

COMPARISON OF EMISSIONS FROM PRE-EURO, EURO-II AND EURO-IV MOTORCYCLES AND CARS IN LAHORE

R. Haider^{*1}, I. H. Sheikh², N. Naz³, M. F. Alam⁴, M. Nadeem⁵, M. Arshad⁶ and T. Mahmood⁷

¹Assistant Director Research, Environmental Protection Agency, Govt. of the Punjab, Lahore (Pakistan)

²Director General Environmental Protection Agency, Govt. of the Punjab, Lahore (Pakistan)

³Director (ML&I), Environmental Protection Agency, Govt. of the Punjab, Lahore (Pakistan)

⁴Deputy Director (Lab), Environmental Protection Agency, Govt. of the Punjab, Lahore (Pakistan)

⁵Assistant Director (Research), Environmental Protection Agency, Govt. of the Punjab, Lahore Pakistan)

⁶Assistant Director (Research), Environmental Protection Agency, Govt. of the Punjab, Lahore Pakistan)

⁷Research Assistant, Environmental Protection Agency, Govt. of the Punjab, Lahore (Pakistan)

Corresponding Author Email: rizwanchemist@gmail.com

ABSTRACT: This study investigated vehicular emissions of carbon monoxide (CO), nitrogen oxides (NO_x), and hydrocarbons (HC) from cars and motorcycles in Lahore, Pakistan. Vehicles were categorized based on emission standards (Euro IV, Euro II) and Pre Euro vehicles. Emissions testing revealed a strong correlation between vehicle age and pollutant levels, with older, pre-Euro vehicles exhibiting significantly higher emissions compared to newer, Euro II and Euro IV compliant models. Specifically, older cars frequently exceeded Punjab Environmental Quality Standards (PEQS) for CO. While Euro II vehicles demonstrated some improvement, the data highlights the effectiveness of stricter emission standards in reducing pollution. These findings underscore the need for policies targeting older vehicles, including scrappage programs and stricter enforcement of existing standards, alongside promoting cleaner vehicle technologies to improve air quality in Lahore.

Key Words: Euro II, Carbon Monoxide, Catalytic Converter, Motorcycles.

(Received

17.09.2024

Accepted 03.12.2024)

INTRODUCTION

Lahore, the second-largest city in Pakistan and the capital of Punjab province, faces significant challenges related to air pollution, with vehicular emissions being a major contributing factor. Rapid urbanization, increasing motorization rates, and a growing reliance on personal vehicles have led to a substantial increase in traffic volume, exacerbating the problem (Ghauri et al., 2017). This surge in vehicular activity has resulted in elevated concentrations of harmful pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), and hydrocarbons (HC) in the urban atmosphere (Colville et al., 2001). These pollutants have detrimental impacts on human health, contributing to respiratory illnesses, cardiovascular diseases, and other adverse health outcomes (WHO, 2021). The problem is further compounded by factors such as the prevalence of older, poorly maintained vehicles with less efficient emission control technologies, as well as the quality of fuels used (Hussain et al., 2013). The meteorological conditions in Lahore, including temperature inversions and low wind speeds, can also trap pollutants near the ground, intensifying the effects of vehicular emissions (Alam et al., 2007). Understanding the specific contribution of different vehicle types and age categories to the overall

pollution burden is crucial for developing effective mitigation strategies and improving air quality in Lahore. This study focuses on analyzing the emissions of CO, NO_x, and HC from cars and motorcycles in Lahore, categorized by emission standards and age, to provide insights into the current state of vehicular pollution and inform policy interventions.

Lahore, a megacity in Pakistan, grapples with severe air pollution, posing significant risks to public health and environmental sustainability. Vehicular emissions are a primary contributor to this crisis, driven by rapid urbanization, increasing vehicle ownership, and traffic congestion (Nadeem et al., 2021). The city's air is laden with harmful pollutants, including carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM_{2.5} and PM₁₀), and volatile organic compounds (VOCs), largely originating from the transport sector (Harrison et al., 2021). These pollutants are linked to a range of adverse health effects, including respiratory diseases, cardiovascular problems, and even premature mortality (Landrigan et al., 2018). The aging vehicle fleet, often lacking modern emission control technologies, further exacerbates the problem (Afzal et al., 2020). Moreover, fuel quality and traffic management practices contribute to the overall emission burden. Meteorological factors, such as temperature inversions and stagnant air conditions, can trap pollutants, leading to

episodes of severe air pollution, particularly during winter months (Lawrence et al., 2022). Addressing vehicular emissions is therefore crucial for improving air quality and safeguarding public health in Lahore. This study investigates the emissions of CO, NO_x, and HC from different categories of cars and motorcycles in Lahore, considering emission standards and vehicle age, to provide a detailed assessment of the current situation and inform effective mitigation strategies.

The contribution of vehicular emissions to smog in Lahore is a significant and complex issue. While the Lahore Urban Unit has attributed 83% of air pollution in the city to vehicles (Urban Unit, 2023). The Food and Agriculture Organization (FAO) has estimated a 43% contribution from the transportation sector in Punjab province (FAO, 2019). These differing figures highlight the nuanced nature of air pollution sources and the challenges in accurately quantifying their contributions to smog formation.

Factors such as the specific methodology used for data collection, the pollutants considered in the analysis, and the spatial and temporal scales of the assessments can all influence the estimated contribution of vehicles to air pollution. Furthermore, the impact of vehicular emissions can vary depending on factors such as vehicle type, fuel quality, and traffic congestion.

The collaborative effort between the EPA Punjab, Transport Department, Safe City Authority Punjab, and Traffic Police to combat smog in Punjab is a significant step towards improving air quality. The strict challaning campaign for vehicles with excessive emissions is a crucial measure to enforce emission standards and deter the use of poorly maintained or modified vehicles. The new plan of EPA Punjab to monitor all vehicles and issue green stickers to compliant vehicles has the potential to promote vehicle owners to maintain their vehicles properly and reduce emissions.

METHODOLOGY

The methodology employed for testing vehicular emissions of cars and motorcycles for CO, NO, and HC involved several key steps. Different categories of vehicles were selected for the study. For cars, the categories included Euro IV and Euro II compliant vehicles, as well as a range of pre-Euro vehicles categorized by age (e.g., 0-5 years, 5-10 years, 10-20 years, and over 20 years old). Motorcycles were similarly categorized into Euro II compliant models, Chinese motorcycles (likely representing a specific type or brand prevalent in the region), and motorcycles grouped by age.

Emissions testing was conducted using appropriate equipment, likely including gas analyzers designed to measure the concentration of CO, NO (which is often measured as NO_x, Nitrogen Oxides), and HC in the vehicle exhaust. These procedures would have specified parameters such as engine warm-up time and idle speed. Emission calculations were based on 9 m³ emissions per liter fuel consumption.

Equipment and sampling detail is provided at Table 1. For each vehicle tested, measurements of NO, and HC were recorded in units such as parts per million (ppm) and then converted to grams per kilometer (g/km). While CO is measured in % and converted to g/Km. These measurements were then compiled and analyzed to compare emission levels across the different vehicle categories and age groups. The collected data allowed for the assessment of the impact of emission standards (Euro IV, Euro II) and vehicle age on pollutant emissions. The results were then compared with existing environmental quality standards, such as the Punjab Environmental Quality Standards (PEQS), to determine compliance and identify areas of concern.

Table 1: Equipment and Sampling Detail.

Aspect of Methodology	Description
Instrumentation	Kane automotive gas analyzer. This analyzer is equipped with NDIR sensors for CO and HC measurement.
Target Pollutants	Testo 350 was used to monitor NO. Carbon Monoxide (CO), Nitrogen Oxides (NO - often reported as NO _x , which includes NO and NO ₂), and Hydrocarbons (HC).
Vehicle Selection	Vehicle Type: Car, motorcycle; Fuel type - gasoline; Age range; 0-5, 5-10, 10-20, 20 Onward Emission standard - Euro II, Euro IV, pre-Euro). At Least 10 Samples of each vehicles category were taken through random sampling.
Test Procedure	1. Probe Connection: The analyzer's exhaust probe was securely inserted into the vehicle's exhaust pipe. 2. Analyzer Warm-up: The analyzer was turned on and allowed to warm up according to the manufacturer's instructions to ensure accurate readings.

Calibration and Maintenance

and

Emissions Calculation

3. **Engine Conditions:** The vehicle's engine was operated under specified conditions, typically at idle.

4. **Measurement:** The analyzer measured and displayed the concentrations of CO, NO, and HC in the exhaust gases.

5. **Data Recording:** The measured values were recorded

The analyzer was calibrated regularly according to the manufacturer's recommendations. Regular maintenance, including cleaning, checking seals, and replacing consumables, was performed to ensure accurate and reliable measurements.

The vehicles are tested in the idle condition in ppm unit for HC and NO, and % unit for CO. These units are then converted to g/Km units, assuming 9 m3/Litre (based on 2.3 kg of CO₂ or 1300 litres of CO₂ per liter of Gasoline) of exhaust emissions of each vehicle (chevalier technologies, 2017).

Average mileage of Motorcycle is taken as 40 Km/Lit.

Average mileage of car is taken as 13 Km/Lit.

For example 2% CO $\longrightarrow$ 20 Lit/m³ $\longrightarrow$ 180 lit/9m³

22.4 Lit CO $\longrightarrow$ 28 g

180 Lit CO $\longrightarrow$ 225 g

Average mileage of Car $\longrightarrow$ 13 Km/Lit

CO emissions $\longrightarrow$ 225/13 $\longrightarrow$ 17 g/Km

Limitations: The emission calculation is research based and not being done on a chasis dynamometer. The vehicles are tested in idle position.

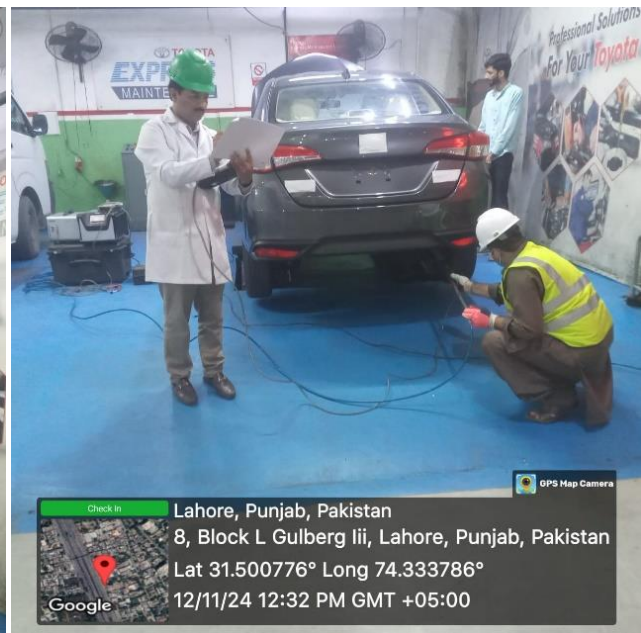
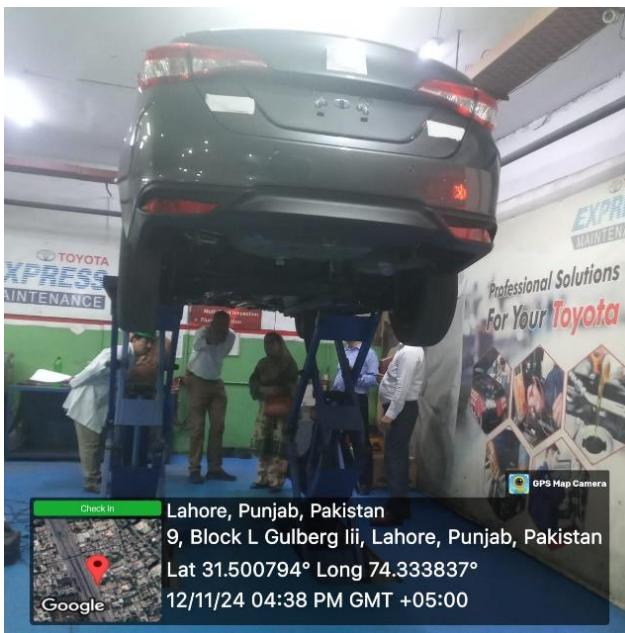


Figure 1: Testing of car emissions at Toyota Garden Motors Lahore

RESULTS

Motorcycle emissions: The Figure2 reveals a clear trend: older motorcycles (Pre-Euro) generally exhibit higher emission levels of HC+NO and CO compared to newer ones (Euro II and Euro IV). This is expected as emission standards have evolved over time, with newer standards (like Euro II and Euro IV) being more stringent and requiring vehicles to meet lower emission limits.

Specific Observations:

- **Euro IV:** The Euro IV Honda ATK 151 with EGR demonstrates the lowest emissions across both HC+NO and CO, aligning with the stricter Euro IV standards.
- **Euro II:** The Euro II Honda 125CC with EGR also shows relatively low emissions, although slightly higher than the Euro IV model.
- **Pre-Euro:** The Pre-Euro motorcycles exhibit the highest emission levels, with some models exceeding

the PEQS (Punjab Environmental Quality Standards) for CO. This highlights the significant pollution contribution from older, less regulated vehicles.

Factors Influencing Emissions

Several factors contribute to these emission differences:

- **Engine Technology:** Newer engines often incorporate technologies like electronic fuel injection, exhaust gas recirculation (EGR), and catalytic converters, which help reduce emissions.

- **Maintenance:** Poorly maintained vehicles, regardless of their age, can emit higher levels of pollutants.

- **Fuel Quality:** The quality of fuel used can also influence emissions.

Implications: The data underscores the importance of phasing out older, more polluting vehicles and promoting the use of newer, cleaner models. Implementing stricter emission standards and enforcing regular vehicle inspections can also help reduce air pollution from motorcycles in Lahore.

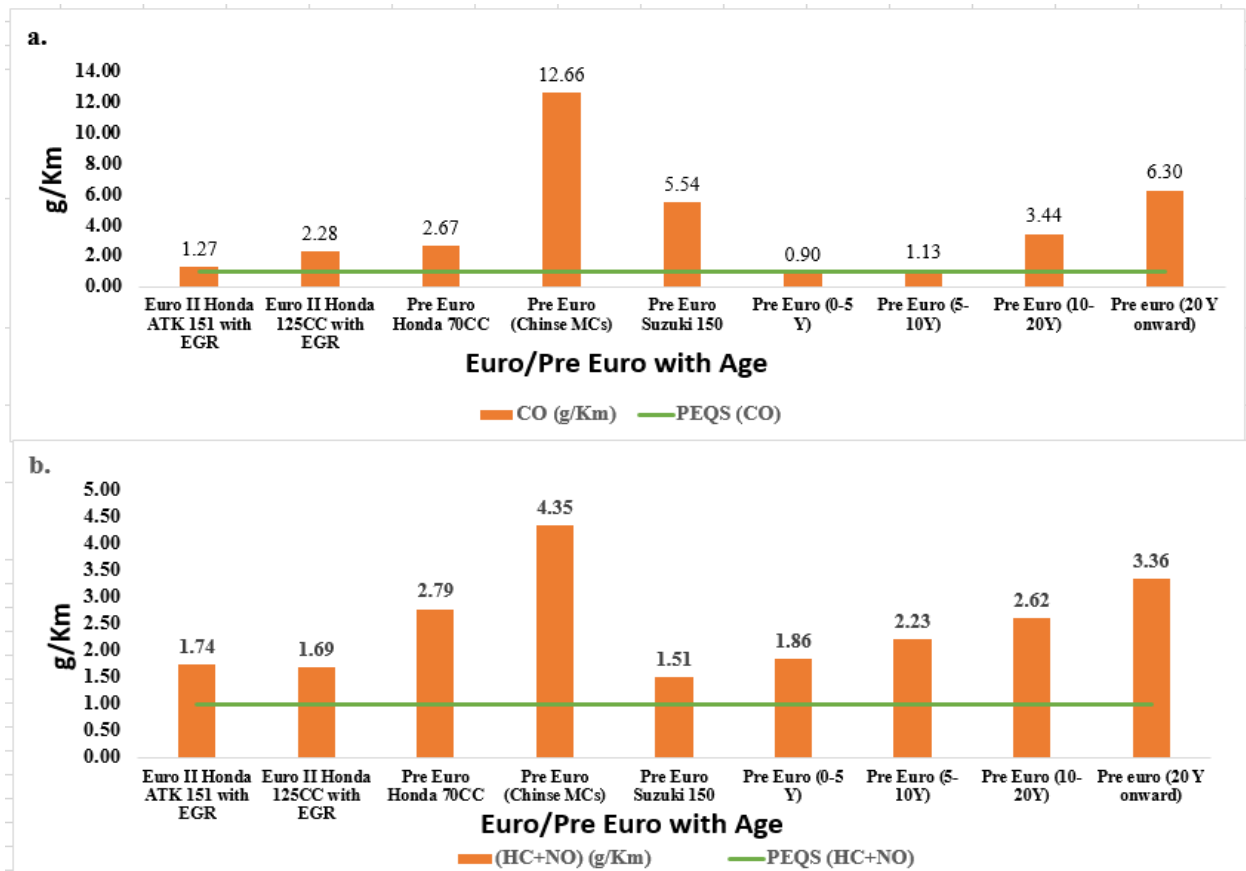


Figure 2: Comparison of Motorcycle emissions (a) CO emissions, (b) HC+NO emissions from Euro II and Pre Euro Motorcycles based on vehicle age

Car Emissions: The Figure3 presents car emissions in Lahore, categorized by emission standard (Euro IV, Euro II, and Pre-Euro) and further subdivided by age within the Pre-Euro category (presumably representing years since manufacture). Let's analyze the trends:

General Trend: The most striking observation is the clear correlation between vehicle age and emissions. As cars get older (moving down the table from Euro IV to older Pre-Euro categories), both HC+NO (Hydrocarbons + Nitrogen Oxides) and CO (Carbon Monoxide)

emissions increase significantly. This is a common trend globally, as older vehicles typically lack the advanced emission control technologies found in newer models.

Specific Observations:

- **Euro IV:** Cars meeting Euro IV standards exhibit the lowest emissions, with HC+NO at 0.025 g/km and CO at 0.260 g/km. This demonstrates the effectiveness of stricter emission standards in reducing pollution.

- **Euro II:** Euro II cars show a moderate increase in emissions compared to Euro IV, with HC+NO at 0.142 g/km and CO at 0.519 g/km. While higher than Euro IV, these levels are still considerably lower than the Pre-Euro categories.

- **Pre-Euro:** This category shows a dramatic increase in emissions with age.

- The "Pre-Euro (0)" category (presumably the newest of the Pre-Euro cars) has emissions significantly higher than Euro II.

- As we move to "Pre-Euro (5)," "Pre-Euro (10)," and "Pre-Euro (20)," the emissions escalate rapidly. The "Pre-Euro (20)" category shows extremely high levels of both HC+NO (0.852 g/km) and CO (33.058 g/km), far exceeding the PEQS (Punjab Environmental Quality Standards) for CO (2.2 g/km).

Comparison with PEQS: The PEQS provide a benchmark for acceptable emission levels. While Euro IV and Euro II cars comfortably meet these standards, the older Pre-Euro vehicles, especially those in the older age categories, significantly exceed the PEQS for CO. This highlights a critical issue: older vehicles are a major source of air pollution in Lahore.

Implications for Lahore's Air Quality: The data strongly suggests that phasing out older, highly polluting vehicles is crucial for improving air quality in Lahore. Implementing stricter vehicle emission standards, promoting newer and cleaner vehicles, and enforcing regular vehicle inspections are essential measures. Additionally, programs that incentivize the scrapping of older vehicles could be beneficial.

Possible Contributing Factors: Besides age and emission standards, other factors can influence vehicle emissions:

- **Vehicle Maintenance:** Poorly maintained vehicles, regardless of age, will emit more pollutants.

- **Fuel Quality:** Lower quality fuels can lead to increased emissions.

- **Driving Conditions:** Stop-and-go traffic, common in urban areas like Lahore, can increase emissions.

The data clearly indicates that older cars are a significant contributor to air pollution in Lahore. Implementing policies to promote cleaner vehicles and remove older, highly polluting ones is essential for improving air quality and public health.

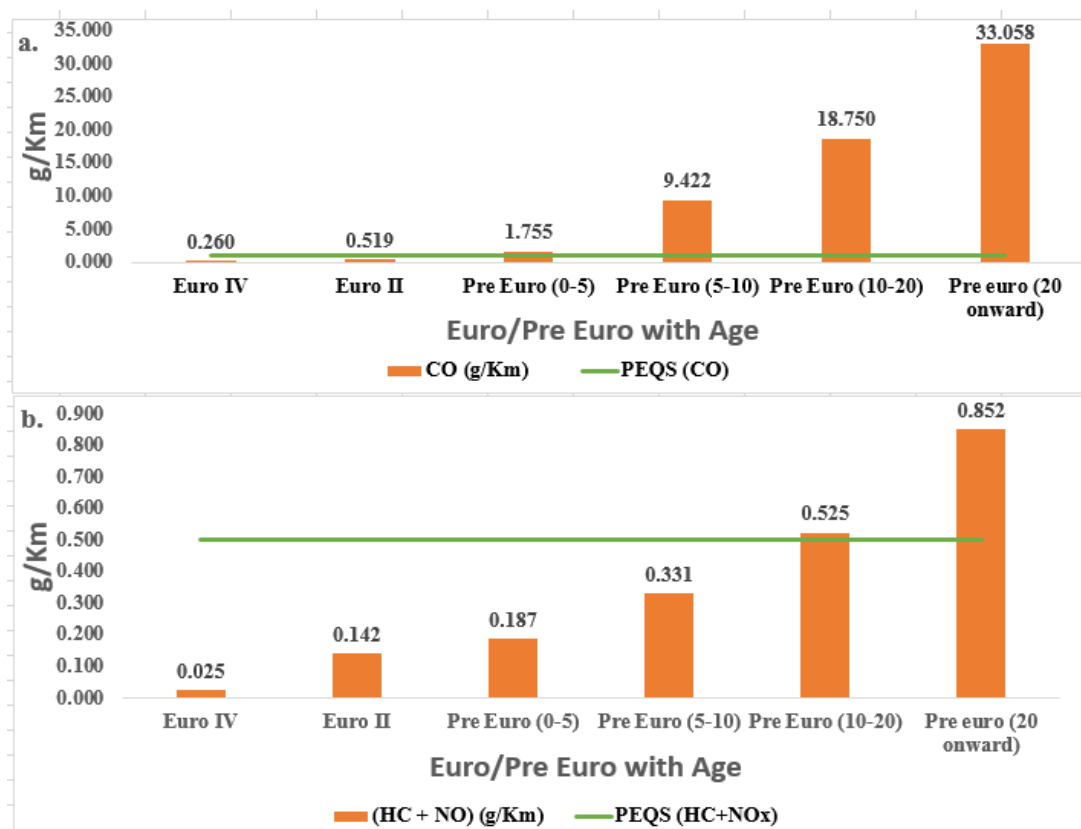


Figure 3: Comparison of car exhaust emissions (a) CO emissions, (b) (HC+NO) emissions from Euro IV, Euro II and Pre Euro vehicles

Conclusions

General Trends:

- **Age Matters:** For both cars and motorcycles, vehicle age is a strong predictor of emissions. Older vehicles, particularly those predating stricter emission standards (Pre-Euro), consistently exhibit significantly higher levels of CO, NO, and HC compared to newer models.
- **Emission Standards are Effective:** The data clearly demonstrates the positive impact of stricter emission standards like Euro II and Euro IV. Vehicles meeting these standards show substantially lower emissions compared to older, less regulated vehicles.

Specific to Cars:

- **Significant Improvement with Euro IV:** Cars meeting Euro IV standards show the lowest emissions, highlighting the effectiveness of these stricter regulations.
- **Older Cars Exceed Standards:** Pre-Euro cars, especially those in the older age categories (10+ years), significantly exceed the PEQS for CO, indicating a major source of pollution.

Specific to Motorcycles:

- **Similar Trend with Age:** Motorcycles follow a similar trend, with older models and those not meeting Euro II standards exhibiting higher emissions.
- **Need for Further Regulation:** While Euro II motorcycles show some improvement, there might be a need for even stricter standards and better enforcement to further reduce emissions from this vehicle category.

Overall Implications:

- **Targeting Older Vehicles:** Phasing out older, highly polluting vehicles (both cars and motorcycles) should be a priority for improving air quality. Scrappage schemes or incentives for upgrading to newer, cleaner vehicles could be effective strategies.
- **Enforcement of Standards:** Strict enforcement of existing emission standards and regular vehicle inspections are crucial to ensure compliance and identify high-emitting vehicles.
- **Promoting Cleaner Technologies:** Encouraging the adoption of cleaner vehicle technologies, such as hybrid or electric vehicles, can further reduce emissions in the long term.
- **Public Awareness:** Raising public awareness about the impact of vehicle emissions on air quality and promoting eco-friendly transportation choices can also contribute to reducing pollution.

In conclusion, the data underscores the need for a multi-pronged approach to address vehicular emissions, including stricter standards, enforcement, and promoting cleaner technologies, with a particular focus on targeting older, more polluting vehicles

Recommendations: Based on the conclusions about the significant contribution of vehicular emissions to air pollution and its associated health risks in Lahore, here are some recommendations:

Strengthening Vehicle Emission Standards and Enforcement:

- **Mandate stricter emission standards for new vehicles:** All new cars sold in Lahore should be required to meet at least **Euro IV emission** standards, and all new motorcycles should meet at least **Euro II standards**. This will ensure that newer vehicles entering the fleet are significantly cleaner.
- **Strict Standards for in-use Vehicles:** The 6% standard of CO for in-use vehicles may be reduced to 2.5% at least. Other standards should also be stricter for in-use vehicles. Smoke Opacity should be reduced from 40% to 20%.
- **Implement regular and rigorous vehicle emissions testing:** Establish and enforce a comprehensive vehicle inspection and maintenance program that includes regular emissions testing for all vehicles on the road. This will help identify and remove high-emitting vehicles from circulation.
- **Emission Control System:** emission control systems like Exhaust Gas Recirculation (EGR), catalytic converters etc must be installed in the vehicles to lower the pollutants level.

Phasing Out Older, High-Polluting Vehicles:

- **Implement scrappage schemes or incentives:** Introduce programs that incentivize the scrapping of older, pre-Euro vehicles and provide financial or other incentives for individuals to switch to newer, cleaner vehicles or alternative modes of transportation.
- **Restrict the use of older vehicles in certain areas:** Consider implementing restrictions on the use of older, high-polluting vehicles in designated areas of the city, such as city centers or highly polluted zones.

Promoting Cleaner Transportation Alternatives:

- **Invest in public transportation:** Improve and expand public transportation systems, such as bus rapid transit (BRT) systems, metro lines, and efficient public buses, to provide viable alternatives to private vehicle use.

- **Promote non-motorized transportation:** Develop infrastructure to support cycling and walking, such as dedicated bike lanes and pedestrian walkways, to encourage active transportation.
- **Incentivize the adoption of electric and hybrid vehicles:** Provide financial incentives, such as tax breaks or subsidies, to encourage the purchase and use of electric and hybrid vehicles.

Acknowledgement: The authors gratefully acknowledge the invaluable contributions of several individuals and organizations to this research. We extend our sincere gratitude to Muhammad Gill from Toyota Garden Motors, Ferozepure Road, Lahore, for generously providing vehicles for testing and for his valuable insights and expertise. We also express our deep appreciation to Mr. Umair Rasheed, Mr. Iftexhar Ahmad, and Mr. Adil Javed from Pak Green Enviro-Engineering Lab, Lahore, for their cooperation and technical assistance in conducting the car and motorcycle emissions testing.

REFERENCES

- Afzal, M., Rashid, A., & Farooq, M. (2020). Assessment of vehicular emissions and their impact on urban air quality: A case study of Lahore, Pakistan. *Journal of Environmental Management*, 270, 110915.
- Alam, K., Blaschke, T., & Mukhtar, A. (2007). Modeling urban air pollution in Lahore, Pakistan. *Environmental Modelling & Software*, 22(5), 654-665.
- Chevalier technologies, (2017). Calculation-1-Chevalier-Single-Motor-Latch-CO2-Emission
<https://chevalier technologies.com/wp-content/uploads/2017/12/Calculation-1-Chevalier-Single-Motor-Latch-CO2-Emission.pdf>
- Colville, R. N., Hutchinson, E. J., Stedman, J. R., & Carslaw, D. C. (2001). The transport sector as a source of air pollution. *Atmospheric Environment*, 35(9), 1537-1565.
- FAO. (2019). Emission Factors for Greenhouse Gas Inventories: 2006 Refinements
- Ghauri, B. M., Lodhi, G. M., & Qureshi, A. H. (2017). Vehicular emissions and their impact on air quality of Lahore city. *Pakistan Journal of Engineering and Applied Sciences*, 20, 1-10.
- Harrison, R. M., Beddows, D. C. S., & Dall'Osto, M. (2021). PM_{2.5} in the atmosphere: Recent trends and its chemical composition. *Atmospheric Environment*, 244, 117864.
- Hussain, S., Khan, M. I., & Shah, M. T. (2013). Assessment of vehicular emissions and their impact on urban air quality of Peshawar city, Pakistan. *Atmospheric Environment*, 70, 371-381.
- Urban Unit Lahore. (2023). Lahore Climate Action Plan. [Source: Local Government Report]
- Landrigan, P. J., Fuller, R., Fisher, S., Suk, W. A., Sly, P., & Carpenter, D. O. (2018). Pollution and global health. *Annals of Global Health*, 84(1), 1-3.
- Lawrence, M. G., Lelieveld, J., & Spracklen, D. V. (2022). Global atmospheric chemistry and its influence on climate. *Philosophical Transactions of the Royal Society A*, 380(2218), 20210314.
- Nadeem, M., Hussain, S., & Shah, M. T. (2021). Spatio-temporal assessment of air quality and associated health risks in Lahore, Pakistan. *Environmental Pollution*, 286, 117534
- WHO. (2021). *WHO global air quality guidelines: particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization.