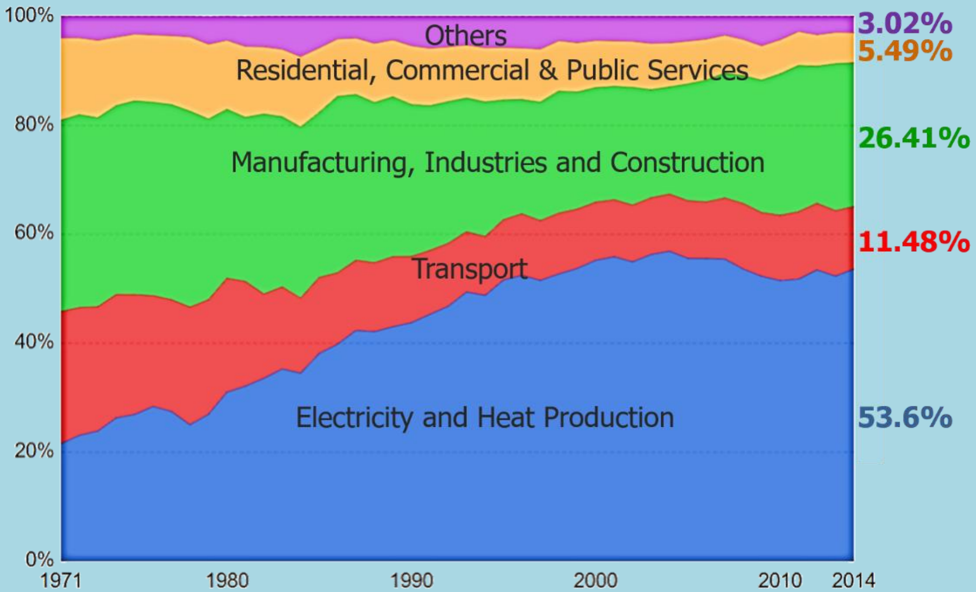
- ✓ Rapid development activities from 1990's have resulted in increased demand for transportation network
- ✓ **Transportation networks direct the economic and spatial development of a region**
- ✓ Transportation sector is a major contributor in global climate change, accounting for almost **23%** of worlds carbon dioxide emissions from combustion of fossil fuels
- ✓ Emissions from various transport systems is **Road – 72%,** Rail – 8%, Air – 10% & Water – 10% (IPCC)
- ✓ Road Transport emissions are maximum and are still increasing, keeping pressure on oil demand & fuel prices

CO2 emissions from fuel combustion by sector in India

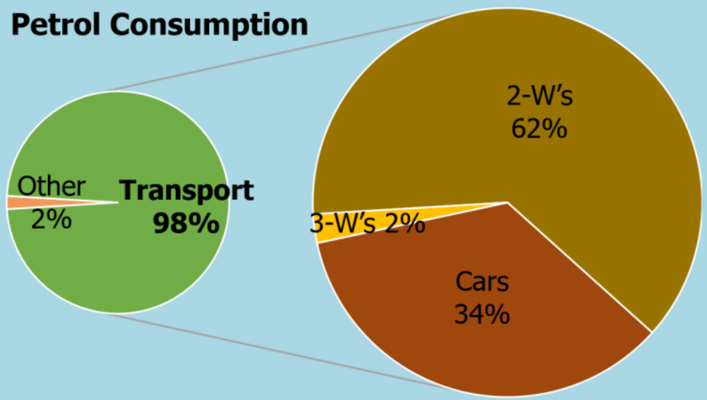


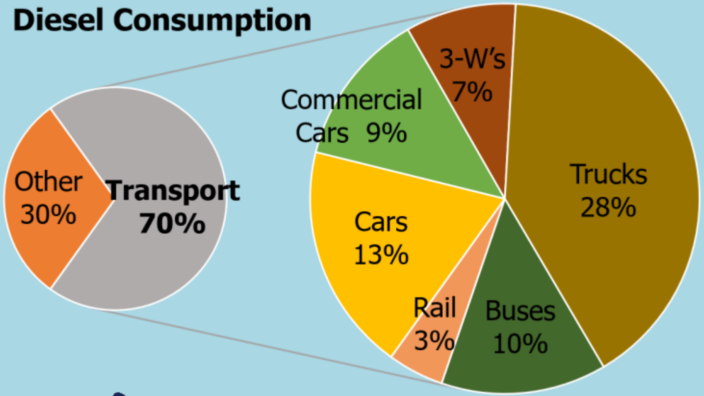
Source: International Energy Agency (IEA) via The World Bank

- ✓ India's Urban Population are predominantly dependent on Road Transport, with a share of **85% of total passenger trips and 65% of freight movement**

Need for the Study

Mode wise fuel consumption in India





Emission standards per fuel type

PETROL EMISSION NORMS – g/Km					
Norm	CO	HC	NOx	HC + NOx	PM
BS III	2.30	0.20	0.15	---	---
BS IV	**1.00**	**0.10**	**0.08**	**---**	**---**
Euro VI	1.00	0.10	0.06	---	0.005

DIESEL EMISSION NORMS – g/Km					
Norm	CO	HC	NOx	HC + NOx	PM
BS III	0.64	---	0.50	0.56	0.05
BS IV	**0.50**	**---**	**0.08**	**0.30**	**0.025**
Euro VI	0.50	---	0.06	0.17	0.005

Proportion of vehicular emissions

CO	**61.4%**
HC	34%
Nox	3.85%
SO 2	0.54%
SPM	0.18%
Lead	0.023%

CO – Poisonous gas that directly enters into haemoglobin of humans leading to headaches, fatigue and even death

Conceptual Framework

LITERATURE REVIEW

Pollution Calculation
- Pollutant assessment
- Dispersion Models

Green Cover Absorption
- Quantifying absorption capacities of urban green

Green Transport solutions
- Alternative Fuels
- Policies & Schemes

RESEARCH GAP

No research on relation between Ambient Air Quality and the absorption capacities of green cover along sides and median of roads

AIM

To achieve Sustainability by establishing a relation between vehicular pollutant concentrations and green cover along urban roadways

SCOPE

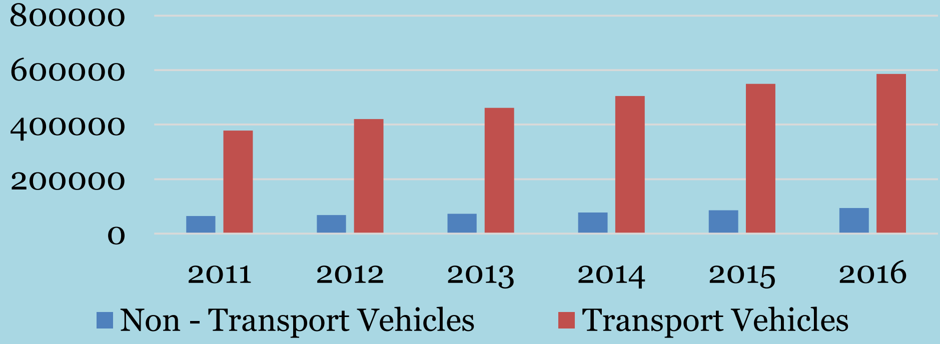
- Study addresses three dimensions – Pollutant Concentration, Absorption by Green Cover and strategies for Suitability
- Green cover absorption capacities and Impact of Pollutant concentrations are predicted till 100m on either side of the roads
- Pollutant estimates are done for Three Arterial roads of the city

LIMITATION

- Traffic survey – 1 hr.
- Pollutant considered – Carbon Monoxide (CO)
- Study does not consider age of vehicles

Study Area - Vijayawada Municipal Corporation

Growth in registered vehicles

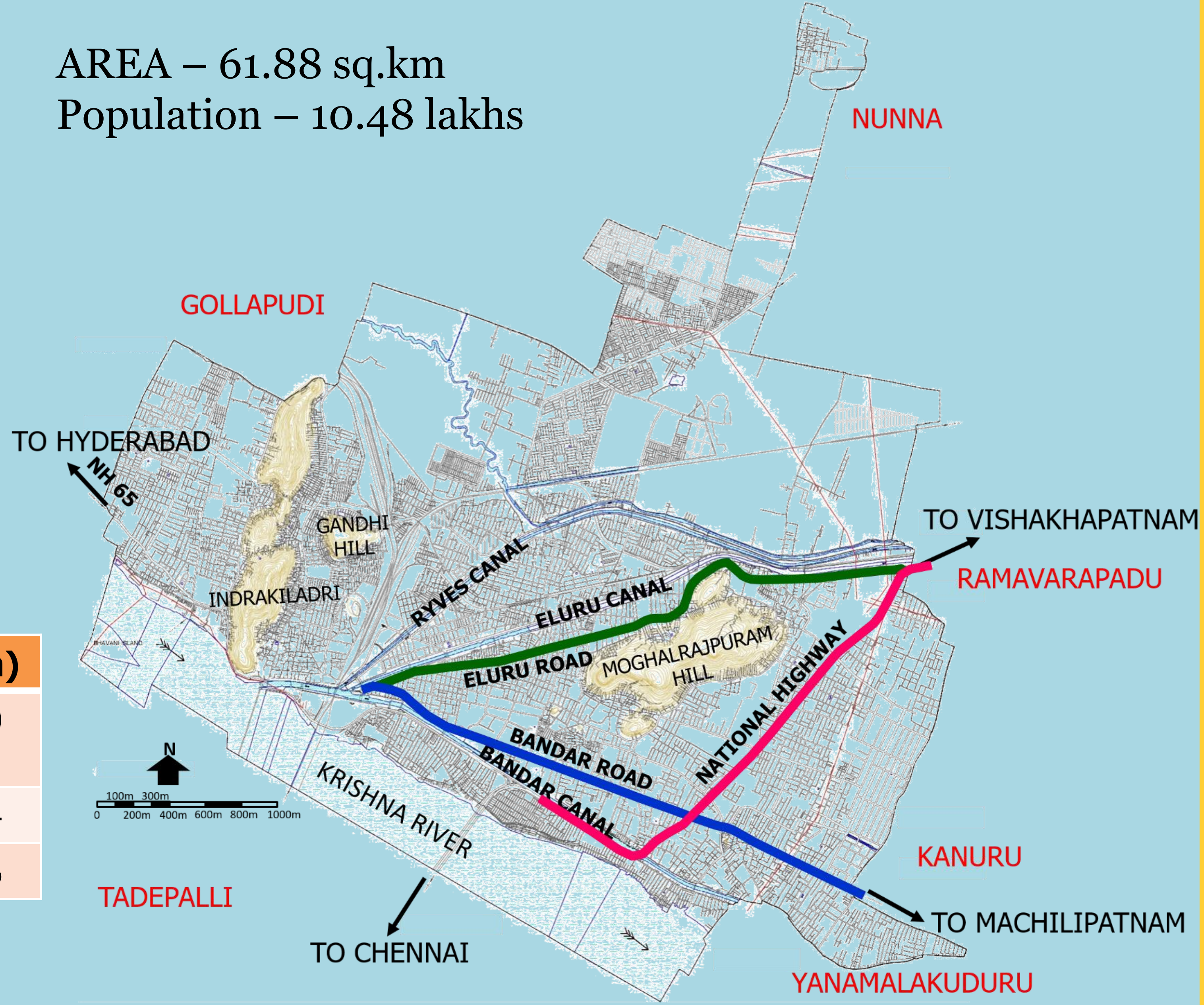


Ambient Air Quality

Year	PM 2.5	PM 10	NOx	CO	SO2
2017	39.6	88.72	33.98	1.13	16.16
2018	49.16	102	65.52	1.21	13.71
2019	38.07	47.12	25.07	1.79	10.73

Road	Hierarchy	Length	ROW(m)
NH 16	4 lane divided + 2 lane undivided	6.5 km	32 – 60
NH 65	4 lane divided	7 km	24 – 34
Eluru Rd.	4 lane divided	7 km	24 – 26

AREA – 61.88 sq.km
Population – 10.48 lakhs



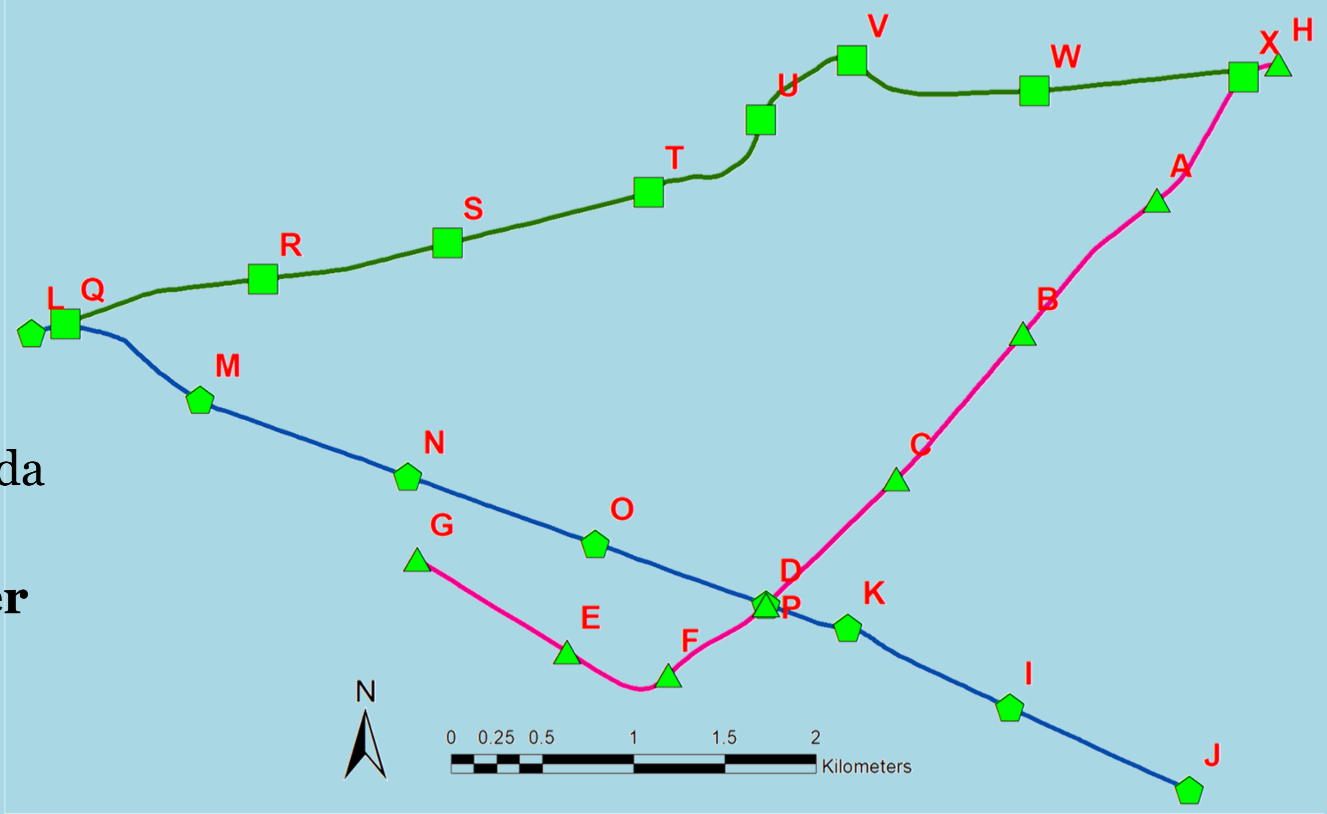
Estimation of CO Concentrations

CALINE MODEL is used for estimating CO concentrations along selected roads

- Originally developed for Carbon Monoxide (CO)
- Principle – dividing road into series of elements; Concept of 'Mixing Zone'

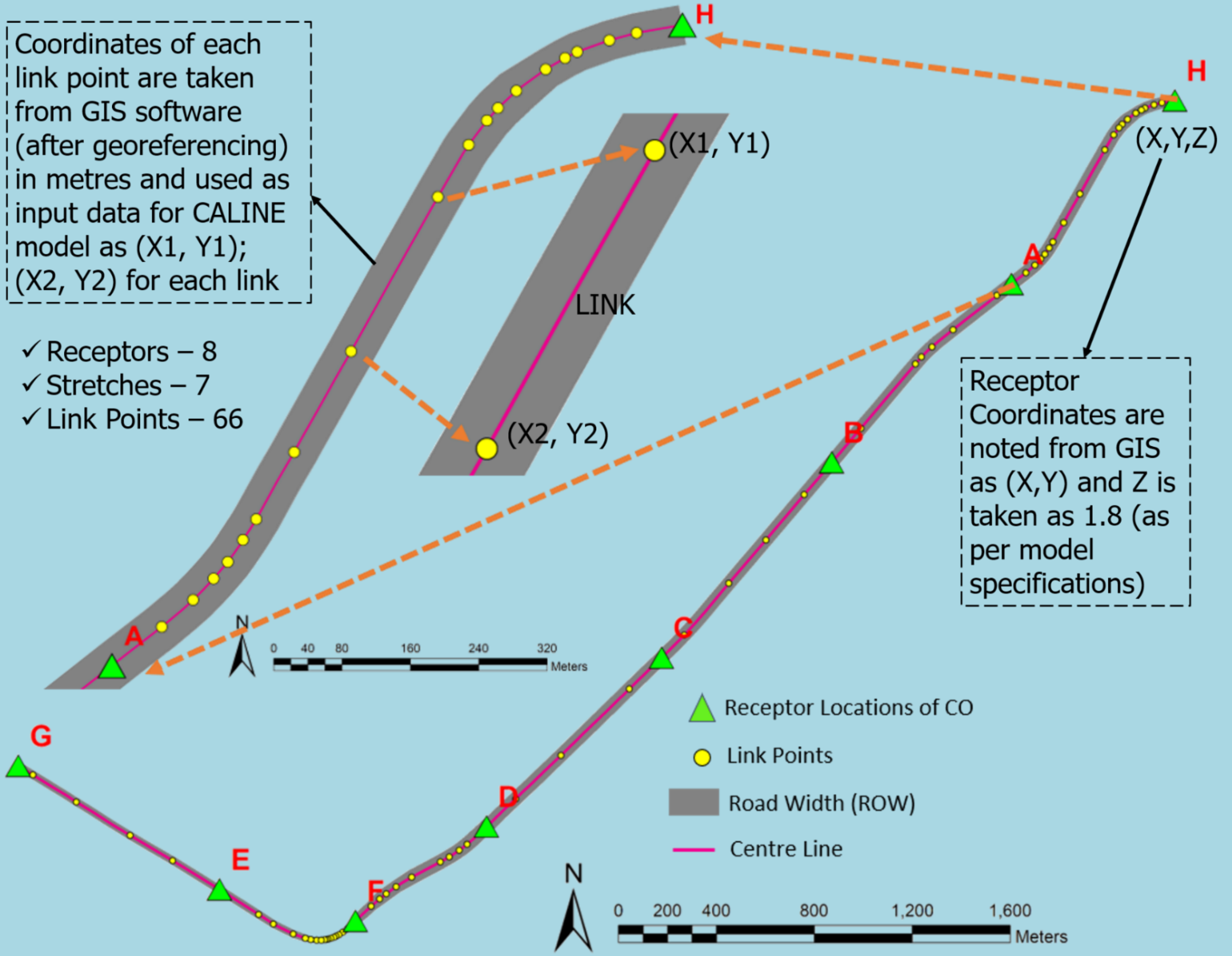
INPUT PARAMETRS

- ✓ Units - Metres
- ✓ Aerodynamic Roughness Coefficient – **300** (for major roads of large towns)
- ✓ Run Type – **Worst case wind direction**
- ✓ CO Emission Factor (g/mi) for 1 hr
- ✓ Pollutant - Carbon Monoxide
- ✓ Molecular Weight – 28
- ✓ Altitude above sea level – **23m** for Vijayawada
- ✓ Link Type – **At Grade**
- ✓ Mixing Zone Width – **ROW + 3m on either side of the road**
- ✓ Wind Direction Standard Deviation - 5°
- ✓ Ambient CO Concentration – 3 ppm



Model simulation for stretch "H – A" of NH-16

- Receptor points are given using X, Y and Z coordinates so as to ensure accuracy of observed values with predicted values
- The output of model is given in results tab, where concentrations of CO are noted in terms of ppm
- Similarly, entire process if performed for the three stretches to obtain the concentration of the stretch



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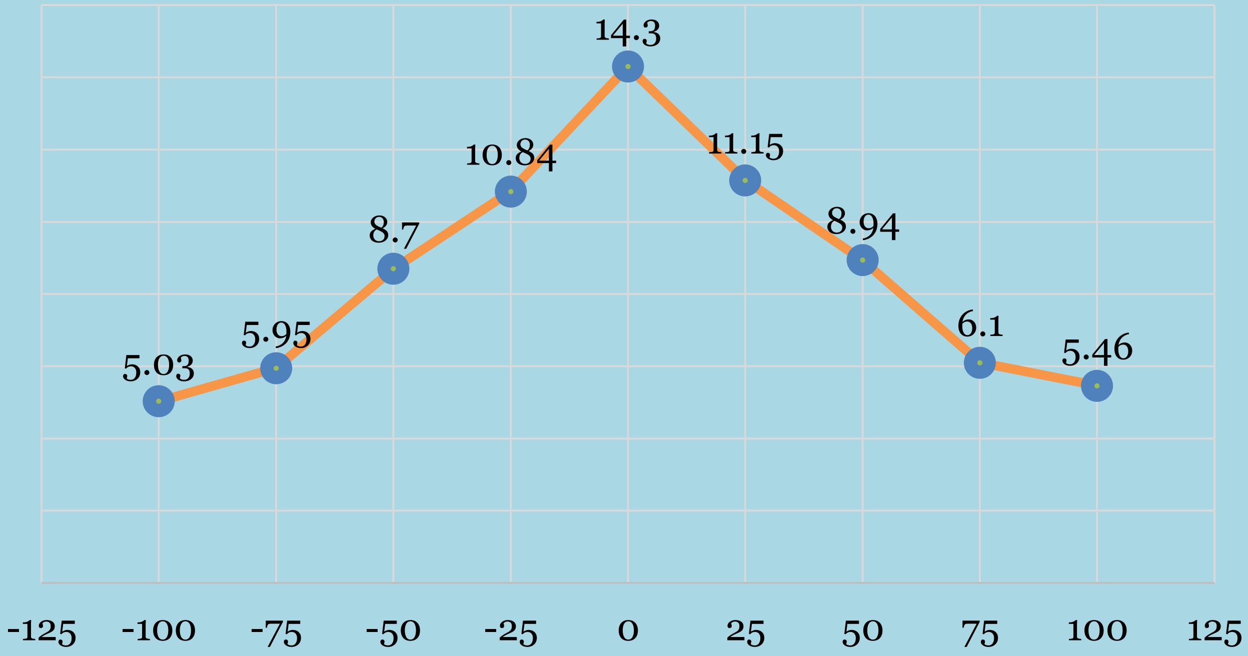
Predicted CO Concentrations along NH-16

Assessment of Pollution Concentrations

Receptor	Observed (CO) - ppm	Predicted (CO) - ppm	% Change
H	13.9	14.7	5.75%
A	12.7	13.6	7.09%
B	13.8	14.4	4.35%
C	13.4	14.4	7.46%
D	12.1	13.3	9.91%
F	13.9	15.2	9.35%
E	14.7	15.5	5.44%
G	12.6	13.2	4.76%

Impact of CO concentration till 100m



Average CO Emission Concentration = 14.3 ppm

CO_2 Emission Concentration = CO emissions concentration x 44 / 28

= 14.3 x 44 / 28 = **22.47 ppm of CO_2**

Estimation of Absorption Capacities

The biomass of trees has been estimated based on GBH (Girth at Breast Height) and tree height. Girth of tree is measured at breast height (1.3m)

AGB (Kg/tree) = Volume of tree (m3) x Wood density (Kg/m3)

Volume of Tree = 0.4 x $(GBH)^2$ x H / 3.14

BGB (Kg/tree) or (ton/tree) = AGB (Kg/tree) or (ton/tree) x 0.26

Total Biomass = AGB + BGB

Carbon Storage = 1% of total biomass per species

Green Cover Absorption Capacities along NH-16

Tree Name	GBH (m)	Height (m)	Bio-Volume	Wood Density (Kg/m3)	AGB	BGB	Total Biomass	Carbon Storage/ Tree	Total Carbon Storage
Albizia Lebbeck	0.18	3.5	0.0144	630	9.1009	2.3662	11.4671	0.114671	4.586849
Azadirecta Indica	0.22	5	0.0308	650	20.0382	5.2099	25.2482	0.252482	2.272334
Delonix Regia	0.13	4.5	0.0097	600	5.8127	1.5113	7.3241	0.073241	3.662025
Ficus Religiosa	0.15	5.2	0.0149	600	8.9427	2.3251	11.2678	0.112678	2.591587
Mangifera Indica	0.12	4.5	0.0083	590	4.8703	1.2663	6.1366	0.061366	1.043222
Tamarindus Indica	0.15	4.2	0.0120	700	8.4268	2.1910	10.6177	0.106177	1.061771
Terminalia Arjuna	0.17	4.8	0.0177	680	12.0165	3.1243	15.1408	0.151408	0.605632
Bougainvillea	0.025	0.45	0.0000	200	0.0072	0.0019	0.0090	9.03E-05	0.072229
Conocarpus Erectus	0.05	1.2	0.0004	230	0.0879	0.0229	0.1108	0.001108	0.276879
Tecoma Stans	0.06	1	0.0005	210	0.0963	0.0250	0.1213	0.001213	0.018202

CARBON STORAGE (CO_2) = 16.19073 ppm

CO_2 concentration = emissions – absorption = 22.47 – 16.19 = **6.28 ppm ≈ 4 ppm of CO**

Therefore, 4 ppm of CO is not being absorbed by the vegetation along NH – 16

Scenario Building

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Based on Population & Traffic projections, the following scenarios are considered to estimate for **2030**

SCENARIO I

Desirable modal share based on city size/ population

SCENARIO II

Desirable proportion of Electric Vehicles - NEMMP

SCENARIO III

Tress species suitable for along side and median of roads

- **BUSINESS NEUTRAL SCENARIO –** Vehicle and Fuel Composition are taken same as present

SCENARIO – I : Change in Vehicular Composition & respective variation in Fuel Composition

SCENARIO – I + II : Change in Vehicular and Fuel Composition, shift to e-mobility is considered

SCENARIO – III: Increased Green Cover and introduction of suitable new species

BUSINESS NEUTRAL+ SCENARIO – III : Vehicle & Fuel Composition as present + Increased Green Cover

SCENARIO – I + III : Change in Vehicular Composition + Change in Green Cover

SCENARIO – I + II + III : Change in Vehicular Composition + Shift to e-mobility + Green Cover change

Results

Summary of Scenarios along three roads

Scenarios	NH - 16	NH - 65	Eluru Road
Present	4 left	9 left	8 left
Business Neutral (Increased)	Emission – 17.5	Emission – 16.8	Emission – 15.1
I (Increased)	Emission – 16.2	Emission – 15.25	Emission – 14.7
I + II	0.7 left	3.37 left	2.56 left
III (Increased)	Absorption – 20.02	Absorption – 8.7	Absorption – 9.23
Business Neutral + III	3.74 left	11.26 left	9.23 left
I + III	3.46 left	9.74 left	8.83 left
I + II + III	3.16 left	1.65 left	1.02 left

Thus the two scenarios falling within the standard of 3.4 ppm - Scenario I + II and Combination of all three scenarios (I + II + III) are recommended, highlighting the need of shift towards electric vehicles and increased green cover