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Impact of Drive Days and No-Drive Days on Atmospheric Carbon Monoxide (CO) concentration

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Abstract

Automobile emissions rise in tandem with population growth. Increases in motorised vehicles lead to high urban traffic congestion, air pollution and health effects such as asthma, cardiorespiratory illness, headaches and cardiorespiratory disorders. The carbon monoxide (CO) released by vehicles acts as a greenhouse gas and is correlated with climate change. The study aims to evaluate and compare CO levels and vehicle counts on Drive Days (DD) and No-Drive Days (NDD) and to analyse the correlation between CO Concentration and vehicle count. The vehicles were counted, and CO concentrations were monitored using a CO meter over a five-year period. The research focused on observing No-Drive Days at Bishop Heber College, where commuters are encouraged to avoid motorised vehicles and to use eco-friendly transport. The number of vehicles has reduced significantly from DDs to NDDs ranging from 36% to 90.3%. On the DD, the CO concentrations were higher than the maximum permissible level signifying the need to take measurements. However, the CO levels have reduced on NDDs with a mean of 1.52 mg/m^3 well below the maximum permissible level. The investigation concluded that a decrease in vehicle numbers decreased the atmospheric CO concentration. The organisation and execution of No-Drive Days, as well as participant support greatly influence the level of success and sustainability of such initiatives.

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Introduction

Urban air pollution is a significant environmental issue in developing countries worldwide. An air quality study conducted in 20 out of the 24 megacities (with population exceeding 10 million by the year 2000) revealed that ambient pollution levels were high enough to pose severe health risks. Typical sources of gases and particulate matter that contaminate urban air include Sulphur dioxide, nitrogen dioxide, particulate matter, ozone, carbon monoxide and lead.

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In 2015, urban areas accounted for just 0.5% of the global land and sea surface,[1,2] but they contributed approximately to one-third of human- caused CO2 emissions (35%) and significant proportions of global NOx (29%), PM_{10} (27%), CO (26%), and SO2 (37%) emissions. Rapid urbanization is frequently linked to deteriorating air quality.[3,4] With a rising population comes a rise in automobile emissions.[5] The majority of Indian cities and towns are severely polluted due to the two- and three-wheelers for around 80% of all vehicles are fuelled by petrol or diesel. Between 1950 and 2023 the Tiruchirappalli metro population increased from 294,000 to 1,222,000 which is approximately four times higher; otherwise, 76% higher.

Carbon monoxide (CO) is significantly in the troposphere causing impact on air quality, atmospheric chemistry, and global climate. CO alters the atmosphere's oxidizing capacity by depleting the hydroxyl (OH) radical,[6,7] the primary oxidant in the troposphere, and by affecting the balance of tropospheric ozone.[8,9] It can indirectly contribute to climate change by influencing the concentrations of major greenhouse gases such as carbon-dioxide, methane, and ozone.[10] Elevated CO levels in the boundary layer can also pose severe health risks.[11] The effects of urban air pollution on the atmosphere and human well-being have become a growing concern thus necessitating air quality evaluation. It is needed to accurately comprehend the current state of urban air pollution, the trend in pollution, policy-making and strategize appropriate pollution management measures.

No-Drive Day activities are scheduled in an effort to temporarily prohibit or limit the use of private vehicles and prioritize movement by foot, bicycle, and public transportation. The primary goal of No-Drive Day is to offshoot changes beyond the day itself, by inspiring change toward healthy transportation[3] exemplified by the outcome of the practice.

Health Effects of CO

The incomplete combustion of organic substances results in the production of CO, a poisonous gas that is tasteless, odourless, colourless, and non-irritating. Epidemiological studies have found a significant link between Carbon monoxide (CO) and various health effects, although it is challenge with fully separate CO's impact from that of other air pollutants. Compared to oxygen, carbon monoxide has a far stronger affinity for haemoglobin.[13] Everyone has some CO in their blood (around 5%), but heavy smokers and people who engage in particular industries, like those that require operating diesel engines, forklifts, welding, police work, industrial painting, firefighting, or warehouse labour, may reach saturation levels of 10%.

Similarly, prolonged Interaction to elevated amounts of carbon monoxide can cause severe poisoning, reduction in oxygen levels due to the competitive binding of carbon monoxide can resulting hypoxia, ischemia, and cardiovascular diseases.[2,8]

CO can also have prenatal effects. Pregnant women exposed to elevated ambient CO levels (5-6 ppm) face a greater chance of having babies with low birth weights and experiencing fetal death.[12]

Severe carbon monoxide poisoning in humans has been linked to various eye-related conditions, including deficiencies in the visual field, papilledema, retinal hemorrhage, retinal venous congestion, optic atrophy, and temporary or permanent blindness.[13]

Acute exposure to elevated carbon monoxide causes poisoning symptoms in the central nervous system.[14] Headaches, nausea, vomiting, dizziness, drowsiness, weakness, confusion, disorientation, irritability, visual problems, seizures, and coma are some of these symptoms.

Overall, these studies offer compelling evidence of negative cardiovascular effects linked to carbon monoxide exposure, particularly when blood COHb levels reach or exceed 2.4%.The correlation between ambient CO and cardio respiratory disorders have been reported in numerous research.[3,15] Since the respiratory system does not appear to be the main organ that carbon monoxide targets, there is not enough soild evidence to associate airborne carbon monoxide values below 30 ppm with compromised lung function.[14,15] However, gastrointestinal (GID), genitourinary (GUD), and neuropsychiatric (NPD) illnesses were not frequently addressed.

The CO can cause headache, tinnitus (ringing in the ear) andclouding of consciousness, vomiting, and weakness, light-headedness nausea and coma and even death.

Hence it is important to estimate the CO concentration in atmosphere and rationalize the causes in order to take precautionary steps and avert adverse consequences.

CO Risk Groups

The major sources of CO to outdoor air are vehicles or industrial processes and machinery that burn fossil fuels, biomass burning, and wildfires. CO emitted from tobacco smoke and other combustion sources (such aswood stoves,fossil-burning heaters, gas,fireplaces, coal, kerosene, and appliances) may present problems.[7] Additionally, children, foetus, pregnant women, elderly, anaemic individuals, persons with cardiovascular problems, smokers, traffic controllers, workers involved in commercial driving, pipelining, oilfield work, and welding are more susceptible to CO exposure.

Materials and Methods

Study Area

The study was conducted at Bishop Heber College, Tiruchirappalli, Tamil Nadu, India located at 10.8147º N and 78.6731º E at 80m AMSL.The campus sprawled in 33acres is rich withdiverse flora and fauna. Tiruchirappalli experiences an average annual temperature of 28.8º C and receivesapproximately 860 mm of rainfall each year. Forstudy, three locations were chosen for observation of vehicle count and measurement of atmospheric carbon monoxide concentrations during Drive Days (DD) and No-Drive Days (NDD).

Methods

Vehicles entering the campus were counted and Carbon monoxide emission was estimated at Bishop Heber college on the event of Drive Days (DD) and No-DriveDays (NDD) when the usage of motorized vehicles is restricted to compare and contrast the emission values. Sampling was done from three different sites and measurements were taken from 08.00 a.m. to 04:00 p.m., covering duration of eight hours at 15-minute interval using a CO meter. All the values were noted down in data sheet and consolidated at the end.The CO emissions were monitored for five years from 2016 until 2023 except in 2020 due to covid restrictions. The results were calculated and assessed.

CO reduction % = ((CO mg/m³ on Drive Days)-(CO mg/m³ on No-Drive Days))/(CO mg/m³ on Drive Days) X 100

The obtained results were compared and analysed.

Results

The Vehicle Counts During Drive Days (DD) and No-Drive Days (NDD)

The vehicle counts and CO concentration in the atmosphere during Drive Days (DD) and No-Drive Days (NDD) are presented and discussed.

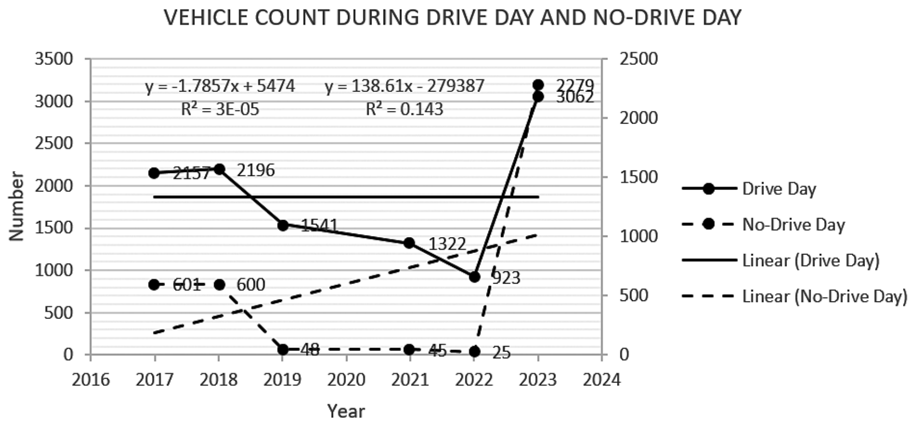

Fig. 1: Vehicle Count during Drive Day and No-Drive Day

The figure 1 reveals a neutral trend in the usage of vehicles over the years. Assuming there should be an increasing trend in coherence with the increasing general vehicle population,[5] the present scenario is contradictory. It could be noted that there is a mild decreasing trend from 2019 to 2022 which could be attributed to the covid restrictions and partial on-line class mode. However, the vehicle population has increased during 2023 attaining normalcy after the covid restrictions had been lifted. The vehicle counts have reduced significantly during the No-Drive Days compared to the Drive Days ranging from 36% to 90.3%.

Atmospheric CO Concentration during Drive Days (DD) and No-Drive Days (NDD)

The CO values on Drive-Days and No-Drive Days over the six years were recorded and analysed. It is evident from the data that atmospheric CO varied between 1.2 and 3.1 mg/m^3 on DDs and between 1 and 2.5 mg/m^3 on NDDs. The concentration in ambient air prescribed[18] is 2 mg/m^3. for eight hours-time weighted average. The CO concentrations are higher than the prescribed values on DD (2.3 mg/m^3) signifying the air quality is moderate and the need to take control measurements. However, the CO levels have reduced ranging from 1.0 to 2.5 mg/m^3 on average, up to 1.5 mg/m^3 well below the maximum permissible level achieving satisfactory air quality which has been achieved due to No-DriveDay.

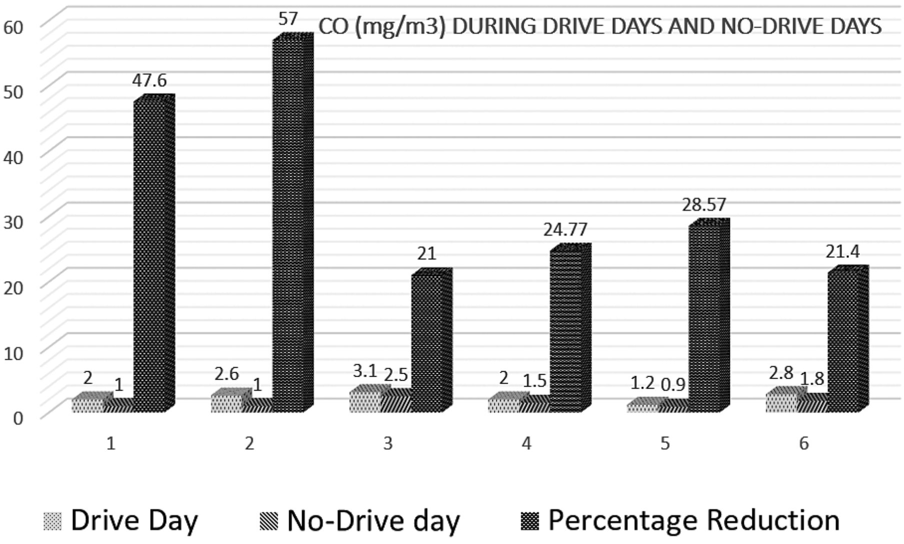

Fig. 2: CO (mg/m^3) During Drive Days and No-Drive Days

Discussion

With regard to No-Drive Days, the trend is increasing and not neutral as Drive Days. This indicates that the commuter's willingness to observe the No-Drive Day has been diminishing over the years. Prior to the No-Drive Days the college members were advocated through circulars, poster displays, canvassing door to door, videos or and road shows. In spite of advocacy people's participation were only minimal. The variations in reduction are indicative of participant's response to the participation of No-Drive Days. This further affirms the diminishing contribution of the participants towards environmental conservation initiatives.

Atmospheric CO Concentration

This indicates that such No Drive-Day practices can be imposed in phased manner to combat air pollution. It is further noted that on both DD and NDD the CO concentration trend increased from the first to third year but decreased from the fourth to fifth year and again showed an upward trend. The declining trend could be attributed to the lesser vehicles due to covid restrictions. The figure 2 reveals that the CO levels have reduced ranging from 21% to 57% during the No-Drive Days compared to the DriveDays. This substantiates that the motorized vehicles have significantly contributed to the atmospheric CO concentration. The central region of Tiruchirappalli hosts more than 10 higher educational institutions. If a single college can achieve up to a 57% reduction in CO emissions, a coordinated effort by all colleges to observe NDD on the same date could result in a substantial reduction in atmospheric CO levels.

Suggestions

- Public awareness campaigns should be launched to address the health concerns related to ambient air quality, specifically focusing on atmospheric CO.
- Install carbon monoxide detectors in several areas.
- Monitor the CO concentration on long term basis.
- The most susceptible groups as traffic regulators and street vendors should be educated on the health implications and encouraged to take regular COHb check-ups.
- To lower CO levels from air pollution, the use of N95, carbon, and surgical masks should be promoted and even made required.
- No-Drive Days should be introduced in educational institutions and government offices on specific days or at regular intervals in initial phases.
- At later phasesthe practice should be expanded to the public on certain specified days as it can serve as a tool to create awareness, reduce atmospheric CO concentration as well as reduce general atmospheric pollution and sensitize on the responsibility of an individual in environmental protection.

Conclusion

Estimation of atmospheric carbon monoxide concentration at Bishop Heber College on Drive Days and No-Drive Days for six years affirmed considerable decrease during No-Drive Days. The CO levels during DriveDays were above permissible limits while it had substantially decreased on No-Drive Days. The positive results imply that such practices should be implemented. These are in association with the vehicle counts which are in turn dependent on partakers response which is diminishing over the years. Thus, the outcomes of No-Drive Days and events are highly variable and dependent on the scale and goals of participant's initiative. Observing No Drive-Day not only reduces the atmospheric CO but also it substantiates the benefits of driving less and illuminates the essence ofenvironmental protection. Measures to protect from CO toxicity impact specifically for traffic regulators are pertinent. The current study substantiates that the air quality with refence to CO has improved from moderate to satisfactory Reducing motorized vehicles directly reduces the CO concentration and improves the air quality and provides a healthier environment. Such practices can be implemented across higher educational institutions, followed by expansion to corporate and governmental organizations. Ultimately these initiatives could be scaled up for implementation at state and national levels. Additionally, this practice will involve in reduction of other air pollutants, including CO_2, SO_2,, NO_2, and particulate matter.

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Conflict of Interest

The author(s) do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

Each author mentioned has significantly and directly contributed intellectually to the project and has given their approval for its publication.

- **Carlton Relton:** Conceptualization, Methodology.
- **Daisy Caroline Mary Arockiasamy:** Data Analysis, Writing – Original Draft.
- **Teneson Rayappan:** Visualization, Data compilation
- **Sheela Mary Mariaselvam:** Writing – Review & Editing.
- **Ramprasath Mookkaiyaraj:** Data Collection
- **Gopianan Ganesan:** Data Collection

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