IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

CARBON DIOXIDE AND CARBON MONOXIDE EMISSION AT SELECTED TRAFFIC JUNCTIONS IN THE BENGALURU URBAN, KARNATAKA

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Abstract

The study addresses the levels of atmospheric carbon dioxide (CO_2) and carbon monoxide emission at eight selected traffic junctions of Bengaluru. The concentration of Carbon dioxide and carbon monoxide were recorded using portable Co and CO_2 meter - AZ-7755 every 5 minutes for two hours at morning (8:00AM – 10:00AM) evening (5:00PM-7:00PM) and Night (10:00PM-12:00AM). The findings revealed that the significant range of results variation of carbon dioxide (CO_2) and carbon monoxide (CO) levels at two key locations of Silk Board Junction and Jalahalli Cross, at Silk Board Junction, it could be influenced by factors such as heavy traffic, road congestion, which contribute to higher emissions whereas, Jalahalli Cross may exhibit different concentration levels could be due to industrial activities in addition to traffic patterns. The study suggests for reduction of vehicles and relocation of industrial pockets to outskirts of city and traffic management.

Keywords: Emissions, Climate change, Road transportation, Traffic Congestion, Mitigation Measures

1. Introduction

Many people are exposed to dangerously high level of air pollution could be halved by 2040 with targeted policy action as per a new World Bank report 2024. The outdoor air pollution kills assumed 5.7 million lives annually, with 95% of deaths occurring in low- and middle-income countries, and accounts for a loss equivalent to nearly 5% of global GDP, due to health impacts, lost productivity, and reduced life expectancy.

Recently it was noticed that, human activities have released around 35 billion tons of carbon dioxide into the atmosphere every year. Atmospheric carbon dioxide concentrations have increased by more than 40 percent since pre-industrial times, from approximately 280 parts per million (ppm) in the 18th century to 419 ppm in 2023 Lan *et al.*, (2024). India's carbon emissions are projected to increase by 4.6% in 2024, representing 8% of global emissions. The report indicates that global fossil CO_2 emissions have been recorded 37.4 billion tonnes on 2024 increase of 0.8% from 2023, including emissions from land-use changes such as deforestation, total CO_2 emissions are set to reach 41.6 billion tonnes compared to 40.6 billion tonnes during 2023 (Friedlingstein *et al.*, 2024).

In urban areas across the world, vehicle exhaust emissions significantly contribute to air pollution. Transportation produced more than eight billion metric tons of carbon dioxide ($GtCO_2$) worldwide during 2023. Road vehicles were the biggest polluters by far, making up three-quarters of total transportation-related emissions that year. There is a strong correlation between air pollution and health issues among the personnel, highlighting important implications for urban planning, policy development, and public health initiatives to mitigate air pollution effects (Kar *et al.*, 2024).

The long-term monitoring of carbon monoxide concentrations is necessary to characterize the health effects and the valuable insights for urban planners to implementing measures to mitigate the negative effects Yirdaw *et al.,* (2024). The concentration of carbon dioxide is still low level to cause any serious health effects but it would help for Policy makers and Town planners (Kumar and Nandini, 2012). It was observed that the CO level would be as high as 14 ppm at or below the average speed of 25 km/h for vehicles. The results would help for Pollution Control Board and traffic control authorities to implement necessary measures for improving air quality in the cities under consideration (Angath and Mehar, 2020).

Methodology

2.1 Description of Study Area

Bengaluru a capital city of Karnataka is the sixth largest metropolis in the country was chosen as the location for this study. it is one of the fastest growing cities in the country and is a hub for technological innovations, start-ups, and information technology (IT) based industries. The city is located at 12°59’N latitude and 77°57’E longitude and has a mean sea elevation of 920 m. The city receives an annual rainfall of around 880 mm. Bangalore urban with a population of about 15 million and consists of 12 million of vehicular population. The city apart from being the political capital of the state is also a very important commercial centers and major industrial establishments.

2.2 Data Collection and Analysis

The study was carried out at six highly congested intersections in urban Bengaluru, which serve as connections between major National and State Highways. The most traffic locations, referred to as hotspots, were selected for preliminary data collection. The intersections were examined included Jalahalli Cross, Hebbal, Tin Factory, Silk Board Junction, Nayandahalli Junction, and Majestic, in addition to two control sites of Bangalore University and Lalbagh. This data was collected during July and August 2024, observations recorded at five-minute intervals over two-hour periods in the morning (8:00 AM – 10:00 AM), evening (5:00 PM – 7:00 PM), and night (10:00 PM – 12:00 AM).

Figure.1 Map showing Study area location for monitoring of CO and CO_2

2.3 Methodology

The concentration of Carbon dioxide and carbon monoxide at selected traffic junctions, a calibrated portable CO_2 meter (AZ-7755) was used and the readings were recorded with an interval of every 5 minutes and were averaged for on-peak traffic hours and off-peak traffic hours. An infra-red beam passes through the sampling chamber and each gas component in the sample absorbs some particular frequency infra-red.

2.4 Traffic data collection

The information on the amount of traffic flow, hourly variation, and traffic composition, hourly traffic counts were performed at each survey station in both directions. Vehicles passing the survey station in both directions at 15-minute intervals were manually counted and classified as part of the survey. According to the vehicle classification system, the counts for motorized and non-motorized traffic were conducted independently.

3 Results and Discussion

3.1 CO Emissions

Carbon monoxide (CO) is a colourless, odourless, and toxic gas, which is predominantly produced by incomplete combustion of carbon-containing materials. Incomplete combustion occurs when insufficient oxygen is used in the fuel (hydrocarbon) during burning process.

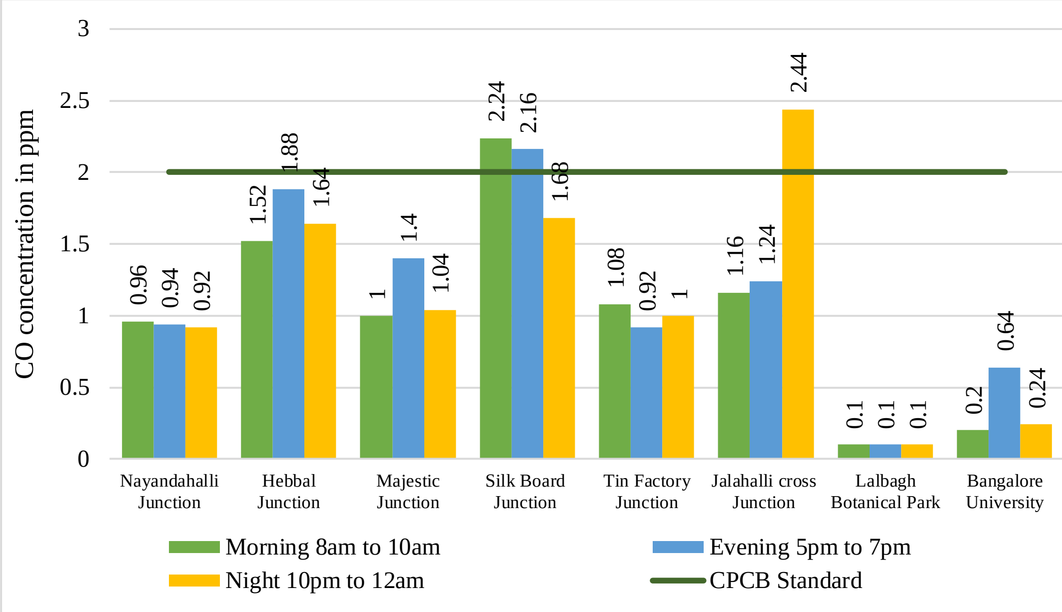

Figure 2. Concentration of Carbon monoxide recorded at sampling locations

The monitoring of carbon monoxide (CO) levels at various locations was significant variations influenced by factors such as traffic density and local activities. Notably, Silk Board and Jalahalli Cross stand out as the areas with the highest concentrations of carbon monoxide, of 2.24 ppm and 2.44 ppm, respectively. These elevated levels can be primarily attributed to the heavy vehicular traffic that characterizes these junctions, compounded by point source emissions resulting from ongoing metro construction activities at the Silk Board junction. The combination of these factors creates an environment where CO levels are significantly elevated, posing potential health risks to the surrounding population. In contrast, Hebbal consistently shows carbon monoxide levels that exceed 1.5 ppm during all sampling periods. This persistent elevated level suggests that Hebbal region is also affected by substantial traffic, although it does not reach the extreme levels as observed at Silk Board and Jalahalli Cross. The continuous monitoring indicated that the area is a hotspot for CO emissions, likely due to its role as a major thoroughfare in the city.

On the other hand, Bangalore University indicated a different scenario, with carbon monoxide levels remaining below 0.7 ppm. This lower concentration can be attributed to the reduced vehicular activity in and around the university campus, which is likely a result of its more controlled environment and possibly limited access for non-student vehicles. The lower levels of CO in this area highlight the impact of traffic management and urban planning on air quality. Nayandahalli Junction, while not as heavily trafficked as Silk Board or Jalahalli Cross, maintains a steady carbon monoxide emission level of 0.9 ppm. This suggests that while it experiences some vehicular activity, it is not sufficient to cause significant spikes in CO levels, indicated a moderate level of air quality.

In stark contrast to these locations, the control station, situated within a garden area, consistently registers zero emissions of carbon monoxide. This absence of CO is primarily due to no vehicular movement in the garden, which is enveloped by a dense green canopy. The natural vegetation not only contributes to a serene environment, but also plays a crucial role in filtering air pollutants, thereby ensuring that the air quality remains pristine in this controlled settings. The findings from these various locations underscore the critical influence of traffic patterns and urban infrastructure on air quality, highlighting the need for targeted interventions to mitigate air pollution in high-emission areas. To reduce in-vehicle CO buildup, it is recommended to use A/C in fresh air mode or open the windows during extended journeys (Giri *et al*., 2021).

Carbon monoxide (CO) has major impact on human health and its concentration was observed 80 ppb. Major anthropogenic sources of CO are vehicle exhaust due to incomplete combustion of hydrocarbons in internal combustion engine (Horner *et al.*, 2000). Exposure to carbon monoxide impedes the blood's ability to carry oxygen to body tissues and vital organs. When carbon monoxide is inhaled, it combines with hemoglobin (an iron-protein component of red blood cells), producing carboxyhemoglobin (COHb), which greatly diminishes hemoglobin's oxygen-carrying capacity (Ernst, 1998).

3.2 CO_2 emissions

The incomplete combustion of hydrocarbon in vehicles is a significant contributor to air pollution, particularly through the release of carbon dioxide (CO_2) into the atmosphere. This process occurs when fossil fuels, such as gasoline and diesel, are burned in internal combustion engines, resulting in the production of CO_2.

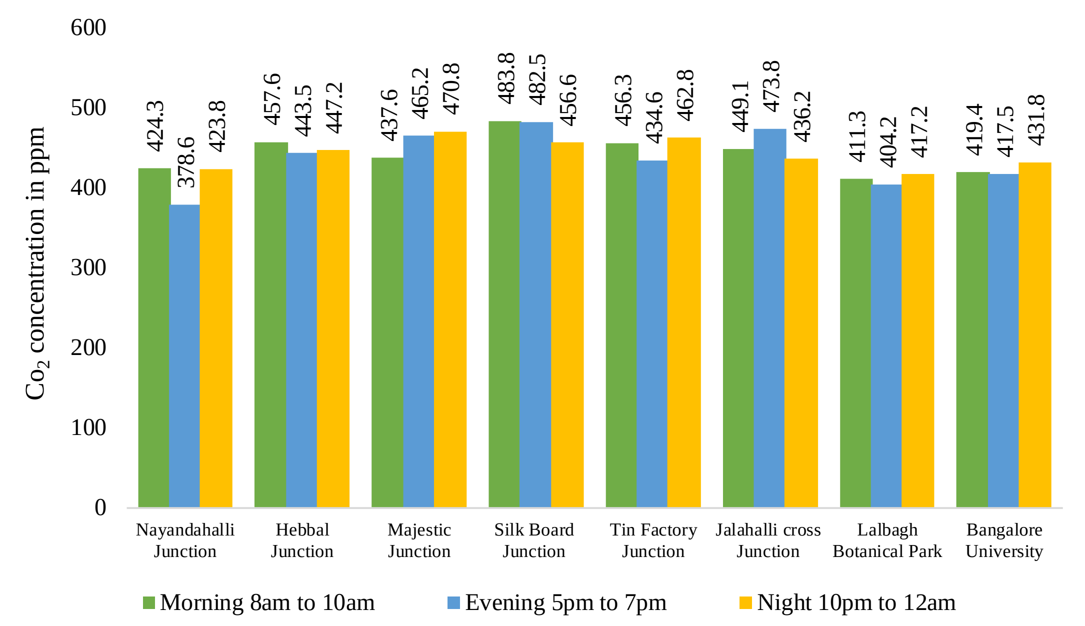

Figure 3. Concentration of Carbon dioxide recorded at sampling locations

The results were indicated that the highest concentrations of carbon dioxide were recorded at traffic junctions, specifically at Silk Board and Jalahalli Cross. These locations are known for heavy vehicular traffic, which contributes to the accumulation of CO_2 in the surrounding air and can be attributed to factors such as congestion, idling vehicles, and the overall volume of traffic, which collectively exacerbate the problem of air pollution.

In contrast, the control site at Lalbagh, a well-known botanical garden and green space in the city, showed a significant lower concentration of carbon dioxide. This difference can be attributed to the presence of vegetation in Lalbagh, which plays a crucial role in absorbing CO_2 through the process of photosynthesis during daylight hours. The lush greenery and diverse plant life in this area help to mitigate the levels of carbon dioxide, providing a natural buffer against the emissions generated by vehicular traffic.

Interestingly, during night time hours, both Lalbagh and Bangalore University, experience a slight increase in carbon dioxide concentration. This phenomenon can be explained by the dark reactions of plants, which occur when photosynthesis ceases in the absence of sunlight. During the night, plants continue to respire, a process that involves the uptake of oxygen and the release of carbon dioxide. As a result, the CO_2 levels in these green spaces may rise slightly, although they generally remain lower than those found in heavily traffic areas. These findings improve the accuracy of carbon emissions assessments for highway vehicles, support source management, promote sustainable development, and provide technical assistance for achieving carbon neutrality.

Overall, the dynamics of carbon dioxide concentration in urban environments are influenced by a various factor, including vehicular emissions, vegetation cover and the time of day. Due to unprecedented urbanization, road transport and industrial activities contribute 70% of total global CO_2 emission in which transport sector contribute 25%–30% emissions (Rosenzweig, *et al.*, 2010). Understanding these patterns is essential for developing effective strategies to improve air quality and promote sustainable urban living. In urban areas, where vehicle density is high, the levels of carbon dioxide can become particularly elevated, leading to concerns about air quality and its impact on public health and the environment.

3.3 Vehicular Mobility at Traffic Signals

The selected sampling locations are busiest roads in the city, serving as a major thoroughfare for daily commuting. Road is a two-way road and is a major thoroughfare in Bengaluru urban, and it typically has multiple lanes in each direction to accommodate the flow of traffic. The traffic counts during peak traffic hours indicate an average vehicular movement in all sampling locations. The quantitative analysis of traffic data of sampling sites shows that, huge movement of two wheelers followed by cars, 3 wheelers, light commercial vehicles and bus at both morning and evening peak hours. the highest number of two wheelers recorded at Tin factory junction. The use of two wheelers was steadily increased especially in metropolitan cities like Bengaluru. Many medium income residents prefer motorcycles for personal transportation due to affordability, whereas public transport, people tend to prefer three-wheeler rickshaws over buses as local bus routes may not cover all areas and take more time. The prevalence of private vehicles was influenced by cars compared to public transport. This surge is particularly pronounced in the morning due to peak hours when commuters are heading to their offices. Road surface conditions play a significant role in generation of air pollutants as vehicle pressure pulverizes unpaved materials, contributing to air pollution and health impacts.

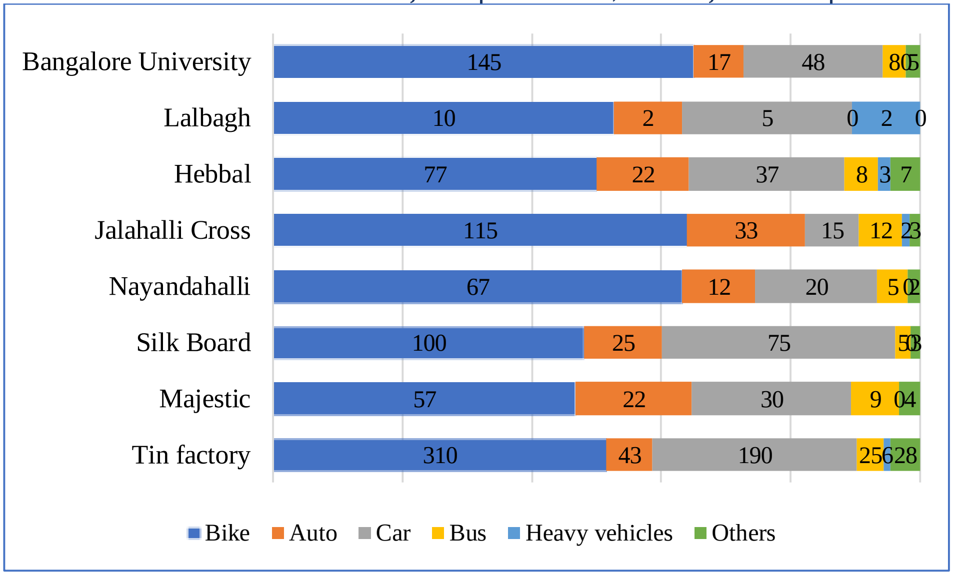

Figure 4. Vehicular Movement in Morning Hours (8:00 AM – 10:00 AM) at sampling locations

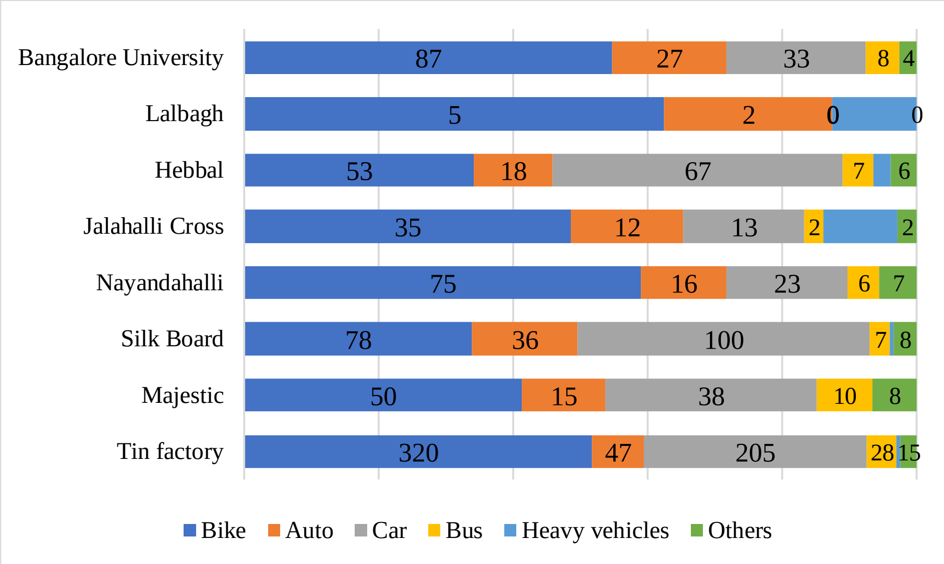

Figure 5. Vehicular Movement in Evening Hours (5:00 PM – 7:00 PM) at sampling locations

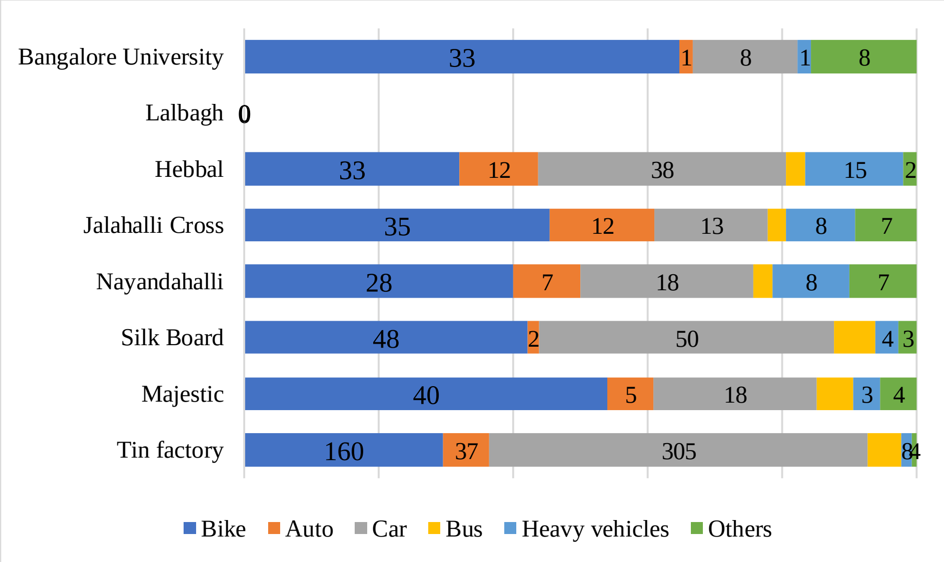

Figure 6. Vehicular Movement in Night Hours (10:00 PM – 12:00 AM) at sampling locations

4. Conclusion

A significant variation in the concentrations of carbon dioxide (CO_2) and carbon monoxide (CO) was at two key locations of Silk Board Junction and Jalahalli Cross. At the Silk Board Junction, the levels of these gases may be influenced by factors such as heavy traffic, road congestion, which contribute to higher emissions. In contrast, Jalahalli Cross may exhibit different concentration levels due to, industrial activities, and urbanization, variations in traffic patterns.

The research evaluates the level of pollution decrease that can be achieved through enhancements in the design of traffic light intersections. The importance of timing signals to fulfill specific operational goals, as well as the importance of tracking performance to adjust to varying travel demands that can influence efficiency. Well-designed, managed, and maintained traffic signals can facilitate the uninterrupted movement of vehicles along roads and highways at specified speeds, thus minimizing congestion; effectively oversee the traffic-handling capacity of intersections to enhance mobility through the application of suitable layouts and control strategies, along with regular assessments and updates of the operational parameters; and decrease vehicle stops and delays, consequently: mitigating the adverse effects on air quality.

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