భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

# Assessing real-world emissions from BS-VI Diesel Buses in Indian Urban and Sub-urban Traffic

Source: ZEVpoint

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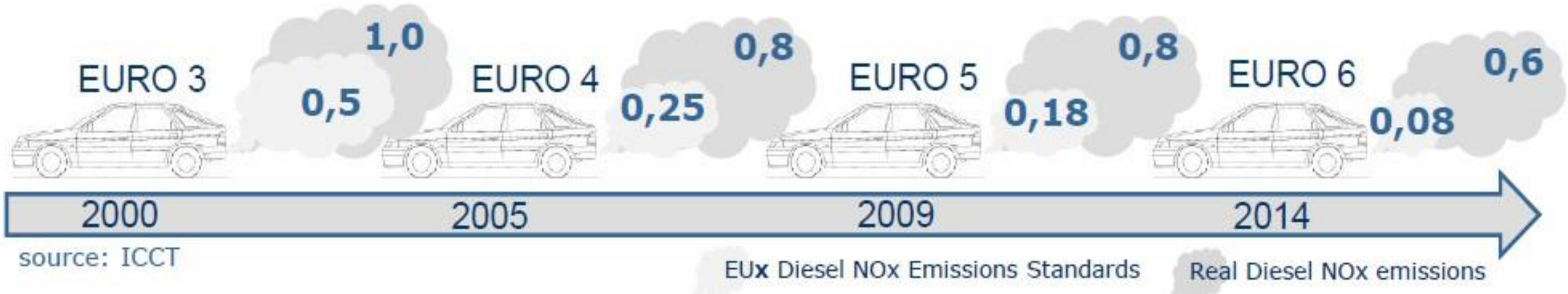
**Indian Institute of Technology Hyderabad**

## Why do we need Real-World Emission Test?

- **Real-world measurements** are crucial for understanding and addressing India's air quality concerns, especially in urban areas where **diesel buses** contribute significantly to pollution.
- To ensure that diesel buses, particularly those equipped with advanced **BS-VI technology**, meet and adhere to emission standards and regulatory requirements.
- Understanding how emissions vary in real-world conditions, such as **traffic congestion,** is essential for implementing targeted interventions.
- Accurate measurements are necessary to refine **emission factors**, ensuring they accurately represent **real-world emissions.**




**Gap between Cycle and Road as collected by ICCT for EU**

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## INDIAN DRIVING / ROAD CONDITIONS ARE DIFFERENT

- SITUATION IN INDIA REGARDING ON-ROAD BUS EXHAUST EMISSIONS
- There is no data available. ARAI has collected some data lately
- There is a Need to Study : Elaborate Data collection required

## Research Objectives

To assess real-world emission rates and emission factors from BS-VI diesel buses in urban and suburban traffic environments

To study the impact of Speed and Vehicle Specific Power on real-world emissions and develop distance-based emission factors

# METHODOLOGY

## STEP 1

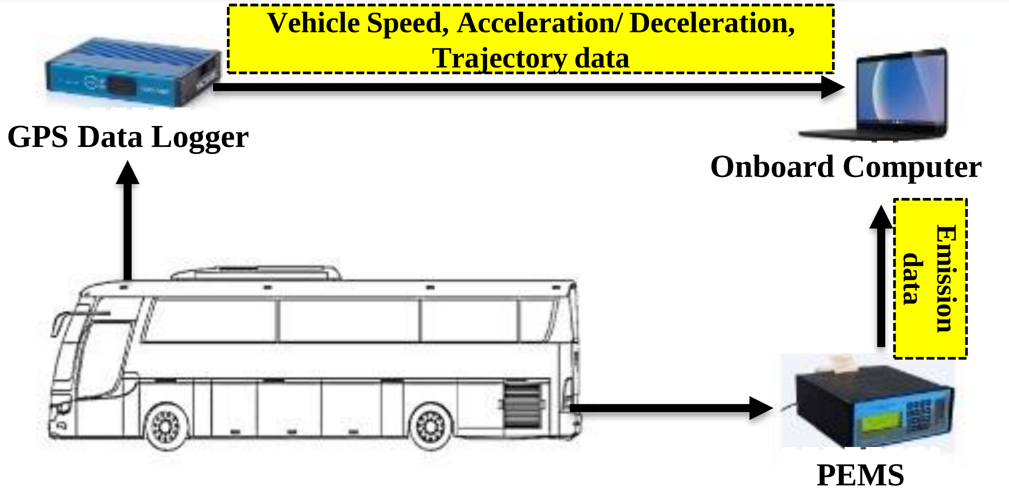
### DATA COLLECTION

Test Route Selection

Vehicle Selection

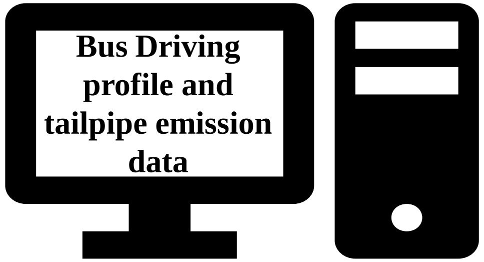
Traffic Characteristics Data

## DATA COLLECTION TEST SETUP




## STEP 2

### DATA EXTRACTION AND PREPROCESSING




## STEP 3

Matching the time stamps of Vehicle speed and the emission data

## STEP 4

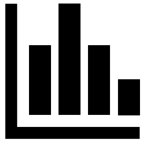
Compilation of the final speed-emission data file for the test route

## STEP 5

Classification of test-route based on traffic characteristics as urban and sub-urban

## STEP 6

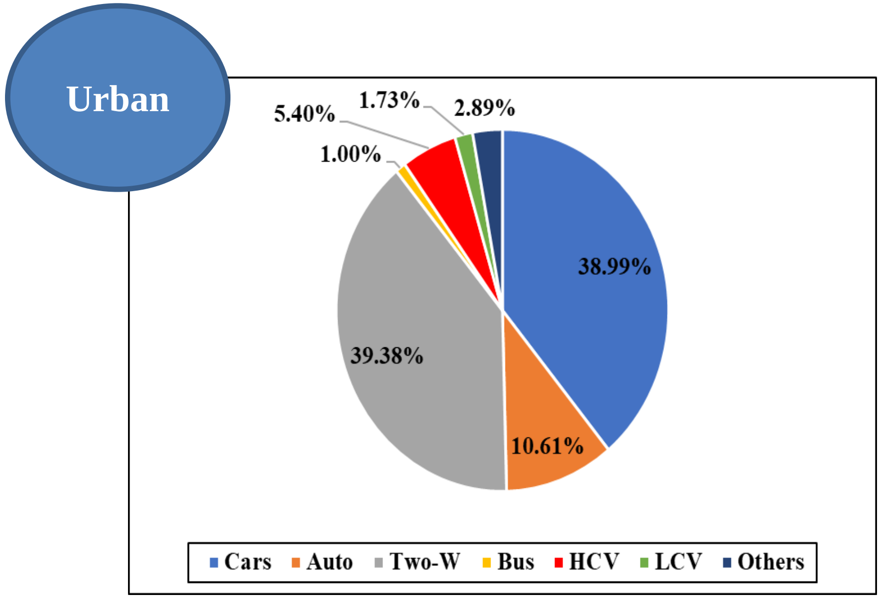
Data Analysis and result interpretation

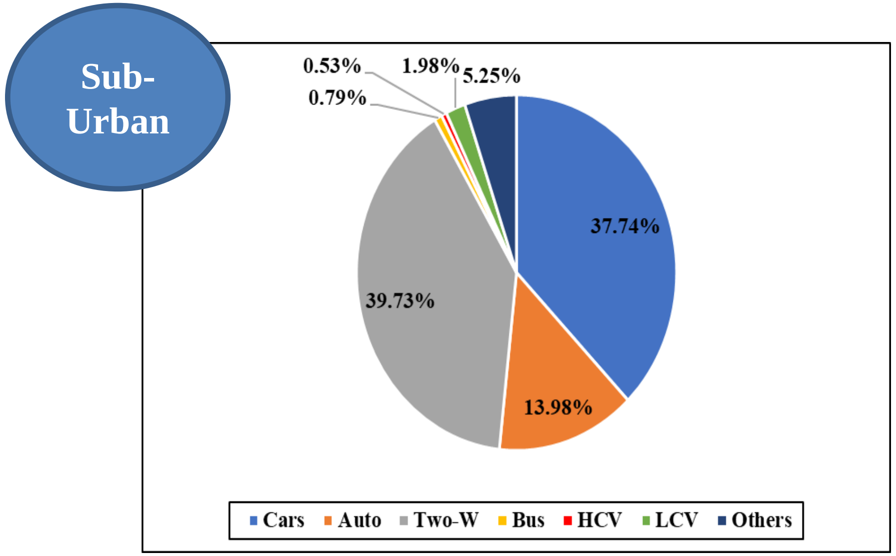


# Test Route Selection

## HYDERABAD CITY


Fig. Test route for the study



# Instrumentation of test vehicle

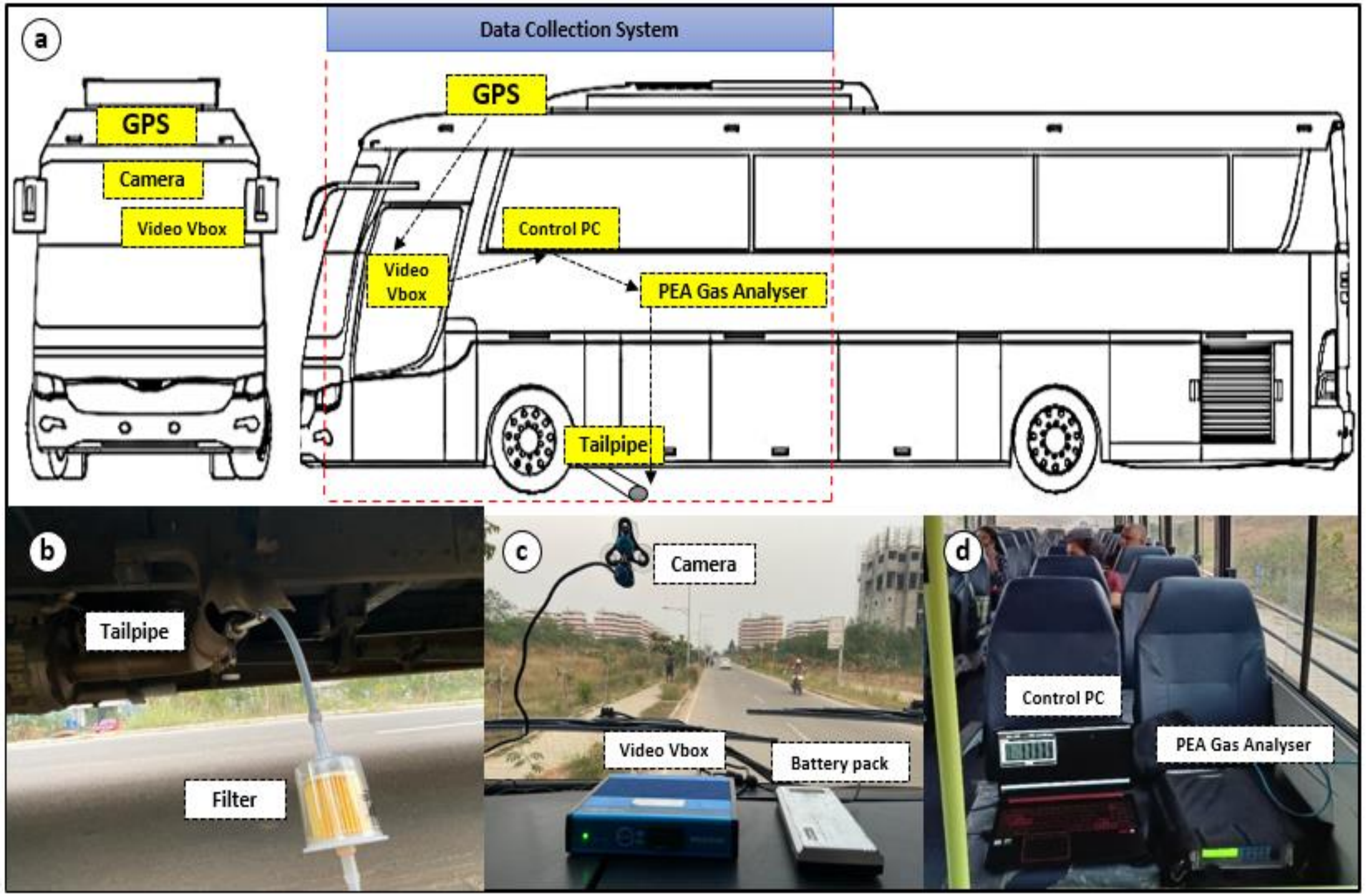


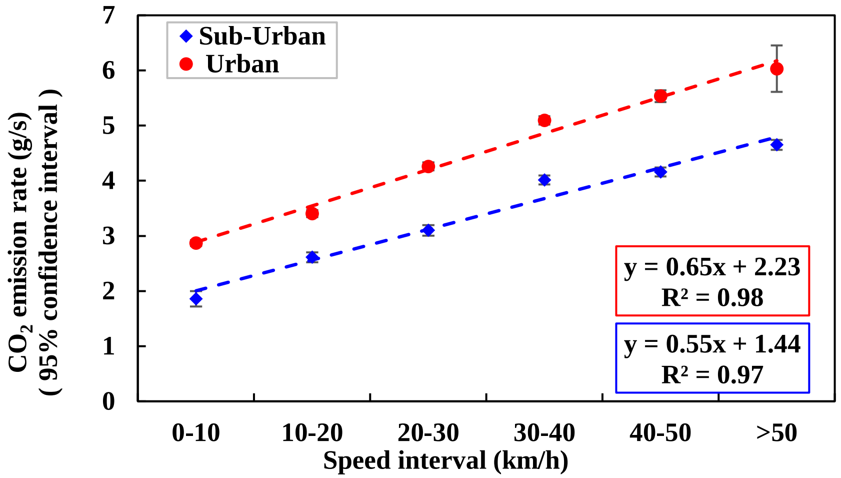

Fig. Data collection system on the test vehicle

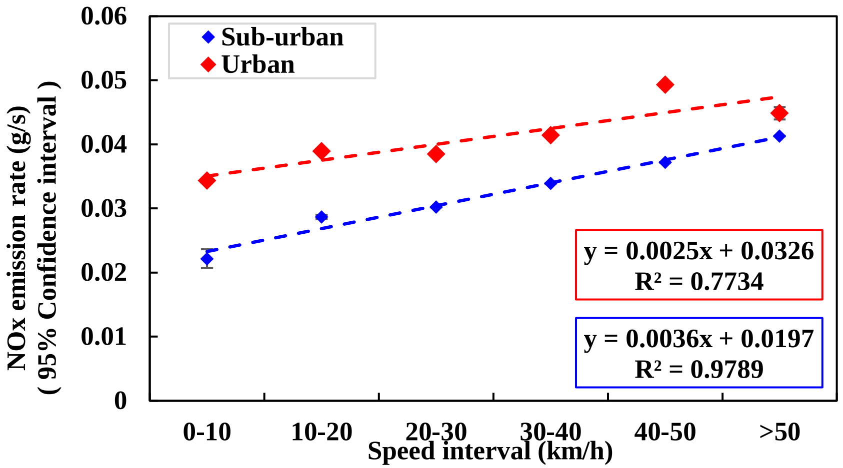
20 PEMS TRIPS CONDUCTED

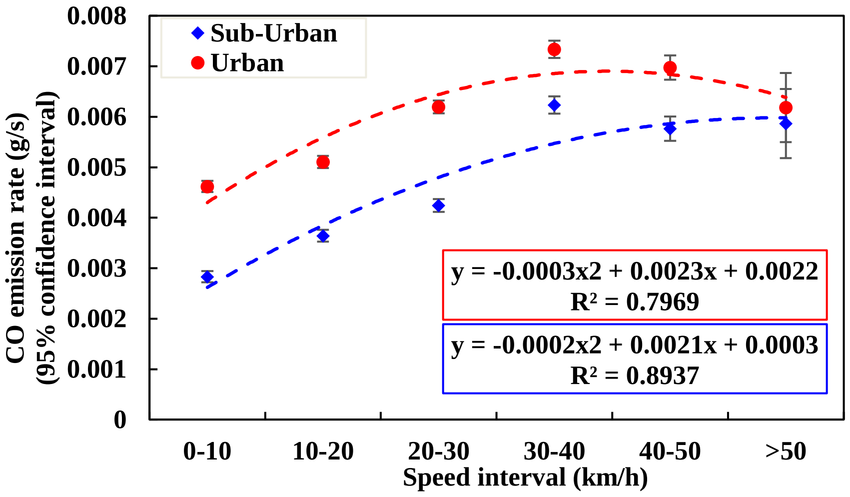
PEAK AND NON-PEAK HOURS

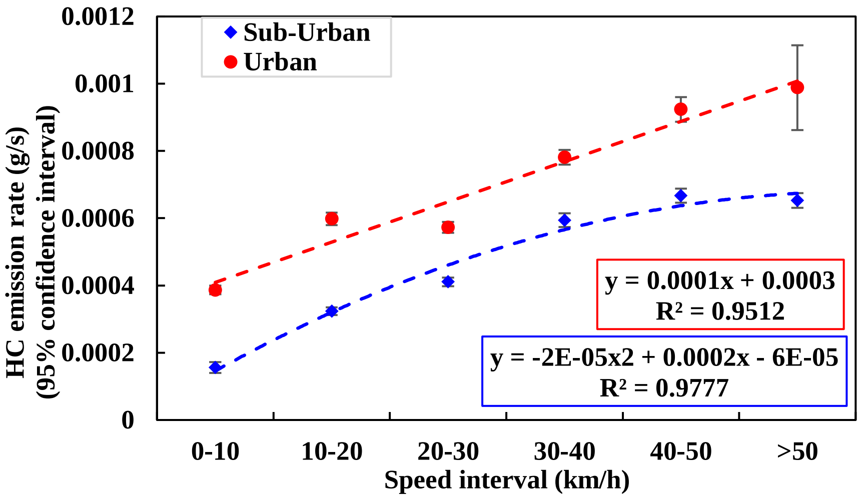
SINGLE DRIVER THROUGHOUT TRIP

# Impact of vehicular speed on emission rate



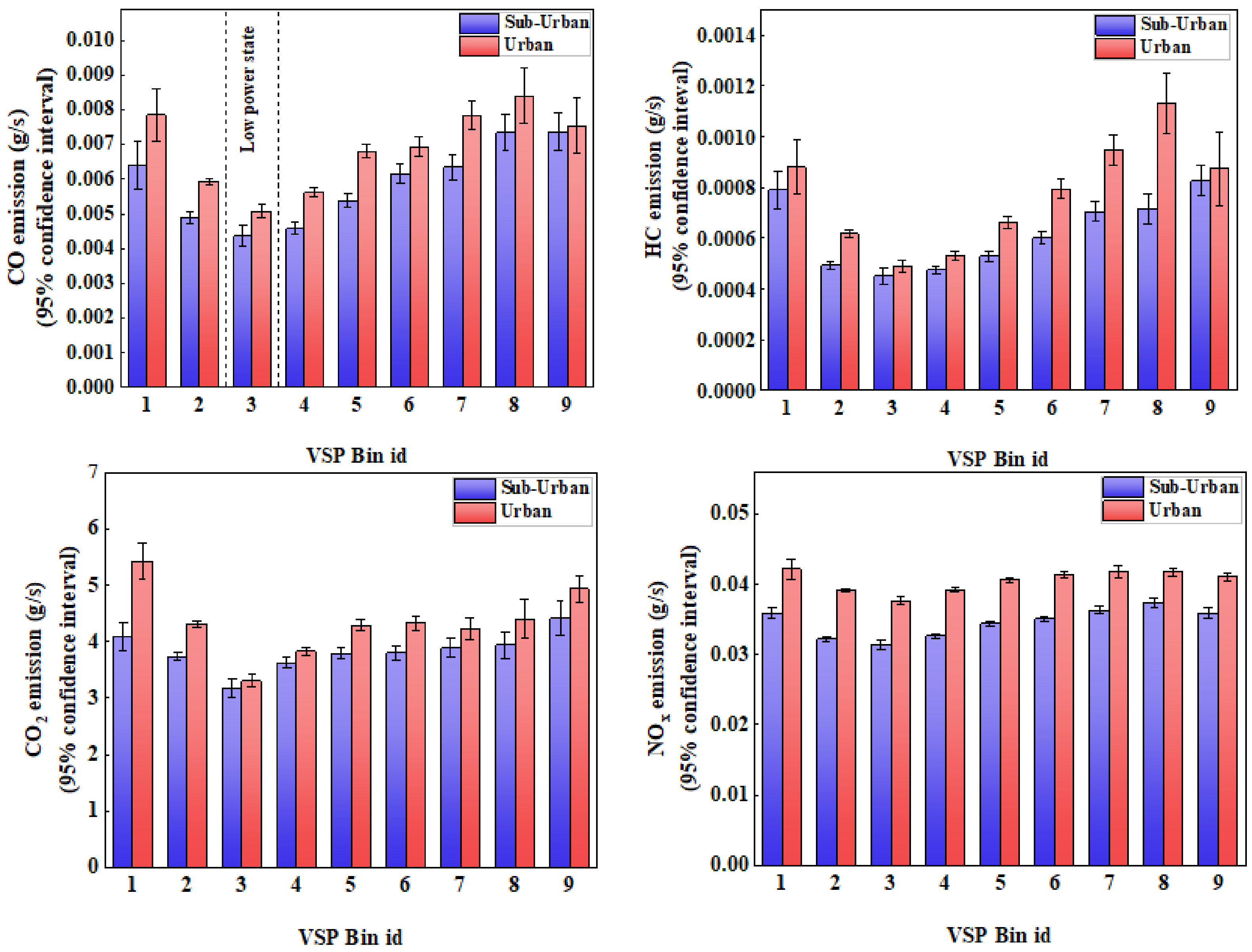



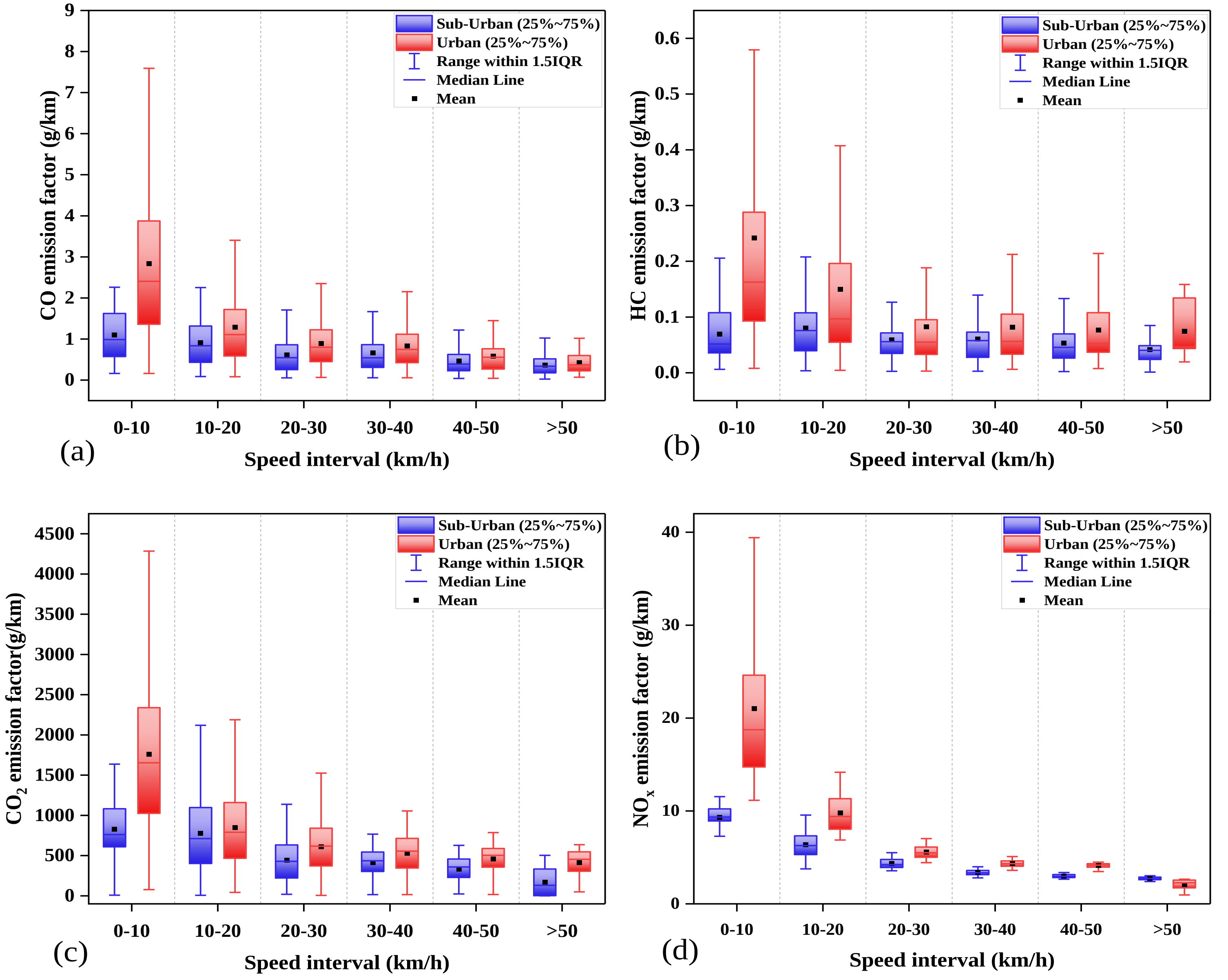

- With **increasing** vehicle speed, there is a corresponding escalation in **$CO_2$, $NO_X$, and HC** emissions
- At speeds below 20 km/h, **CO2** emissions in urban traffic environments are 26.15% **higher** than in suburban traffic environments.
- **CO** emissions exhibit a **second-order** polynomial trend.
- For speeds below 20 km/h, **CO** emissions in urban traffic are 38% higher than in rural traffic

# Impact of Vehicle Specific Power (VSP) on emission rate



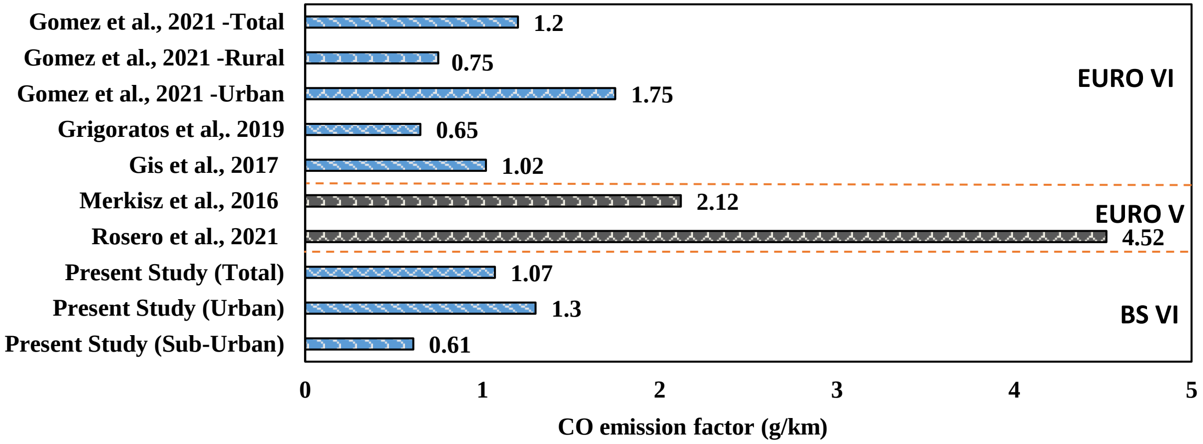

- Emission rates are closely linked to the **power demand** supplied by the engine.
- **VSP** analysis highlights that rapid acceleration, deceleration, and congestion increase engine power demand, resulting in **higher** fuel consumption and emissions.
- **Lower VSP values** (0-2.5 KW/ton) correspond to average vehicle speeds of 19 km/h in urban and 32 km/h in suburban traffic.
- Lower VSP values coincide with the **lowest emissions** observed during the trip on both types of roads.

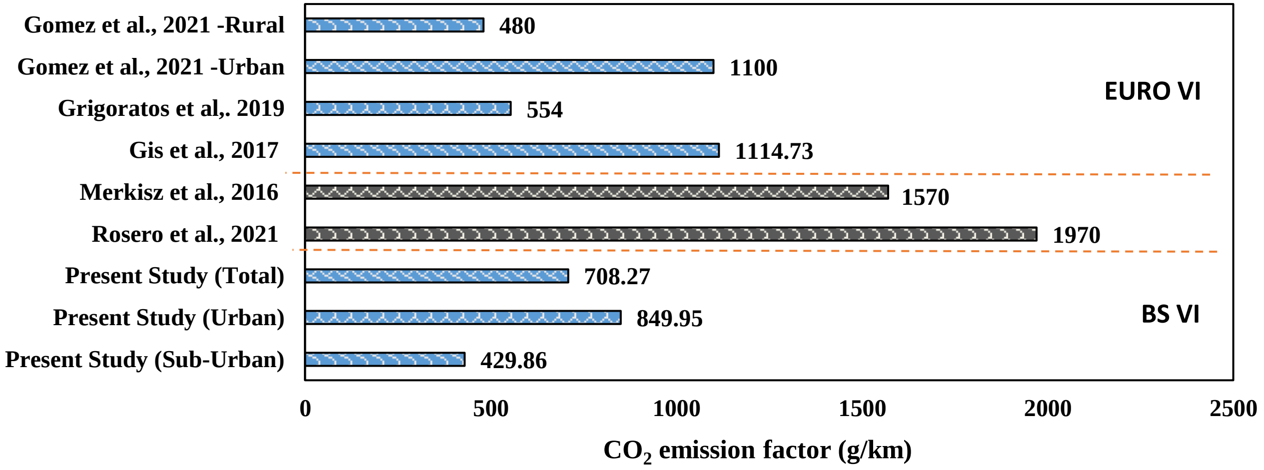
# Impact of speed on emission factor

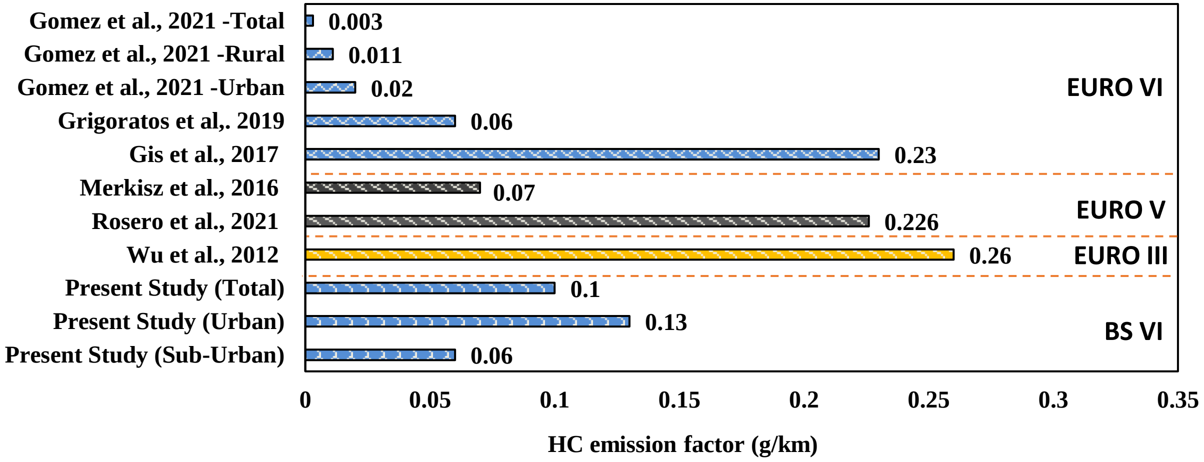


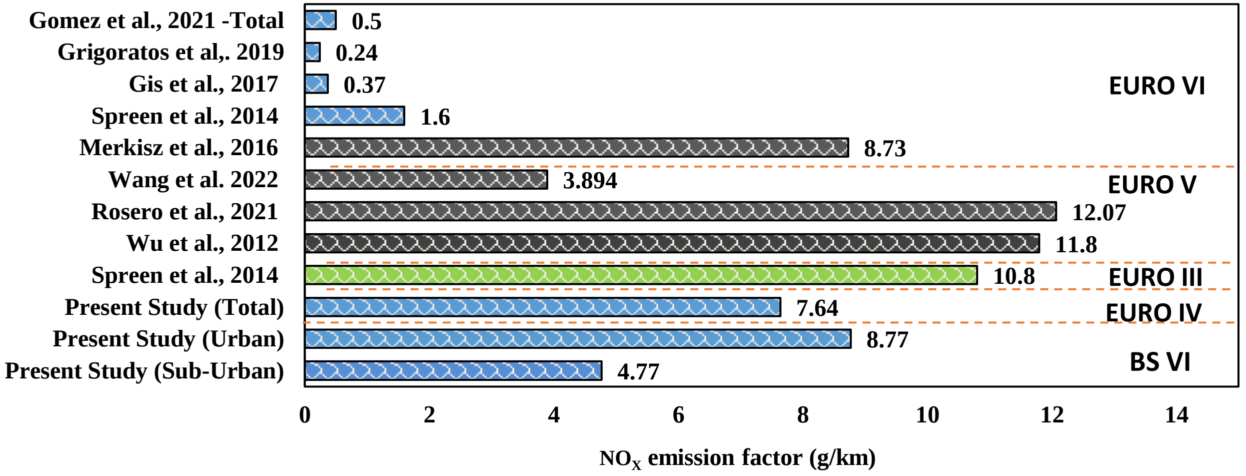

- It is observed that the emission factors for all exhaust gases exhibit a gradually **decreasing trend** with an increase in vehicle speed.
- The **CO** emission factor is **1.3 g/km** and **0.61 g/km** in urban and sub-urban traffic environment, respectively.
- The HC emission factor is **0.13 g/km** and **0.06 g/km** in urban and sub-urban traffic environments, respectively.
- The $CO_2$ emission factor is **849.95 g/km** and **429.86 g/km** in urban and sub-urban traffic environments, respectively.
- $NO_X$ emission factor is **8.78 g/km** and **3.95 g/km** in urban and sub-urban traffic environments, respectively.

# Comparison of this study with existing studies



# Conclusion

- Emissions are found to be significantly higher in Urban traffic compared to Sub-urban traffic.
- The test vehicle shows higher CO, HC, $CO_2$, and $NO_X$ emissions with increasing speed.
- Emissions are higher for rapid acceleration and rapid deceleration events compared to low load state.
- The average CO, HC, $CO_2$, and $NO_X$ emission factors are 1.06 g/km, 0.1 g/km, 708.27 g/km, and 7.64 g/km, respectively.

# Limitations and Future Scope

- This study only assessed a vehicle complying with BS VI emission standards. The results may not accurately reflect the total fleet.
- Future studies can incorporate other gaseous pollutants, such as Particulate matter (PM).
- Future studies can expand their scope to include buses that comply with the latest BS-VI phase 2 emission standards.

# References


- Söderena, P., Nylund, N. O., Pettinen, R., & Mäkinen, R. (2018). Real Driving NOx Emissions from Euro VI Diesel Buses (No. 2018-01-1815). SAE Technical Paper.
- Frey, H. C., Rouphail, N. M., Zhai, H., Farias, T. L., & Gonçalves, G. A. (2007). Comparing real-world fuel consumption for diesel-and hydrogen-fueled transit buses and implication for emissions. Transportation Research Part D: Transport and Environment, 12(4), 281-291.
- Quiros, D. C., Thiruvengadam, A., Pradhan, S., Besch, M., Thiruvengadam, P., Demirgok, B., ... & Hu, S. (2016). Real-world emissions from modern heavy-duty diesel, natural gas, and hybrid diesel trucks operating along major California freight corridors. Emission Control Science and Technology, 2, 156-172.
- Misra, C., Collins, J. F., Herner, J. D., Sax, T., Krishnamurthy, M., Sobieralski, W., ... & Chernich, D. (2013). In-use NOx emissions from model year 2010 and 2011 heavy-duty diesel engines equipped with aftertreatment devices. Environmental science & technology, 47(14), 7892-7898.
- Rosero, F., Fonseca, N., López, J. M., & Casanova, J. (2021). Effects of passenger load, road grade, and congestion level on real-world fuel consumption and emissions from compressed natural gas and diesel urban buses. Applied Energy, 282, 116195.
- Spreen, JS, Vonk, W., Vermeulen, R., Zuidgeest, SML, & Baarbé, MH (2014). NOx and PM emissions of a Mercedes Citaro Euro VI bus in urban operation . Delft: TNO.
- Li, P., & Lü, L. (2021). Evaluating the real-world NOx emission from a China VI heavy-duty diesel vehicle. Applied Sciences, 11(3), 1335.
- Ko, S., Park, J., Kim, H., Kang, G., Lee, J., Kim, J., & Lee, J. (2020). NOx emissions from Euro 5 and Euro 6 heavy-duty diesel vehicles under real driving conditions. Energies, 13(1), 218.

# THANK YOU !

## Queries?

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