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Temporal Analysis of Carbon Monoxide Levels at a Congested Urban Road Intersection

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Abstract
Carbon monoxide (CO) is a major air pollutant released from road traffic, alongside particulate matter, nitrogen oxides, volatile organic compounds, and ozone. It is mainly generated due to inefficient fuel combustion in motor vehicles. Urban signalized intersections often experience heavy congestion, frequent idling, and repeated acceleration and deceleration, which significantly increase pollutant emissions. This study examines hourly variations in CO concentrations at a highly trafficked urban intersection. Four intersecting roads were selected, with two monitoring points established on each approach. CO levels were measured from 8:00 AM to 8:00 PM using a portable real-time analyzer during the period from March to May 2011. Results indicate the presence of two clear daily peaks associated with morning and evening traffic rush hours. One-hour and eight-hour average concentrations frequently exceeded recommended air quality limits. Higher CO concentrations were observed near tall buildings, while lower levels were recorded in open or low-rise areas, demonstrating the combined effects of traffic density and urban form on roadside air quality.
Keywords: Carbon monoxide, Traffic emissions, Urban intersection, Diurnal variation, Air pollution

I. Introduction

Rapid population growth, urban expansion, and economic development have resulted in a substantial rise in vehicular traffic in Indian cities. Although advancements in engine technology and fuel standards have contributed to lower emissions per vehicle, road traffic continues to be a dominant source of urban air pollution. Motor vehicles now account for a significant portion of total emission loads in metropolitan areas.

Carbon monoxide is a key pollutant emitted from vehicles, particularly under congested driving conditions. It is a colorless and odorless gas that poses serious health risks by reducing the blood's ability to transport oxygen. Exposure to elevated CO levels can lead to cardiovascular and neurological problems, especially among sensitive population groups. Prolonged exposure, even at relatively low concentrations, may result in long-term adverse health effects.

Road intersections are widely recognized as pollution hotspots because of frequent stopping, idling, and acceleration of vehicles. Numerous studies have reported higher pollutant concentrations near busy roadways compared to background urban locations. These concentrations are influenced by traffic flow patterns, meteorological conditions, road design, and surrounding building structures. The objective of this study is to analyze temporal variations in CO concentrations at a congested urban intersection and assess the impact of the built environment on pollutant distribution.

II. Materials and Methods

A. Study Area
The investigation was carried out at the ITO intersection in Delhi, India, which is a fully signalized junction experiencing heavy traffic volumes. The intersection connects four major roads leading toward Laxmi Nagar, Minto Road, Delhi Gate, and India Gate. Surrounding land uses include institutional buildings, schools, police facilities, and open spaces, offering diverse urban configurations and ventilation characteristics.

B. Monitoring Location Selection
Two monitoring sites were identified along each approach road, resulting in a total of eight receptor locations. These sites were chosen to represent different roadside conditions, such as areas adjacent to high-rise buildings and relatively open spaces, to capture spatial differences in CO concentrations.

C. Reconnaissance Survey
A preliminary survey was conducted to record roadway features such as lane width, number of lanes, and median layout. Traffic volume and vehicle composition were documented during the monitoring period and categorized into heavy

commercial vehicles, light commercial vehicles, cars, three-wheelers, and two-wheelers. Traffic counts were collected on an hourly basis, with special attention given to peak traffic periods.
Meteorological data, including wind speed, wind direction, atmospheric stability, and mixing height, were obtained from the Indian Meteorological Department to support interpretation of pollutant dispersion conditions.

D. CO Measurement and Data Processing
Carbon monoxide concentrations were measured using a portable real-time CO analyzer with a resolution of 0.1 ppm. The instrument was calibrated before deployment. Monitoring was performed from 8:00 AM to 8:00 PM at each location for three consecutive days per month during March to May 2011.

Since the analyzer did not include an internal data logger, readings were manually recorded at three-minute intervals. Hourly average concentrations were calculated from twenty measurements per hour. The data were analyzed using spreadsheet-based tools to examine temporal patterns and spatial variability.

III. Results and Discussion

Across all monitoring sites, CO concentrations displayed a consistent diurnal trend characterized by two distinct peaks. The morning peak generally occurred between 9:00 AM and 11:00 AM, while the evening peak was observed between 6:00 PM and 8:00 PM. These periods corresponded to maximum traffic congestion and reduced vehicle speeds, leading to increased emissions and accumulation of pollutants.

Both one-hour and eight-hour average CO levels frequently exceeded the applicable ambient air quality standards, indicating persistent air quality concerns at the study location. Spatial analysis showed that locations near tall buildings recorded higher CO concentrations due to restricted airflow and reduced dispersion. In contrast, areas with open surroundings or low-rise structures exhibited comparatively lower concentrations.

IV. Conclusions

The findings of this study confirm that carbon monoxide concentrations at heavily trafficked urban intersections exhibit pronounced temporal and spatial variability. Two recurring daily peaks were identified during morning and evening rush hours. Observed CO levels often exceeded recommended air quality limits, posing potential health risks to commuters and nearby residents.

Higher concentrations were typically associated with monitoring sites located near high-rise buildings, where limited ventilation and street canyon effects hinder pollutant dispersion. Conversely, open and low-rise environments allowed better airflow and lower pollutant accumulation. These results highlight the importance of integrating traffic management measures with urban planning strategies to reduce roadside air pollution and improve urban air quality.

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