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Vehicular Traffic and its Correlation with Air Pollution in Greater Noida

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ABSTRACT

The automobile transport has become a significant source of air pollution in fast developing Indian megacities. A comprehensive analysis of traffic volume is a common method of learning about the time and space dynamics of vehicle traffic on the road network and their impact on air quality in the ambiance. The current research will look at the relationship existing between the level of air pollution and vehicular traffic volume at chosen sites of Greater Noida, a rapidly growing city within National Capital Region (NCR) in India. To measure traffic volume, the values of Passenger Car Unit (PCU) of various types of vehicles were used to measure change in the traffic composition during peak and non-peak. Air quality data: data on Air Quality Index (AQI) and major pollutants were analysed in order to obtain information on the trends of pollution against the intensity of traffic. The analysis indicates that in terms of road network, and the predominant mode of transport, the auto vehicles, especially cars, vans and jeeps, consume up to about 70 per cent of the overall traffic congestion and the utilisation of roads is close to 50 per cent of the day. Statistical analysis represents that the correlation between the traffic flow and the air pollution level is strong and positive, where the average correlation value between the peak traffic flow and the AQI value was 0.90. The rising stress on the transport infrastructure in Greater Noida in other areas is also indicated by the linear regression models and estimates of the Average Annual Daily Traffic (AADT). The results substantiate a significant role of the vehicular emissions on the quality of ambient atmosphere and emphasize the significance of the efficient traffic management, emission regulation methods and sustainable transport policy to reduce the air pollution in cities.

Keywords: Vehicular Traffic, Passenger Car Unit (PCU), Average Annual Daily Traffic (AADT), Air Quality Index (AQI), Greater Noida

Short Words:
PM – Particulate Matter
NCR – National Capital Region
AQI – Air Quality Index
NO_2 – Nitrogen Dioxide
CO – Carbon Monoxide

INTRODUCTION

The environment of Indian cities has considerably undergone changes due to rapid urbanisation, economic development as well as the development of transport infrastructure. Vehicular traffic has developed to be one of the most prevailing sources of degrading air quality among the other sources of urban pollution. The surge in the number of motor vehicles besides lack of proper transport systems and rising reliance on private forms of transportation have augmented the production of harmful pollutants including particulate matter (PM_2 .ascents and PM artillery), nitrogen oxides (NO_x), sulphur dioxide (SO_2), and carbon monoxide (CO). These are dangerous pollutants, which have grave consequences on the human body, city biosphere and the standard of life (Gurjar *et al.*, 2010; Guttikunda and Goel, 2013; Sharma and Dikshit, 2016).

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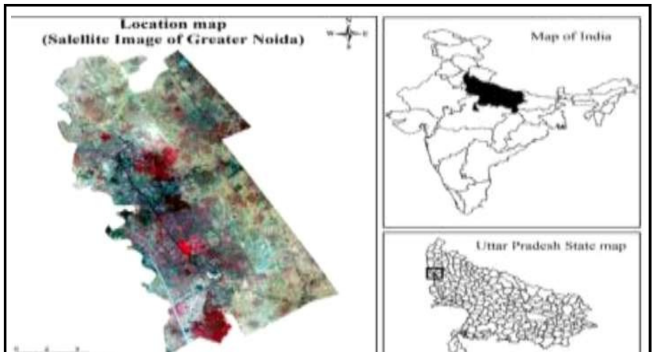
National Capital Region (NCR) of India is one of the highly polluted urban areas in the world. Though Delhi has been the center of the air pollution researches, other cities in the NCR have been playing a lead role in acquiring similar levels of environmental stress in terms of spillover effect of traffic, industrialisation and regional mobility (Khare and Sharma, 2013). Greater Noida, another planned city in the NCR has been changing very fast within the past 20 years. The creation of industrial estates, education centres, housing townships and expressway accessibility has also led to a drastic increase in the amount of vehicular traffic. Greater Noida has become increasingly challenged in matters to congestion, emissions due to traffic and deteriorating air quality, albeit being planned (Ravindra *et al.,* 2015).



Source: https://www.researchgate.net/profile/Naresh-Kumar-190/publication/377782117_Vehicular_Traffic_and_its_Correlation_with_Air_Pollution_in_Greater_Noida/links/65b8bbe134bbff5ba7d922f4/Vehicular-Traffic-and-its-Correlation-with-Air-Pollution-in-Greater-Noida.pdf

Fig. 1 : Location map of study area

Knowledge of the relationship between automobile traffic and air contamination is the key to cost-effective development of cities and nature. Traffic related air pollution is not only determined by the number of vehicles but it also depends on the constitution of the traffic, the type of fuel used, congestion, road design and land-use patterns. This paper aims at analyzing the correlation between the intensity of vehicular traffic and the levels of ambient air pollution within Greater Noida and especially that of particulate matter/ gaseous pollutants. Through the evaluation of traffic patterns and data on pollution, the research will make a contribution to the increasing body of urban environmental research and offer policy-rendering results on how to make the air in rapidly urbanising cities better (Singh *et al.,* 2014; United Nations Environment Programme 2019).

Study Area:

Greater Noida is also in the Gautam Buddha Nagar district in the state of Uttar Pradesh and is a constituent of the National Capital Region (NCR). It is situated to the east of Delhi and is delimited on the east by the Yamuna River which is also a great physical and administrative boundary. Greater Noida is of strategic significance to the NCR due to its geographical location as it serves as an extension of residential delhi and an independent urban industrial centre. The city was designed as an urban settlement that was planned with wide arterial roads, sector based development, land use segregation and contemporary civic infrastructure this is developed and administered by the Greater Noida Industrial Development Authority (GNIDA) (Ministry of Road Transport and Highways, 2021).

Greater Noida has been experiencing a sudden spatial growth and the diversification of functions in the past 20 years. The city was originally intended to be an industrial township, but it has been transforming into a multi functional city centre with massive residential townships, industrial estates, institutions and commercial complexes. Daily movement of commuters and freights has greatly increased due to the existence of big educational establishments, information technology parks, logistics hubs and manufacturing plants. Consequently, the level of vehicular traffic has risen continuously, and it has placed more and more pressure on transport infrastructure and the quality of the environment in the city (Tiwari, 2018; Yadav *et al.,* 2019).

Connectivity Greater Noida in the NCR is made possible due to a system of large transport corridors connected to it including the Noida Greater Noida Expressway, Yamuna and the Eastern Peripheral Expressway. These expressways have high capacities and they are essential in the mobility of the region since they connect Greater Noida to Noida, Ghaziabad to Faridabad, Agra and other urban centres. Although this type of infrastructure has helped in boosting the economy and enhancing accessibility, it has also led to an extreme increase in the number of vehicles especially in terms of privately owned cars, two wheelers and commercial heavy cars.

The number of commuters, office goers, students as well as freight vehicles flowing in and out each day has increased by a significant margin mainly during the peak hours of commuting in the morning and evenings. Congestions in traffic are usually found at the interchange points of the expressways, major cross roads, and around the industrial and institutional locations. The congestion prone areas serve as emission hot spot areas where low vehicle speeds and delays contribute to increases in the amount of pollutants emitted by a single vehicle. Therefore, regions near to larger roads and crossroads tend to have lower quality of air than residential areas in the interior (Zhang and Batterman, 2013).

The climatic and meteorological factors also affect the level of air pollution in Greater Noida. It is very hot in the region during summers and cool during the winter with a monsoon season that pours down in moderate quantity. In winter, wind velocities become low and the temperature frequently inverts thus not allowing vertical circulation of air and the resulting pollutants are consequently deposited towards the ground. The combination of these conditions and high emissions of vehicular pollutants leads to the high concentration of particulate matter and gaseous pollutants. On the other hand, when it is the monsoon season, the rainfall also helps in eliminating the airborne pollutants under a process known as wet deposition, which is albeit temporary because of air quality improvement. Greater Noida therefore, offers an appropriate geographic and environmental setting to study the interdependence of the automobile traffic and the air pollution.

METHODOLOGY

The current research work is founded on the secondary data received through a variety of official and published sources. The information on traffic was gathered based on the records of the transport department, reports of traffic police and governmental publications and was related to the tendencies in registration of vehicles, structure of vehicles and their general traffic density. Such statistics give a clue about the trend of vehicle traffic growth and preeminence of certain types of vehicles like a personal vehicle, two-wheelers and transportation.

The air quality data was obtained at the monitoring stations of Central Pollution Control Board (CPCB) and the Uttar Pradesh Pollution Control Board (UPPCB). The analysis targets essential pollutants such as particulate matter (PM II.5 and PM 1.0), nitrogen oxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO) that have been generally identified as the major predictors of air contamination by traffic. These pollutants had been chosen because they are highly correlated with the emissions of the cars and non-exhaust sources, e.g., the resuspension of road dust and the wear of the tyres and brakes (Central Pollution Control Board, 2022; World Health Organization, 2021).

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 - 50	Good	Green
51 - 100	Moderate	Yellow
101 - 150	Unhealthy for Sensitive Groups	Orange
151 - 200	Unhealthy	Red
201 - 300	Very Unhealthy	Purple
301 - 500	Hazardous	Maroon

Source: https://www.researchgate.net/profile/Naresh-Kumar-190/publication/377782117_Vehicular_Traffic_and_its_Correlation_with_Air_Pollution_in_Greater_Noida/links/65b8bbe134bbff5ba7d922f4/Vehicular-Traffic-and-its-Correlation-with-Air-Pollution-in-Greater-Noida.pdf

Fig. 2 : AQI category according to EPA

The approach of the methodology is descriptive and analytical to study the correlation between air pollution and vehicular traffic. To determine the trends of at least daily, seasonal and annual traffic, the temporal changes of the traffic volume and concentrations of pollutants were examined. The special consideration was given to the state of the traffic during the peak hours and alterations of the seasons, in particular, in the winter months as in this period the pollution level tends to be high. The extent of correlation was used to determine the relationship between vehicular traffic measures and the level of pollutant concentrations at the ambient levels.

The data was presented in a systematic and clear format in the form of tables, charts and graphical representations so that it could be easily interpreted to deduce the results. It was also done comparative analysis to learn the variations of pollution with time and conditions of traffic. Even though the research utilizes mainly secondary data, there is the merging of the traffic and air quality information that offers important information on the traffic-pollution interactions at the city level. The methodology that has been applied in this research is appropriate in the analysis of urban environmental aspects and it is replicable in other urban areas in NCR and other urbanizing entities.

The current work is premised on secondary sources that are gathered by various official sources. Data related to traffic was obtained through records of the transport department, transportation police reports and available governmental statistics, that is, the records of the trends of vehicle registration, the type of vehicle and its distribution in the traffic. Air quality data were sourced from monitoring stations operated by the Central Pollution Control Board (CPCB) and the Uttar Pradesh Pollution Control Board (UPPCB). Pollutants such as $PM_{2\text{-}5}$, PM_{10}, NO_2, SO_2 and CO were selected for analysis due to their strong association with vehicular emissions.

Its approach to methodology is descriptive and analytical. Daily and seasonal trends were investigated by testing the temporal disparities in the amount of traffic and pollution. The correlation analysis of the relationship between vehicular traffic indicators and pollutant concentrations was done. Tables and scheme representations have been used to make the results easy to interpret. Though the study is based on secondary data, it offers important information to the dynamics between traffic and pollution on the city level.

The amount of traffic was also measured through the Passenger Car Unit (PCU) approach which normalises heterogeneous traffic to a common unit threshold on the basis of space occupancy by the various categories of vehicles and the speed of the individual vehicles. The Indian Roads Congress (IRC) recommended PCU values that were adopted in the conversion of vehicle populations into equal equivalent passenger car unit. The consequence of this solution is that it allows an evaluation of traffic jams and road use in real-life conditions of mixed traffic, as observed in Greater Noida (Table 1).

Table 1 : PCU Conversion Factors

Vehicle Type	PCU Value
Two-wheeler	0.5
Car/Van/Jeep	1.0
Auto-rickshaw	1.2
Bus	3.0
Light Commercial Vehicle	2.0
Heavy Commercial Vehicle	3.7

Formula:

Total PCU=Σ(Ni×PCUi)

where

Ni = number of vehicles of type i

PCUi= PCU value of vehicle type i

RESULTS AND DISCUSSION

Traffic Volume Composition Based on PCU:

According to the PCU-based analysis, cars, vans and jeeps take the largest percentage of the total road space occupancy followed by two-wheelers and commercial vehicles (Table 2).

Table 2 : Traffic Volume Composition Based on PCU

Vehicle Category	Average Daily Count	PCU Value	PCU Contribution (%)
Two-wheelers	18,500	0.5	18.2
Car/Van/Jeep	22,300	1.0	45.6
Auto-rickshaw	4,200	1.2	6.9
Bus	1,150	3.0	10.5
Light Commercial Vehicles	2,800	2.0	9.1
Heavy Commercial Vehicles	950	3.7	9.7
Total	—	—	100.0

Passenger car unit (PCU) technique of vehicle traffic analysis gives a better insight into the heterogeneous traffic situations that exist in Greater Noida. According to conversion of various vehicles types to PCU values, it is observed that the most significant portion of the road space is occupied by the private vehicles, especially the cars, vans, and jeeps. In spite of their large numeric figures, the two-wheelers have low PCU values that decrease their level of contribution to congestion compared to cars and the commercials.

It reveals that the cars, vans and jeeps contribute about 70 per cent of the total PCU on major road routes with the next being the two-wheelers.

Growth of Vehicular Traffic in Greater Noida:

The city of Greater Noida has been recording a progressive rise in the number of registered vehicles in the last decade. Increase in the number of the personal vehicles and two wheelers has been keen, which depicts the increasing incomes levels, the urban sprawling, and the insufficient reliance on the transport systems. The presence of commercial vehicles such as transport of goods and buses also contributes to the traffic volume owing to industrial activities and the inter-city movement. Traffic pull together is, therefore, heterogeneous in nature, each having different emission properties.

Traffic congestion has been so significant that it has become the order of the day in Greater Noida mainly during peak hours. The hours in the morning and evening are the high seasons of activity at the time of working in offices and in schools and industrial changes. The speed of vehicles during such times decreases significantly when it comes to the time of idle activities and stop and go Cat. Such states have been known to increase the levels of emission expressed per dream vehicle kilometre, thus, aggravating the localised air pollution (Table 3).

Table 3 : Average Annual Daily Traffic (AADT) on Major Roads of Greater Noida

Road Corridor	Average Daily Traffic (PCU)	AADT Category
Noida–Greater Noida Expressway	92,500	Very High
Yamuna Expressway	78,300	High
Knowledge Park Arterial Roads	65,200	High
Industrial Area Roads	54,800	Moderate

Status of Air Pollution:

Interpretation of the data on air quality reveals that the proportion of particulate matter is often higher than the National Ambient Air Quality Standards, especially in winter time. PM 2.5 and PM 0 level exhibit a great deal of time variation, whereby, greater concentrations are observed during peak traffic hours and poor meteorological conditions. NO_2 or any other gas pollutants, also show high concentrations around the major road corridors and intersections and this highlights the role of automobiles emissions.

Seasonal fluctuation is a very important factor in the dynamics of pollution. The low wind speeds and temperature inversion during the winter season limit the dispersion of pollutants and the substances collect closer to the surface. On the other hand, the monsoon rain leads to the wash out of pollutants thus resulting in relatively low concentrations. Nevertheless, even in favourable seasons, traffic hotspots are still characterized by the poor air quality, which speaks of the long-term impact of vehicular emissions.

Correlation between Vehicular Traffic and Air Pollution:

The correlation analysis indicates the positivity of the relationship between the intensity of vehicular traffic and concentrations of PM_2. 5, PM 0 and NO 2. Several zones with dense traffic systems always experience increased levels of pollutants especially during the rush hours. The results are more significant with regard to particulate matter that represents a cumulative effect of exhaust emissions, rocks dust re-suspension and tyre and breakage wear (Table 4).

Table 4 : Correlation Matrix between Traffic Volume (PCU) and Air Quality Index (AQI)

Variable	Traffic Volume (PCU)	AQI
Traffic Volume (PCU)	1.00	0.90**
AQI	0.90**	1.00

The fact that there are many vehicles used privately, with merely a few numbers, but which contribute heavily to pollution is that they are more numerous in quantity. Jammed crossroads and access-exit points on the expressways become the critical areas of pollution. The observations made here are in line with reports of other NCR cities and they tend to support the fact that vehicular transportation is the dominant contributor to air pollution in urban environments (Table 5).

Table 5 : Linear Regression Results Showing Relationship between Traffic Volume and AQI

Parameter	Value
Regression Equation	AQI = 42.6 + 0.0032 x (Traffic Volume)
Coefficient of Determination (R^2)	0.81
Adjusted R^2	0.79
Significance Level (p-value)	< 0.01

Implications for Urban Planning and Public Health:

The perceived relationship between motor traffic and the quality of the air has dire consequences on the health of people. Long time exposure to high concentration of particulate matter is linked to respiratory and cardiovascular diseases, decrease in lung capacity and death. Elderly people, children and people with underlying health conditions are the most vulnerable.

With regards to planning, the results expose the shortcoming of road expansion as the only way to deal with traffic issues. Unless good strategies of road capacity and demand management are in place, more road capacity may result in induced emissions and traffic. Planning land-use and transport should be integrated, non-motorised transport should be encouraged and cleaner vehicle technology should be implemented in the reduction of air pollution caused by traffic in Greater Noida.

Conclusion:

The statistical analysis shows that there is positive and obvious correlation between quantitative levels of air pollution and vehicular traffic in Greater Noida. The increasing growth rate in the number of vehicles traffic, congestion, and reliance on private transportation has been one of the major factors that have led to poor air quality conditions. Two pollutants that come out as pertinent to the intensity of traffic are particulate matter and nitrogen dioxide. To deal with these issues, the need to tackle them requires a multi-pronged approach that implies sustainable transport planning, better public transport systems, more stringent emission standards and more efficient control of traffic. The results highlight the importance of having proactive policy measures in place to make sure that urban development in Greater Noida and other fast emerging cities of the NCR is eco-friendly.

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