MANTECH Publications

Journal of Transportation Engineering and Its Applications
Volume 7, Issue 1, January-April, 2022

A Study on Vehicular Emissions Prediction in Vijayawada

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Abstract

In many emerging and developed nations, air pollution is a major issue. The largest source of air pollution in urban road networks is automotive emissions. In this regard, the current research illustrates the prediction of vehicular emissions from various kinds of vehicles seen on Vijayawada city's metropolitan highways. The Automobile Air Pollution Inventory (VAPI) model was used to assess and forecast vehicular emissions based on data collected in the municipality. This study examines the unbound emissions of Carbon Monoxide (CO), Hydro Carbon (HC), Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon Dioxide (CO2), Benzene, 1-3 Butadiene, Formaldehyde, and Acetaldehyde from six distinct modes of transportation. The VAPI model findings revealed that there is a steady rise in emissions of each pollutant category each year, resulting in a decrease of air quality in the research region. The report also offers various mitigating actions to enhance the city's air quality in the next years.

Keywords*: - Air Pollution, Automobile, Transportation, Carbon Monoxide*

INTRODUCTION

Urbanization has risen in many cities in developing nations such as India throughout the years. Increased automobile volume on urban highways has come from population expansion and urbanisation. Increased automobile volume resulted in increased vehicle emissions of hazardous gases. Vehicle emissions include a variety of contaminants that affect the quality of the city's air. The current research focuses on measuring all forms of pollutants utilising a roadside device deployed in Vijayawada. Vijayawada is one of the

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largest cities in the Indian state of Andhra Pradesh, with a population of around 1,034,358 people (as per 2011 census). In recent years, there has been a significant surge in urban migration.

The amount of traffic in the city has grown as the use of personnel cars has increased. From 2005 to 2016, the automobile population rose by 156% (Road Transport Authority headquarters, Vijayawada). The current research aims to quantify automobile emissions using data obtained in Vijayawada. The amount of Carbon Monoxide (CO), Hydro Carbon (HC), Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon Dioxide (CO2), Benzene, 1-3 Butadiene, Formaldehyde, and Acetaldehyde contents expected to be released from six different vehicle types observed on urban roads in Vijayawada city is estimated in this study.

REVIEW OF LITERATURE

A research was conducted on the measuring of air pollutant emissions from motor vehicles. A tunable infrared laser differential absorption spectrometer (TILDAS) was designed to assess emissions from certain vehicle types at varying highway speeds [1]. The prediction of the rate of outflows for light cars and trucks, as well as fuel consumption from hot balanced out vehicles, has been completed using many half and half relapse models [2].

The use of different pollution monitoring technologies in assessing the quality of air on the roadside based on data gathered by Leicester monitoring stations was outlined [3].

The association between traffic capacity and pollution absorptions (Carbon Monoxide and Sulphur Dioxide) was discovered by exhausting a mathematical model. The research proposes models for enclosed and open areas in Malaysia, taking into account various forms of transportation [4].

The rates of emission of major pollutants CO, NOx, and PM10 were determined using empirical emission factors [5].

The COPERT III model was used to estimate vehicular emissions for various vehicle types over a five-year period. COPERT III [6] has employed vehicle speed, mileage, fleet population, fuel consumption, quality, and temperature as inputs. The International Vehicle Emission (IVE) model was used to study the effect of altitude on CO, NOx, and VOC (Volatile Organic Compounds) emission

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rates from gasoline-powered light duty commercial vehicles (LDCVs) in three Indian cities: Delhi, Dehradun, and Mussorie [7]. The effect of the vehicle's quick speed on outflows and fuel consumption was evaluated. They discovered that when the instantaneous speed of cars changes, time and distance-based emission factors increase and fuel-based emission factors decrease [8].

To quantify automobile emissions in Indian cities, the Vehicular Air Pollution Inventory (VAPI) model was created and tested. The VAPI model attempted to bridge the gap between current advanced models and the instruments required in developing nations such as India [9].

The influence of policy changes on total emissions of several air pollutants such as CO2, CO, HC, NOx, TSP, SO2, Pb, and VOCs has been estimated and evaluated for megacity Delhi between the years 2000 and 2005 [10].

Vehicle speed and acceleration are jumble-sale as essential input variables in the INTEGRATION tiny traffic imitation model to fake the network. The regression model was created to estimate carbon dioxide emissions in Arlington, Texas by using predictive factors such as velocity, acceleration, and an interaction term [11].

The instantaneous vehicular emission model (VT-Micro) was used to develop the affinity for vehicle time headway and carbon monoxide emission. A Hong Kong transportation information database was well-known for traffic movement mimicry [12].

The CALINE 4 model was used to approximate and calculate CO absorptions on a highway access strip in Delhi [13]. The study of emissions from automobiles on Delhi's highways has been completed. They investigated VOCs and PM10 from non-exhaust vehicle sources using vaporous, particulate, and portable source air toxics [14].

SITE CHOICE AND DATA COLLECTION

The city of Vijayawada in the Indian state of Andhra Pradesh was selected for data collecting. The bus and auto rickshaw are the most common modes of intra-city public transportation in Vijayawada. Other private forms of transportation include automobiles, motorcycles, and bicycles. Benz circle is one of the busiest traffic intersections in the study region, with 57000 cars passing through each day. The

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number of registered vehicles in the aforementioned vehicle classes from 2005 to 2016 is available from the Road Transport Authority (RTA) and is shown in Fig. 1.

Six types of vehicles were observed: motor vehicles (2 wheelers), cars, taxis, 3-wheelers, LCV (Light commercial vehicles), and HCV (Heavy commercial vehicles). Pollutant data like as Carbon Monoxide (CO), Nitrogen Oxides (NOx), Particulate Matter (PM), and Benzene is gathered from the Vijayawada Continuous Air Quality Monitoring Station (CAQMS), which is located near the road.

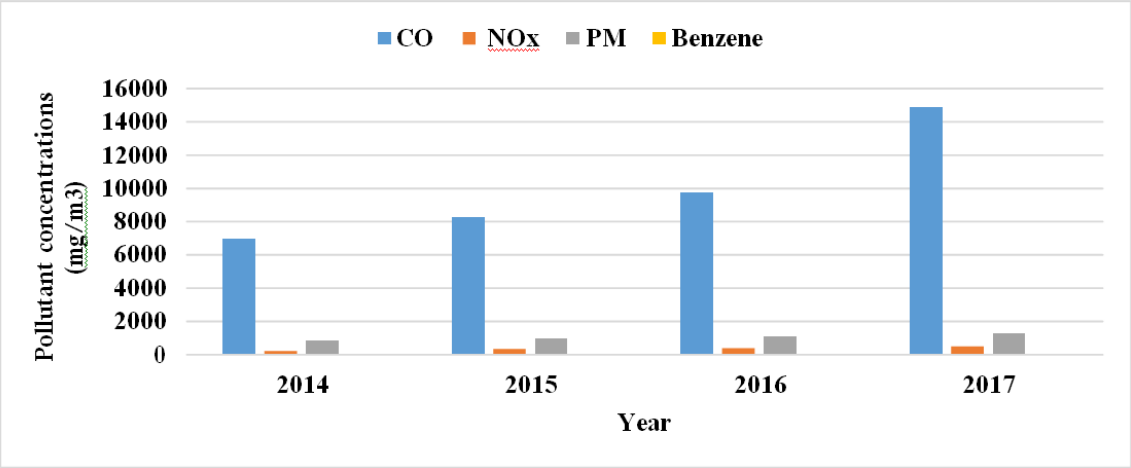


Figure 1(a): Ambient air quality emissions in Vijayawada during the period of 2014 to 2017.

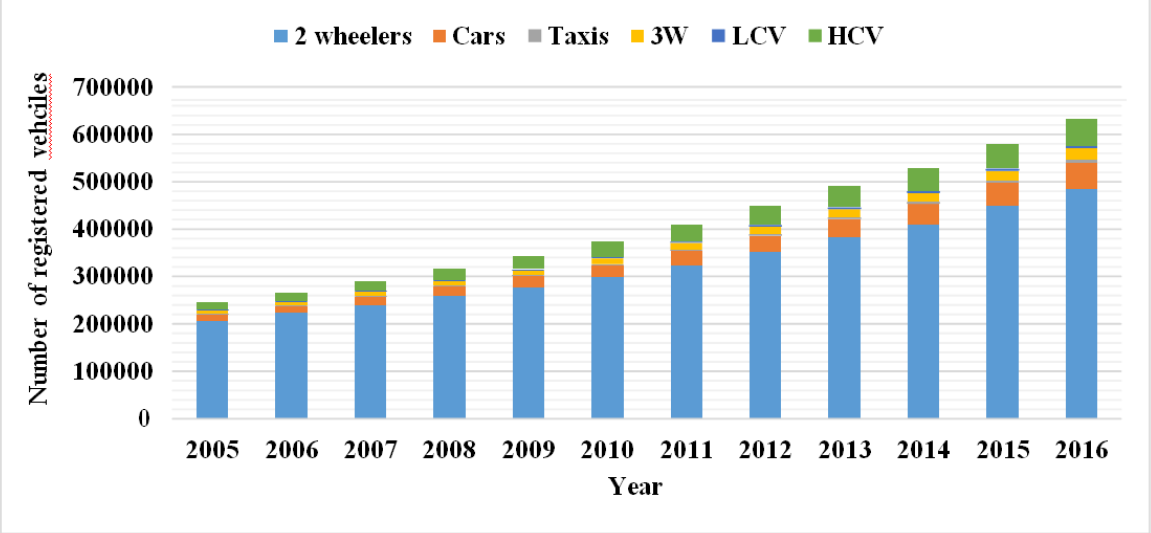


Figure 1(b): Number of registered vehicles in Vijayawada city during the period of 2005 to 2016. [Source: Road Transport Authority (RTO) office, Vijayawada.]

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DATA ANALYSIS AND OUTCOMES

The VAPI (Vehicular Air Pollution Inventory) model is used in this research to predict the anticipated quantity of emissions from different forms of transportation seen in the city. To estimate emissions for certain site circumstances, the model use a base emission rate together with climatic and geographical adjustment factors. The VAPI model is represented by equations (1) and (2), which are used to calculate vehicle emissions. The parameter settings

This equations are derived from a specific location. Emission parameters for the research region were collected from the Automotive Research Association of India (ARAI, 2007) [15]. The modification concerns considered in this investigation were derived from the International Vehicular Emission Model (IVEM, 2008) [16].

$$E_{tpi} = P_i * E_{api} * V_i * D_{ti} \quad (1)$$

$$E_{api} = EF_{pi} * C_{tpi} * C_{hpi} * C_{api} \quad (2)$$

D_{ti} = Annual travelling days of i vehicle category

E_{api} = Adjusted emissions rate of pollutant p from i vehicle category

EF_{pi} = Emissions factor of pollutant p from i vehicle category

EF_{tpi} = Total emissions of pollutant p from i vehicle category

C_{tpi} = Temperature correction factor of pollutant p for i vehicle category

C_{hpi} = Humidity correction factor of pollutant p for i vehicle category

C_{api}=Altitude correction factor of pollutant p for i vehicle category

P_i = Registered Population of i vehicle category

V_i= distance travel by i vehicle category per day

Data gathered in Vijayawada between 2005 and 2016 are used to estimate vehicular emissions for each vehicle type. Vehicle emission predictions are also produced for each vehicle type between 2017 and 2030. Because year-by-year emission factors and correction factors are used in this analysis, the temporal pattern of numerous pollutants from 2005 to 2030 is seen. Figures 2–10 show the quantity of emissions produced by various kinds of automobiles.

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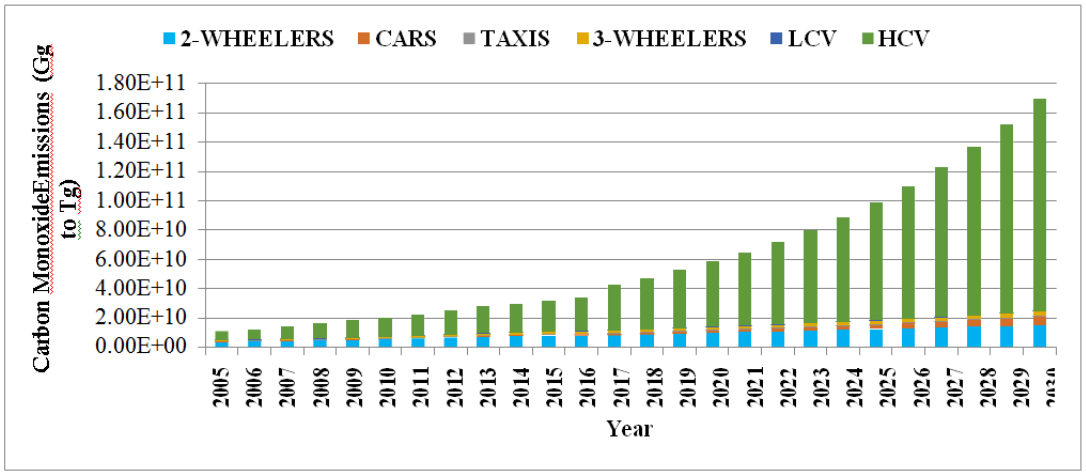


Figure 2: Trend of carbon monoxide emissions between the years 2005 to 2030.

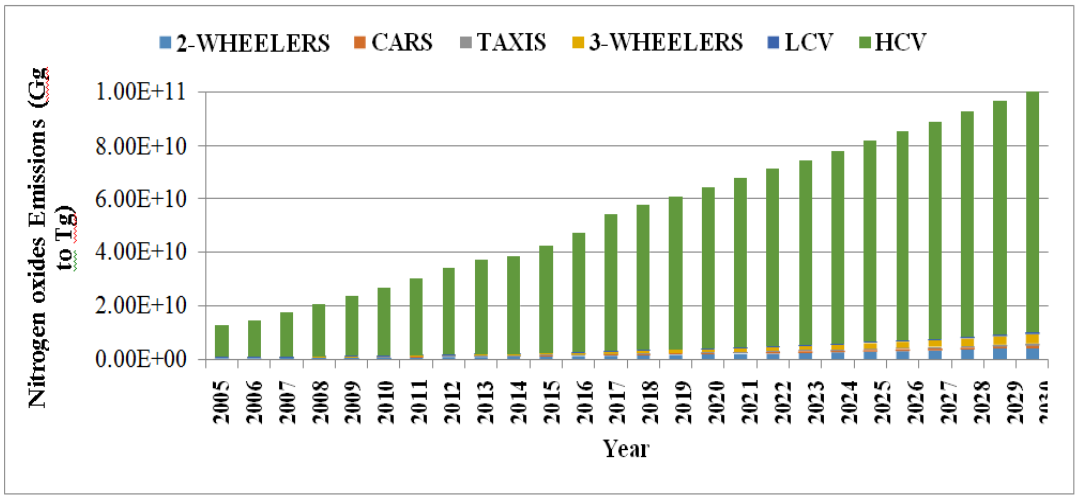


Figure 3: Trend of nitrogen oxides emissions between the years 2005 to 2030.

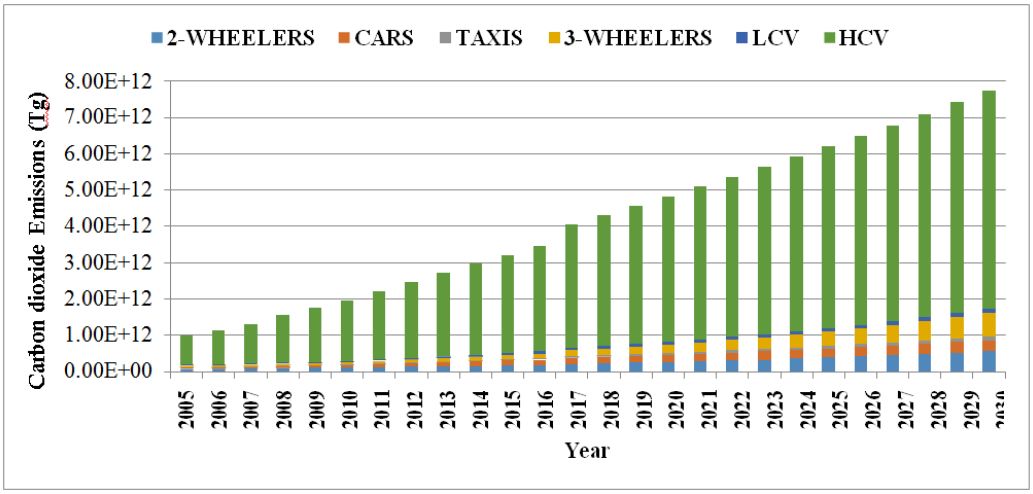


Figure 4: Trend of carbon dioxide emissions between the years 2005 to 2030.

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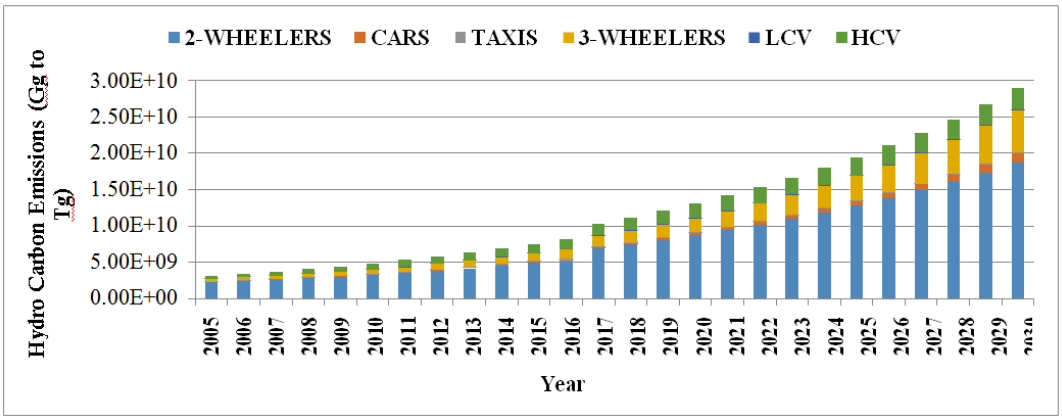


Figure 5: Trend of hydro carbon emissions between the years 2005 to 2030.

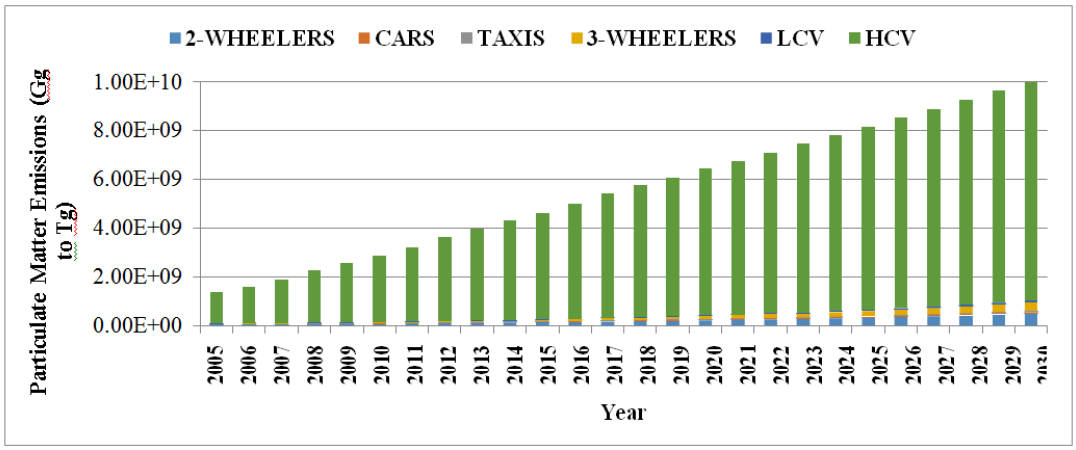


Figure 6: Trend of particulate matter (PM) emissions between the years 2005 to 2030.

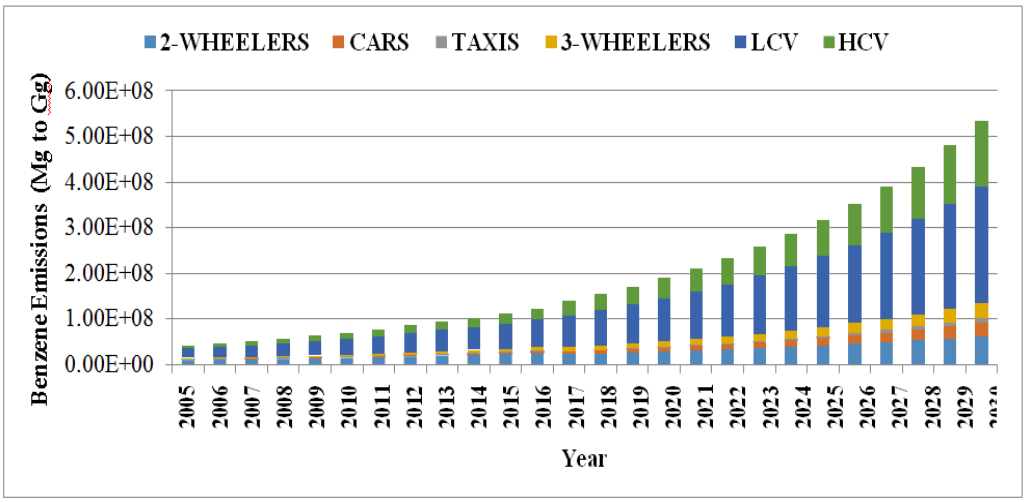


Figure 7: Trend of benzene emissions between the years 2005 to 2030.

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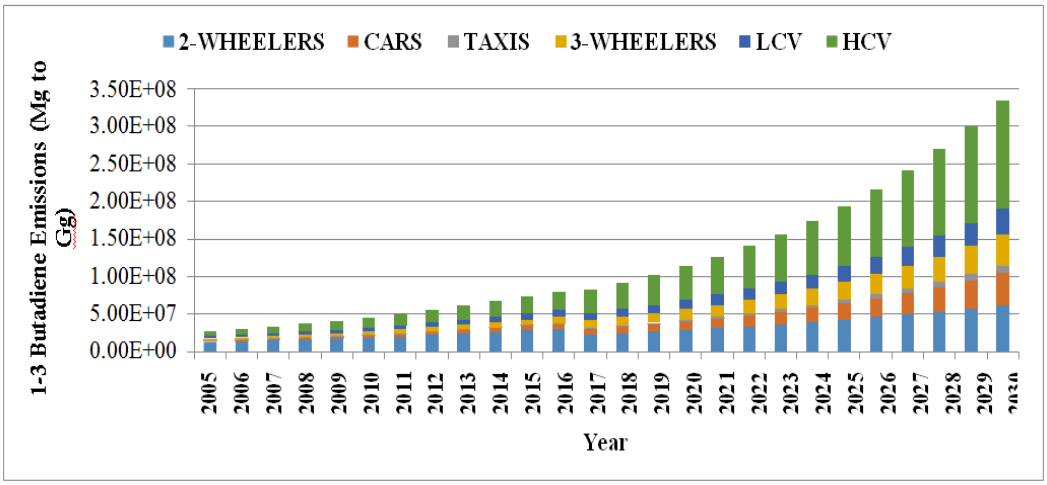


Figure 8: Trend of 1-3 butadiene emissions between the years 2005 to 2030.

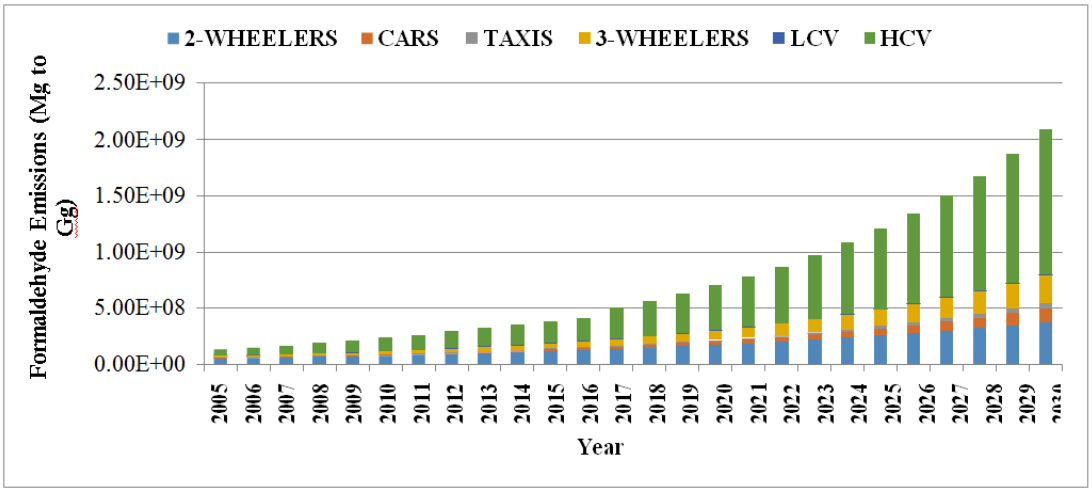


Figure 9: Trend of formaldehyde emissions between the years 2005 to 2030.

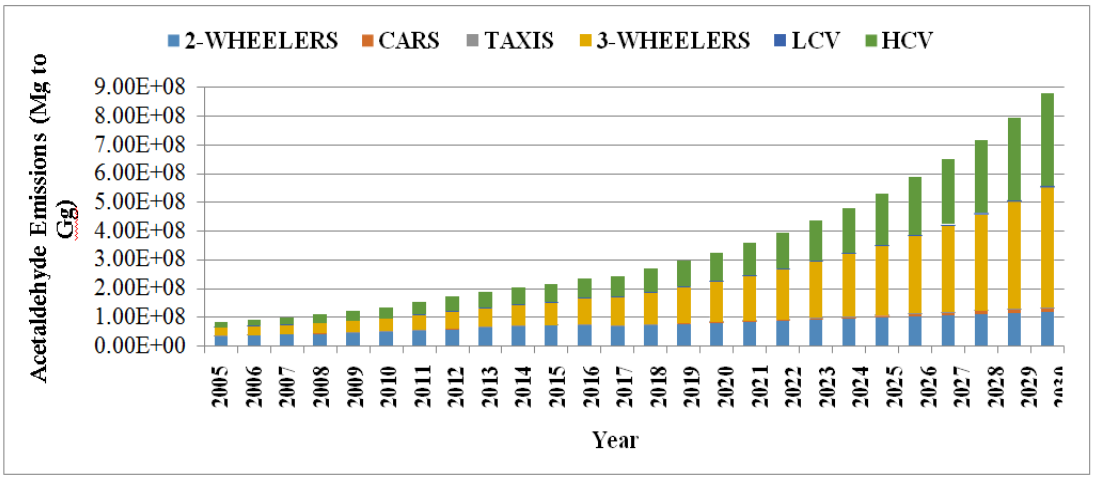


Figure 10: Trend of acetaldehyde emissions between the years 2005 to 2030.

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The findings revealed a continuous rise in the rate of emissions generated from each vehicle type in previous years and in future years up to 2030 throughout the city. Table 1 shows the percentages of various pollutants released by six distinct vehicle types.

According to Table 2, the bulk of the contaminants in the research region are emitted by HCVs. As a result, adequate mitigation techniques and improved regulatory standards are required to limit the emissions emitted by HCVs.

Table 1: Percentage of pollutants emitted from different vehicle types.

Vehicle type	**CO**	**NO x**	**Benzene**	**1-3 Butadiene**	**Formaldehyde**	**Acetaldehyde**	**CO_2**	**PM**	**HC**
	Percentage of pollutants emitted								
2-wheelers	22	03	21	36	30	31	07	03	64
Cars	03	01	03	08	05	02	05	01	03
Taxis	02	0.5	01	03	02	01	01	01	01
3 wheelers	07	02	07	12	12	38	04	02	14
LCV	01	0.5	50	11	01	02	02	01	01
HCV	65	93	18	30	50	26	81	92	17

Table 2: Pollutants mainly released from different vehicle types.

Vehicle Type	**Major Pollutants Released**
Two wheelers	Hydrocarbon
Cars	1-3 Butadiene
Taxis	1-3 Butadiene
Three wheelers	Acetaldehyde
LCV	Benzene
HCV	CO, NOx, Formaldehyde, CO_2, PM

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VAPI model emissions and CAQMS (Continuous Air Quality Monitoring Station) pollutant concentrations are correlated.

The VAPI model emissions are connected with the ambient air concentrations received from the CAQMS (Continuous Air Quality Monitoring Station) in Vijayawada. Due to data scarcity, the connection is limited to four years of data (2014-2017) and four contaminants (CO, NOx, PM, Benzene). Figures 11(a) through 11(c) show regression plots (d).

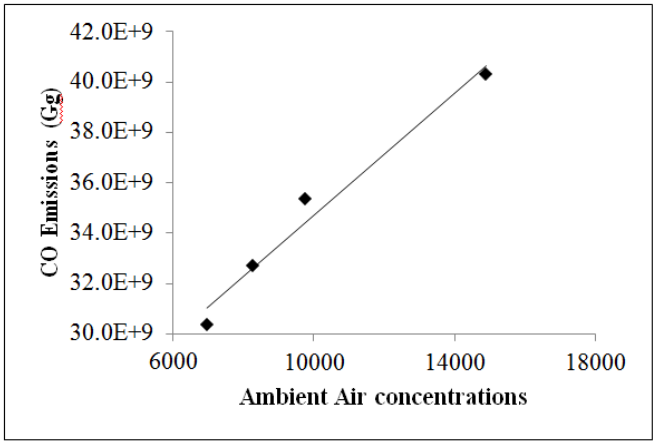


Figure 11(a): Correlation between CO emission and concentration in Vijayawada from 2014 to 2017.

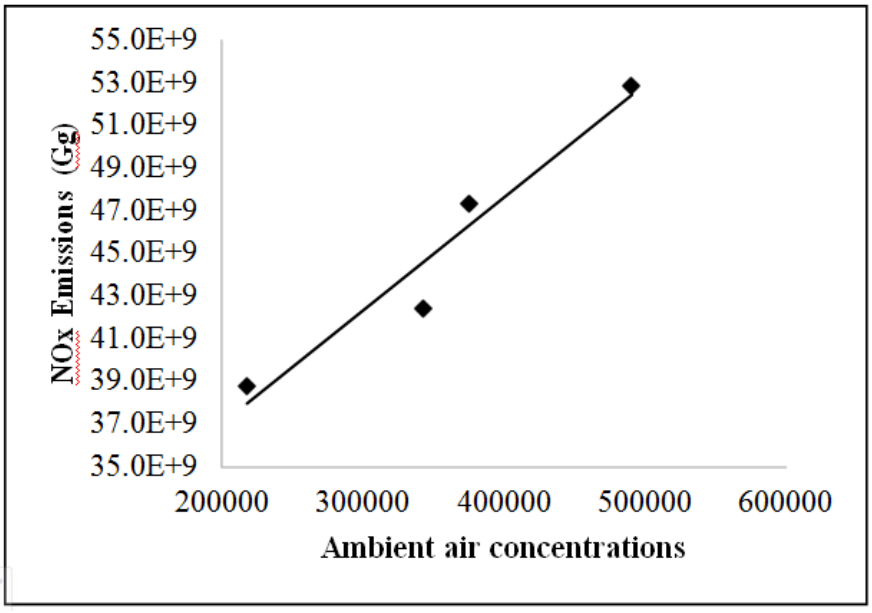


Figure 11(b): Correlation between NOx emission and concentration in Vijayawada from 2014 to 2017.

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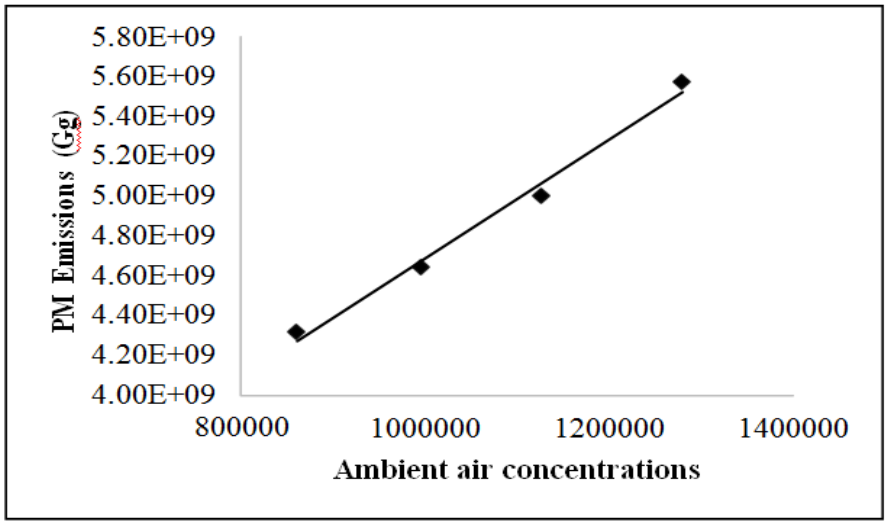


Figure 11(c): Correlation between PM emission and concentration in Vijayawada from 2014 to 2017.

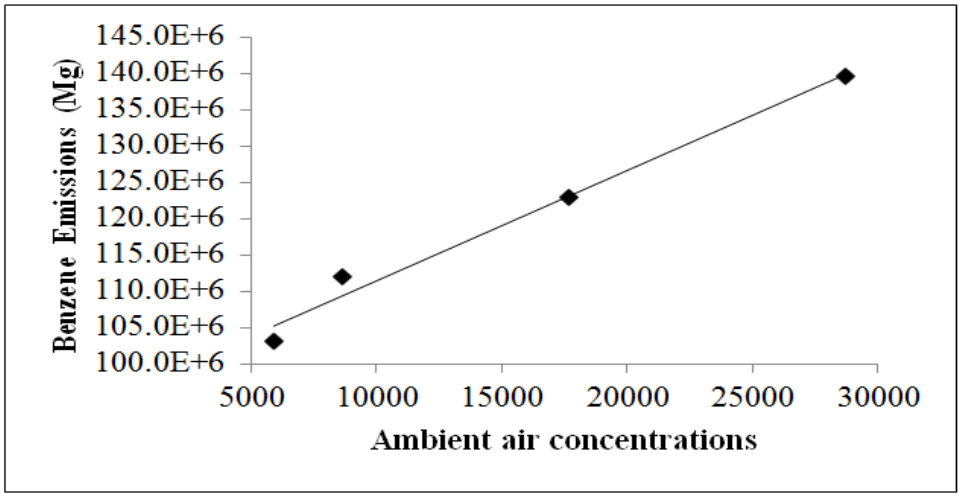


Figure 11(d): Correlation between benzene emission and concentration in Vijayawada from 2014 to 2017.

The following are some of the probable mitigation measures that may be followed in Vijayawada city to reduce the vehicular emissions in the coming years.

- Strict prohibition on phased out vehicles.
- Implementation of regulations on emission norms for all modes of vehicles.
- Inspiring persons to use private transportation in its place of personnel vehicles.
- Enhancing the speed, safety and comfort in public transport.

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- Enforcement on vehicles violating the emission policy norms.
- Fuel efficiency norms regulations of HCV's.
- Shift of petrol and diesel busses and autos to CNG busses and autos.

CONCLUSION

The research found that air quality has worsened in recent years and will continue to deteriorate in the future. The increased number of automobiles in the research region has been recognised as the cause of growing vehicular emissions and hence becoming hazardous to the environment. Heavy Commercial Vehicles (HCVs) are the primary contributors to Vijayawada's deteriorating air quality. As a result, essential steps.

The regulatory authorities should take action to impose certain emission standards, namely for HCVs, in order to safeguard the city from excessive pollution. This research may serve as a baseline for Pollution Control Board officials to examine the state of air quality in the study region in order to determine what mitigation measures should be implemented to minimise pollution in the future years.

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