

# ANALYTICAL EVALUATION OF VEHICULAR AIR POLLUTANTS AT URBAN ARTERIAL ROAD: A CASE STUDY OF RAJKOT CITY

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**Abstract** - Cities and town plays a vital role in promoting economic growth and prosperity in country. With growing population, vehicular air pollution is detected as an eminent problem in Rajkot city due to high growth of motorized vehicles. The increase in travel demand has resulted in rapid growth of number of motor vehicles, buses and other mode of transportation in the arterial and sub arterial road of Rajkot city. Environmental analysis of transportation system is an inclusive and demanding task. Traffic induced emissions pose a serious threat to air quality in many metropolitan cities. Along with increase in motorized vehicles in city amount of CO, CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub> and particular matter is also drastically increasing which cause unhealthy air to breathe in urban areas. The results of the study are discussed and contribution of each of the measures is evaluated. The results are carried out to quantify the emissions of interest for analyzation and traffic air pollution prediction model is developed according to that.

**Key Words:** Air pollution, Traffic, Emission, Urban area, Arterial road

## 1. INTRODUCTION

Air is a part of earth's atmosphere, and one of its most important natural resources. Air is considered as eminent need for all human beings, animals and plants to sustain the life. Eventually it was replaced by transportation means, namely motor vehicles. Since then, the growth in the number and use of motor vehicles has been considered the most conspicuous feature of the modern industrial economy, as well as one of the most influential forces on the natural and built environment. Transportation plays an important role in contribution to urban air pollution. As household cooking is switched to modern fuels (electricity, natural gas), lower quality industrial fuels like lignite, low grade coals and dirty heavy diesel are being replaced by cleaner coals or oils and natural gas, and industries are being moved out of cities, so the role of transportation in air pollution grows dramatically. One main difference is that stationary sources of air pollution are easy to spot and regulate, and they often cause annoyance to the polluter themselves, while mobile sources like vehicles are harder to spot and regulate, and are rarely a cause for direct annoyance to the polluters. The vehicle fleets have even drastically increased in some cities in last one decade. The increased mobility, continuous growth in number of vehicles, and increase in the

consequent congestion, vehicles are now becoming the main source of air pollution in urban India. The bad effects of vehicular exhausted gases are reflected in the form of various environmental problems. Main amongst all is the deterioration of urban air quality in India.

Air pollution because of Transportation is the excessive discharge of particulate matters, fumes into the atmosphere and their suspension in the atmosphere for the long period of time. Air pollutant occurs in all the forms such as solid particles, liquid droplet and/or gases. In urban area major factor related to air pollution is because of transportation system which provides access and mobility for people and goods, and linking origin and destinations in both internal and external of the urban area. Mobile sector is considered as main source of air pollution in urban area. People moving to urban area increase the energy consumption, urbanization and industrial development which lead to increasing number of vehicles.

Control of petrol engines and their impact on ambient ozone pollution (NO<sub>x</sub> and HC) has been the focus of regulatory efforts in developed urban areas, but attention is now being focused to emissions from diesel engines. Diesel engines have higher emissions of NO<sub>x</sub> and they have significant emissions of fine particulates, which in turn may be the most serious threat to human health in urban areas.

## 2. Literature Review

A review of literature plays an important role in any research work. In this aspect, the studies carried out emission rate of air pollution from vehicle as well as relevant information pertaining to the validity of the data from a statistical view point. Most of the research has been conducted to understand the emission rate of pollutants and its effect of different vehicle types. Main focus of the review was factor affecting emission rate of pollutant at various intersection and identifying method which had been measure vehicular emission rate of various pollutants.

**Mitran G., Ilie S. and Ivan F. (2011)**

Estimation of Air Pollution from Road Traffic by Transport Modeling|| in this study air pollution generated by road vehicle traffic consist of these steps such as i. analyze transport demand and the affecting of traffic flows on the

entire analyzed network. ii. Collecting socioeconomic and land use data from the trip generation. iii. Inventory of the emission from road vehicle which composed of the traffic flow. Traffic was represented as a compressible fluid in a macroscopic model; each vehicle movement cannot be monitored and total traffic volume and average speed were used to determined emission. Relation between volume of CO emission  $E(CO)(g/m)$ , traffic flow  $q$  (veh/hr) and average speed  $v$  (km/hr) given below

$$E(CO) = 1031 q v^{-0.795} 10^{-4}$$

In case air pollution from road traffic from mesoscopic level objective the determination of the influence of speed variation (acceleration, deceleration, cruise and queuing). Estimation of volume of emission depends upon the speed variation of motor vehicles.

**Anusha S., Sivanandan R. and Senthilraj S. (2008)**

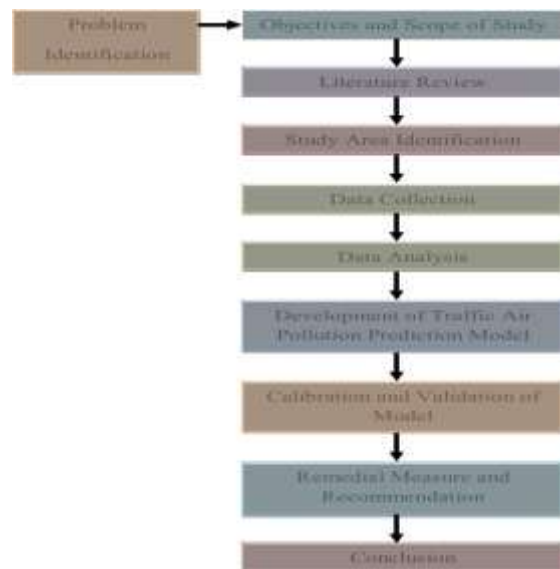
Influence of lane restriction on vehicle emission under heterogeneous traffic|| in this study only motorized two wheelers emission measured under lane restricted and lane less flow in heterogeneous traffic, study was conducted on selected mid block section of different road lengths. Vehicular tailpipe emission measured using a portable gas analyzer for short interval of times for each test runs. Vehicular speeds were measured by using optical sensor fixed to the wheel and also consumption of fuel by test vehicle was measured by using a petrol reading instrument. Multiple linear regression model using SPSS software were carried out to tested and analyzed based on relation between emissions and various traffic factors. . Based on the study it was concluded that lane restricted flow generally produced less level of tailpipe emission compared to the lane less condition, in heterogeneous traffic lane change carried out by vehicles to be an important contributor to emission, reduced level of tail pipe emission generally produced by lane restricted flow, for minimum emission it was found that driving speed in the range of 58 to 62 km/h and for minimum consumption of fuel found speed was around 53 km/h for two wheeler vehicles, this study based on limited tests on selected two wheelers vehicle on selected road stretches.

**Oladnia S., Saeedi M. and Bazkiaei A. (2008)**

Intersection Air Pollution Emission Prediction using Software Hyroad in city of Iran||, in this study they putted more concentrate of CO investigation and they observed pollutant CO has the most emission changes in intersection because of vehicles are forced to reduce speed, change direction, and most likely, stop for a long period of time. In this study modeling practice has been done considering several parameters including, weather characteristics and meteorological characteristics, traffic flow, characteristics of vehicle, and site specific characteristics. Develop Hyroad model to estimate CO concentration near by the intersection

simultaneously integrates three different models such as, measurement of traffic flow by NETSIM model, development of MOBILE5 and MOBILE6 are used to calculate emission factor in terms of gram per mile, and for measurement of dispersion meteorological characteristics is done by Gaussian dispersion equilibrium.

**2.1 Methodology**



**Fig -1:** Flow chart of Methodology

**3. DATA COLLECTION & EXTRACTION**

**3.1 Study Area**

Rajkot is the 4<sup>th</sup> largest city in the Gujarat and 35<sup>th</sup> largest city in India with population more than 1.2 million as per survey in 2015. It is also 147<sup>th</sup> fastest growing city in the world. It is the capital of Saurashtra region. It is located at 22.3° N and 70.78° E and is spread in the area of 170.00 km<sup>2</sup> and located 138m above mean sea level. Climatic condition of Rajkot is generally semi-arid and average low temperature lies between 20°C to 22°C and average high temperature is 40°C



**Fig -2** View of Kotecha to KKV circle



Fig -3 View of Punitnagar to Gondal circle

Following are the major road stretch (as per visual observation) where vehicular volume is maximum which results into high air pollution rate.1)Kotecha to KKV circle2)Punitnagar Circle to Gondal circle.

The main intention of selecting particular major road named 150ft ring road is as it includes all mode of vehicles of urban network traffic. Vehicles are classified under six categories: two wheelers, three wheelers, LCV, HCV, cars and buses. 24 hours data is taken for the traffic volume count.( 9:00 AM to 9:00 AM)

### 3.2 Classified Volume Count (CVC)

For CVC of selected location of a urban arterial road is selected for data collection. Classified volume count data is collected by using videography method and travel time of vehicles are collected by manual method from the top of 5 storey commercial building. 24 hours data is collected for classified volume count.(9:00 AM To 9:00 AM).

**Location:** KKV Circle

24 hour traffic data at selected location is to be taken for survey.

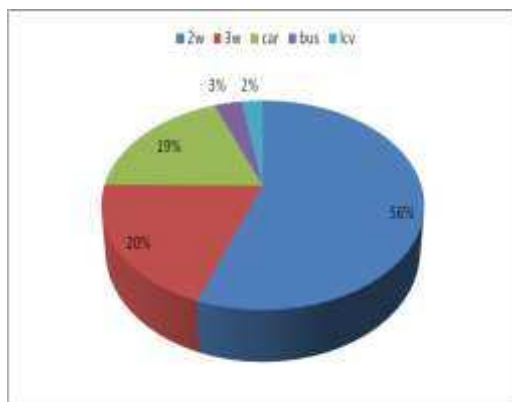


Chart -1: Vehicle Composition (KKV circle)

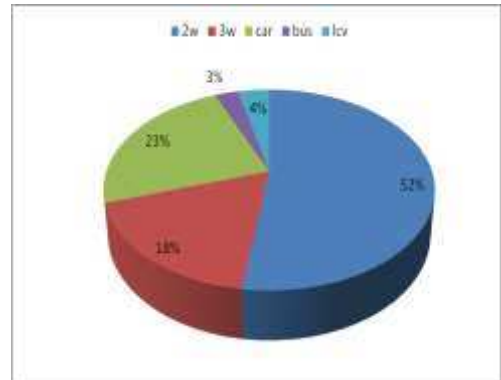


Chart -2: Vehicle Composition (Gondal circle)

### 3.3 Collection of Air Pollutant Data:

Ambient Air Monitoring is used to measure different pollutants such as SO<sub>2</sub>, NO<sub>x</sub>, PM<sub>2.5</sub>, P.M<sub>10</sub> which is the major factor from vehicles. For measurement of these pollutants one of the following samplers are used.



Fig -4 Combo Sampler

Table no-1 Total Air pollution at KKV circle

Location - Near KKV Circle(tulip complex)				
Sr. No.	Parameters	Date	National Ambient Air Quality Standard (µg/m <sup>3</sup> )	Reading (24 HOURS)
1	SO <sub>2</sub>	08-03-2019 (Friday)	80	42.85
2	NO <sub>x</sub>		80	26.5
3	PM <sub>2.5</sub>		60	32.5
4	PM <sub>10</sub>		100	62.68

**Table-2 Total Air Pollution Gondal circle**

Location - Near punitnagar circle				
Sr. No.	Parameters	Date	National Ambient Air Quality Standard ( $\mu\text{g} / \text{m}^3$ )	Reading (24 HOURS)
1	SO2	15-03-2019	80	44.69
2	NOX	(Friday)	80	28.35
3	PM2.5		60	32.96
4	PM10		100	64.53

### 3.3 Development of Air prediction Model

Air pollutant prediction model because of analysis of volume of vehicles at intersection is developed by using the LINEST function in EXCEL. The LINEST function is calculate the statistics for a line by using –least square|| method to calculate a straight line that best fit for data, and then returns in array that briefing the line.

**Model - 1 (CO)-** This model is developed intersection and seleted road stretch .Model is developed on the basis of the data collected of total no. of vehicular composition of 24 hour and vehicular air pollutant data of 24 hour at intersections and midblock.

$$CO=12.35+(0.011*C_{2w})+(0.071*C_{3w})+(0.014*C_c)+(0.0003C_B)+(0.154C_L)$$

Where

- CO = pollutant level of CO in ppm
- $C_{2w}$  = Composition of 2W in numbers
- $C_{3w}$  = Composition of 3W in numbers
- $C_c$  = Composition of Car in numbers
- $C_B$  = Composition of Bus in numbers
- $C_L$  = Composition of LCV in numbers
- 12.35= constant value

**Model - 2 (CO<sub>2</sub>)**This model is developed intersection and seleted road stretch .Model is developed on the basis of the data collected of total no. of vehicular composition of 24 hour and vehicular air pollutant data of 24 hour at intersections and midblock.

$$CO_2=13.57+(0.019*C_{2w})+(0.063*C_{3w})+(0.09*C_{car})+(0.029*C_{bus})+(0.44*C_{lcV})$$

Where  
 12.35= constant value  
 CO = pollutant level of CO in ppm  
 $C_{2w}$  = Composition of 2W in numbers

- $C_{3w}$  = Composition of 3W in numbers
- $C_c$  = Composition of Car in numbers
- $C_B$  = Composition of Bus in numbers
- $C_L$  = Composition of LCV in numbers

### 3.4 Model Validation

#### Model - 1 (CO)

Validation of model using different statically test is described below,

Output of linear software is,

$$R^2 = 0.55$$

$$Df = 30$$

Following are the F-test output

Critical F –test value = 2.0144 (91%significancelvel)

Model F – test value = 4.58

Following are the T – test output

Critical T – test value = 0.3

Model T – test value = 0.6

Following are the chi<sup>2</sup> – test output

Critical chi<sup>2</sup> – test value = 1.145

Model chi<sup>2</sup> – test value = 133.721

#### Model - 2 (CO<sub>2</sub>)

Validation of model using different statically test is described below,

Output of linear software is,

$$R^2 = 0.76$$

$$Df = 30$$

Following are the F – test output

Critical F – test value = 1 (95% significance level)

Model F – test value = 1.46

Following are the T – test output

Critical T – test value = 0.3

Model T – test value = 0.8

Following are the chi<sup>2</sup> – test output

Critical chi<sup>2</sup> – test value = 1.145

Model chi<sup>2</sup> – test value = 68.88

### 4. CONCLUSION

From the above test it is clear from that,  $T_{observed} > T_{critical}$  IS showing that the probability of acceptance of independent variables with the dependent along with the  $chi^2_{observed} > chi^2_{critical}$  and  $F_{observed} > F_{critical}$ . So the model is accepted for the test.

### 5. FUTURE SCOPE AND STUDY

In this model only CO and CO<sub>2</sub> is evaluated at each selected intersection. Other parameters like Sox, Nox, HC, PM<sub>10.0</sub> and PM<sub>2.5</sub> can be evaluated for further study.

Development of air prediction model is done in excel. Other software can also be used for developing a model

This study is limited to concentration of air pollutant in urban area which is totally different from rural area which can be explored in future.

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