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Temporal Variability of Carbon Monoxide Levels in the Near-Road Environment of Urban Streets

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Abstract: *Carbon monoxide (CO) is a highly toxic air pollutant primarily emitted from motor vehicles as a result of incomplete combustion of fossil fuels. Being colorless and odorless, CO poses a serious threat to human health, particularly in urban environments with dense traffic. Exposure to elevated CO concentrations can reduce oxygen transport in the blood, leading to cardiovascular stress, reduced lung function, and impaired cognitive performance. Prolonged exposure to comparatively low CO levels may result in chronic symptoms such as headaches, dizziness, confusion, nausea, and memory impairment.*

In the present study, temporal trends of average hourly CO concentrations were examined at selected locations along major urban roadways. Four urban roads were chosen for monitoring, with two receptor locations identified on each roadway. Continuous CO measurements were conducted between 8:00 AM and 8:00 PM using a portable online CO monitoring device. The collected data were analyzed using spreadsheet-based statistical tools to evaluate hourly and 8-hourly average concentrations.

The results indicate a consistent temporal pattern across all monitoring sites, characterized by two prominent peaks corresponding to morning and evening traffic hours. Observed CO concentrations frequently exceeded prescribed air quality standards, demonstrating widespread non-compliance. Overall, the study highlights similar temporal trends of CO concentration across different urban road environments, with maximum levels occurring during peak traffic periods.

Keywords: *Carbon monoxide, Urban roads, Traffic emissions, Temporal variation, Air quality monitoring*

I. Introduction

Rapid urbanization and increasing vehicular ownership have led to a substantial rise in automobile traffic across Indian cities. Consequently, emissions from vehicular exhaust have become a dominant contributor to urban air pollution. According to reports by the Central Pollution Control Board (CPCB), vehicular emissions currently account for nearly 72% of total air pollution in Delhi.

In response to deteriorating air quality, several initiatives—such as the implementation of stricter emission norms, improvements in fuel quality, and the conversion of public transport vehicles to compressed natural gas (CNG)—have been introduced. Despite these efforts, weak vehicle inspection and maintenance systems continue to limit the effectiveness of emission control strategies, indicating the need for supplementary mitigation measures.

Carbon monoxide is a particularly hazardous pollutant due to its ability to interfere with oxygen delivery in the human body. High exposure levels can cause cardiovascular complications, reduced pulmonary efficiency, and impaired neurological functions. Previous studies have shown that chronic exposure to low concentrations of CO may result in persistent health issues, including headaches, dizziness, depression, memory loss, and gastrointestinal discomfort. Furthermore, long-term exposure has been linked to increased risks of atherosclerosis and adverse effects in vulnerable populations such as pregnant women and individuals with coronary heart disease.

Vehicular traffic remains the primary source of CO emissions in urban areas, often contributing more than 90% of total CO levels. Numerous studies have documented elevated pollutant concentrations in the immediate vicinity of major roadways, with impacts extending several hundred meters from the source depending on traffic volume, meteorology, urban geometry, and roadside structures.

Against this background, the present study investigates the temporal behavior of hourly average CO concentrations at selected locations along major urban roads, with particular emphasis on near-road exposure patterns.

II. Materials And Methods

The methodology adopted for temporal CO monitoring included site selection, identification of sampling locations, description of monitoring equipment, and data collection and analysis procedures.

2.1 Site Selection

Four major urban roadways were selected for this study based on high traffic volume, heterogeneous vehicle composition, and typical urban traffic conditions. These roads are characterized by varying building heights, widths, and configurations, providing representative urban ventilation conditions.

The selected monitoring sites included:

- **Deen Dayal Upadhaya Road** – Monitoring Locations 1 and 2
- **Indraprastha Road** – Monitoring Locations 3 and 4

The spatial distribution of the roads and receptor locations is illustrated in Figure 1.

2.2 Carbon Monoxide Monitoring Equipment

Carbon monoxide concentrations were measured using a portable electrochemical CO detector (Model CO-84). The instrument consists of an electrochemical sensor housed within a perforated casing that allows ambient air to diffuse into the sensing cell.

The detector is capable of measuring CO concentrations in the range of 0.1 ppm to 99 ppm and provides real-time readings. Owing to its portability and reliability, the instrument is suitable for near-road monitoring applications.

2.3 Monitoring Procedure

CO monitoring was conducted at each selected location between 8:00 AM and 8:00 PM. Prior to field deployment, the instrument was calibrated to ensure accuracy. As the device lacked an internal data logging system, measurements were recorded manually at 3-minute intervals and subsequently averaged.

- **Deen Dayal Upadhaya Road (Locations 1 and 2):** Monitoring was carried out from 20 April to 4 May 2011. At each location, 242 samples were collected, from which hourly and 8-hourly average concentrations were calculated.
- **Indraprastha Road (Locations 3 and 4):** Monitoring was conducted from 18 March to 2 April 2011 following the same sampling protocol.

2.4 Data Analysis

The recorded CO concentrations were processed to obtain 1-hourly average values. These hourly averages were further aggregated to calculate 8-hourly average concentrations. Temporal variations in CO levels were analyzed using Microsoft Excel, enabling comparison with prescribed air quality standards.

III. Results And Discussion

This section presents the observed temporal variations of average hourly CO concentrations at selected urban road locations during March, April, and May 2011. The measured values were compared with applicable air quality standards to assess compliance.

3.1 Temporal Variation at Deen Dayal Upadhaya Road

At both receptor locations along Deen Dayal Upadhaya Road, CO concentrations exhibited two distinct peaks corresponding to morning and evening traffic periods. This pattern remained consistent across all monitored months.

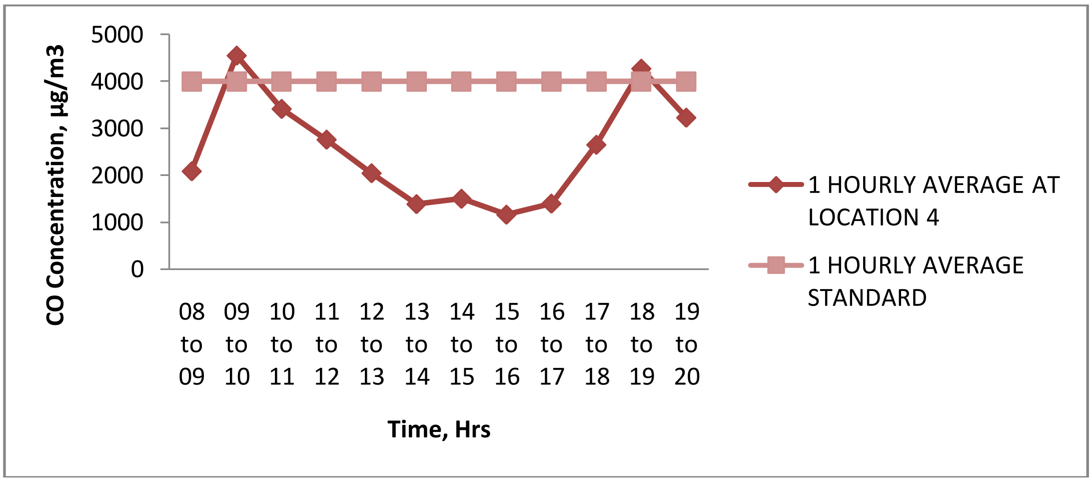

Fig.: Average hourly concentration of CO at location 1

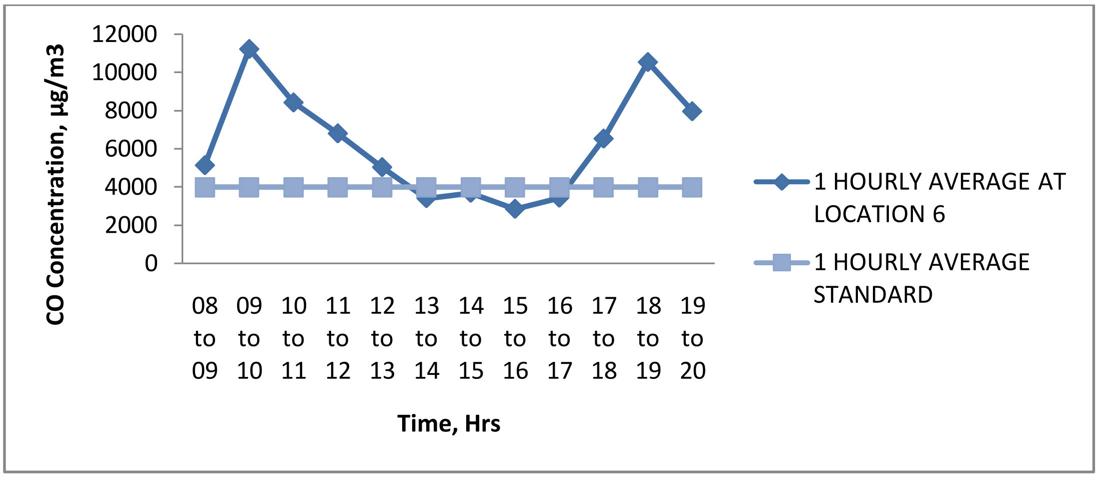

Fig.: Average hourly concentration of CO at location 2

At **Location 1** (near Andhra School Building), the maximum 1-hourly average CO concentration reached approximately 4550 µg/m³ during the morning peak (9:00–10:00 AM) and 4271 µg/m³ during the evening peak (6:00–7:00 PM). Both values exceeded the prescribed standard of 4000 µg/m³.

At **Location 2** (near INSA Building), considerably higher concentrations were observed, with peak values of 11,238 µg/m³ in the morning and 10,554 µg/m³ in the evening. The elevated levels may be attributed to traffic congestion and reduced dispersion caused by surrounding building geometry.

The built environment at this site resembles a step-down street canyon, where airflow patterns can result in pollutant accumulation, particularly near taller structures. Consequently, both hourly and 8-hourly CO concentrations at Location 2 significantly exceeded permissible limits.

3.2 Temporal Variation at Indraprastha Road

Similar temporal trends were observed at Indraprastha Road. At **Location 3** (near Police Headquarters), the 1-hourly average CO concentration peaked at 6619 µg/m³ during the morning and 6213 µg/m³ in the evening, both exceeding regulatory limits. The corresponding 8-hourly average concentration was also above the permissible standard.

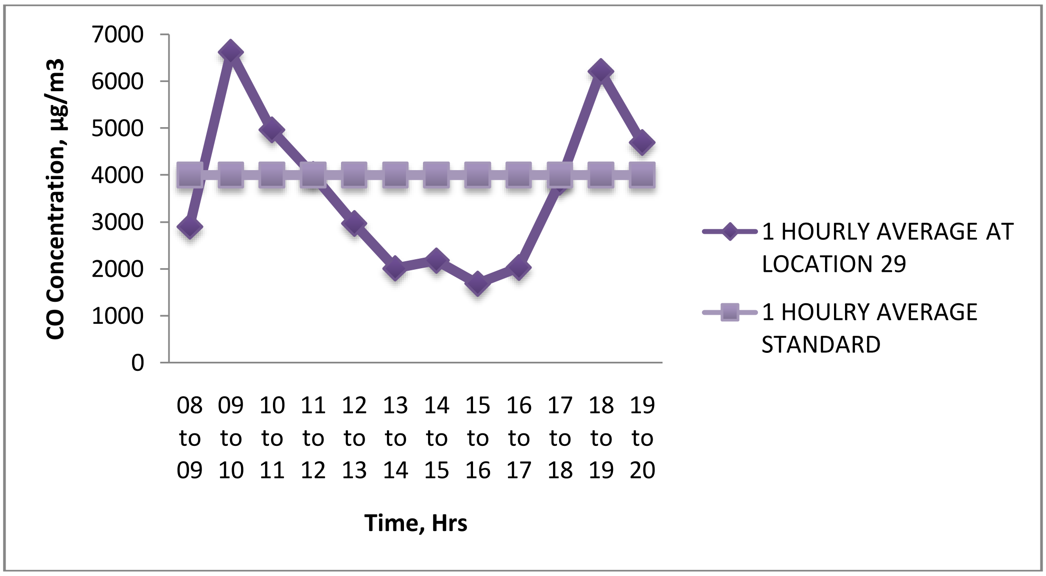

Fig.: Average hourly concentration of CO at location 3

In contrast, **Location 4** (near the Institution of Engineers) exhibited lower CO concentrations, with peak values of 1756 µg/m³ in the morning and 3309 µg/m³ in the evening. These values remained within acceptable limits, likely due to improved ventilation and greater dispersion associated with surrounding open spaces.

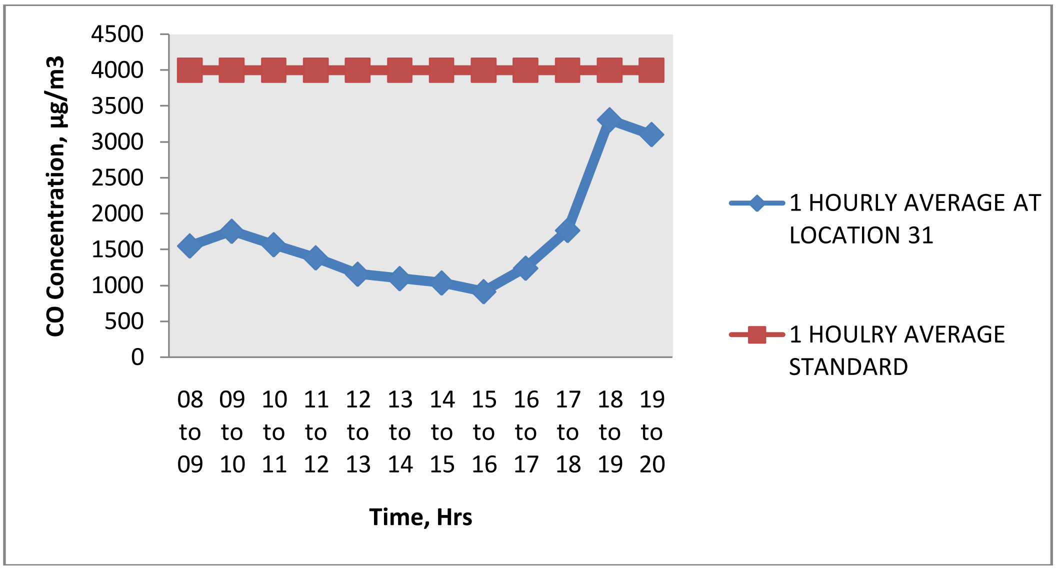

Fig.: Average hourly concentration of CO at location 4

IV. Conclusions

The study demonstrates that average hourly CO concentrations at all monitored urban road locations consistently display two pronounced peaks during morning and evening traffic hours. Throughout the monitoring period, both 1-hourly and 8-hourly average CO concentrations frequently exceeded prescribed air quality standards, indicating non-compliance at several locations.

The results further reveal that CO concentration levels vary significantly depending on roadside geometry and building configuration. Higher concentrations were generally observed near taller buildings, while lower levels occurred in open or better-ventilated areas. These findings suggest that urban form plays a critical role in pollutant dispersion and accumulation, often outweighing traffic volume alone.

Overall, the study underscores the need for targeted traffic management and urban planning strategies to mitigate near-road exposure to carbon monoxide in densely populated cities.

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