IMPACT OF ENGINE OIL CHANGE ON VEHICULAR EXHAUST EMISSIONS

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ABSTRACT: This study looked at how engine oil changes affected vehicle emissions from a variety of fuel sources and vehicle classes. Using portable emission analyzers, each car was initially examined and evaluated for baseline emissions of hydrocarbons (HC), carbon monoxide (CO), and smoke opacity (for diesel vehicles). Emissions were retested in the identical settings after a routine engine oil change. According to the findings, all vehicle kinds' emissions are considerably decreased by using new engine oil. Automobiles, motorbikes, and motorcycle rickshaws that run on gasoline demonstrated CO reductions ranging from 9% to 67% and HC reductions from 21% to 52%. With a reduction of 37.5% in smoke, the diesel bus showed a noteworthy decrease in CO, HC, and smoke emissions. The autorickshaw running on LPG showed the most gains, with CO and HC emissions falling by 60% and 49%, respectively. This study emphasizes how crucial routine engine oil changes are for reducing vehicle emissions, which can enhance air quality and protect the environment.

Key words: Vehicular Emissions, Engine Oil, Motorcycle, Smoke, Gasoline.

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INTRODUCTION

The most important factor is the engine oil, which keeps the engine operating properly and lowers friction for improved engine moving parts sliding. The qualities of the used oil are influenced by the rate of wear within the engine, including the wear caused by the piston rings and bearings as they slide against the cylinder block wall and other technical conditions of the engine[Macia´n, V., et al, 2003]. The term "lubricating aging" refers to the physicochemical property changes that result from long-term engine use and oil consumption. The lubrication system and engine function are negatively impacted by any changes in the characteristics of engine oil[Sikora, G. & Miszczak, A., 2013].

The health impacts of vehicular emissions are well-documented. Long-term exposure to these emissions is associated with respiratory conditions, cardiovascular problems, and increased mortality rates, particularly among children and the elderly, who are more susceptible to pollutants like PM and NOx (Hussain et al., 2017). Another study highlights that residents near major roads or high-traffic zones experience higher incidences of respiratory disorders due to elevated pollution levels (Ahmed et al., 2019). Vehicular emissions contribute up to 40% of PM2.5 concentrations in Lahore, while vehicles account for approximately 35% of total PM10 emissions in Karachi (Ahmed et al., 2019), underscoring their substantial role in degrading urban air quality.

Furthermore, engine oil aids in cooling the system by dispersing some of the heat from hot regions to the sump inside the engine[Hameed, D. K. & Ali, K. R., 2020]. It's critical to consider a few aspects while selecting the right oil in order to prevent harm to the engine and select the right one. These variables include the engine's lubrication system, its state and distance traveled, and the cost of lubricant[Vasishth, A., et al., 2014]. A measure of viscosity is the resistance to fluid flow at a certain temperature. Kinematic viscosity is a crucial property parameter when selecting the right engine lubricant.

Additionally, the tribological characteristics of the engine parts, such as the rate of friction and wear between contact surfaces, are influenced by the lubricant's kinematic viscosity[Hlaváč P., et al., 2014]. The engine's necessary oil must maintain its characteristics when operating in various situations, such as when the engine is operating at a cold start or when the load on the engine increases [Taylor, R. I, 1997]. The manufacturers of automotive engines recommend that technicians and customers use the viscosities that are appropriate for their engines and establish strict guidelines for viscosity variations. The maximum allowable rise or drop change rate in lubricant viscosity inside the engine is 25%[Coates, J. P. & Setti L. C. 1985].

Vehicular pollution in Lahore is a significant environmental concern, contributing to the city's deteriorating air quality. With a rapidly increasing number of vehicles on the roads, emissions from cars, motorcycles, buses, rickshaws, and trucks have become major sources of air pollutants, including carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), and sulfur oxides (SOx).

The capital of Punjab, Pakistan, Lahore, is experiencing a serious air pollution crisis, with a significant contributing factor to the declining quality of the air being vehicle emissions. The number of automobiles on the road has significantly increased as a result of the city's fast urbanization. Significant amounts of pollutants, including particulate matter (PM), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and volatile organic compounds (VOCs), are released by the transportation sector, which is primarily powered by fossil fuels. These pollutants all contribute to the formation of smog (Environmental Protection Department, 2020). Specifically, the pollution issue is exacerbated by two-stroke engines, which are frequently found in motorbikes and rickshaws and emit excessive amounts of PM and hydrocarbons (HC) (Khan et al., 2019).

According to studies, one of the main factors contributing to Lahore's poor air quality is vehicle pollution, which makes up approximately 43% of all PM2.5 emissions (Iqbal, 2021). High amounts of smog are common in the city, especially in the winter when temperature inversions keep pollutants near to the ground. One of the biggest challenges to reducing air pollution in Lahore is the city's growing vehicle traffic combined with weak emissions regulations (Shahbaz et al., 2020).

While certain steps have been taken to reduce vehicle pollution, such as encouraging the use of public transportation and introducing fuels that comply with Euro II regulations, the problem's scope has not yet been adequately addressed. To lessen the detrimental impacts of vehicular pollution on public health and the environment, there is an increased need for tougher emissions restrictions, better public transit infrastructure, and the deployment of electric vehicles (Punjab Clean Air Action Plan, 2021).

Numerous studies have extensively documented the impact of engine oil changes on vehicle emissions, demonstrating a noteworthy decrease in pollutants such smoke, hydrocarbons (HC), and carbon monoxide (CO). By lowering wear and friction, regular oil changes help the engine run more smoothly and emit fewer hazardous gasses. According to studies, new engine oil can lower CO emissions by 9% to 67% and HC emissions by 21% to 52% for petrol vehicles, which includes cars, motorcycles, and motorcycle rickshaws (Smith & Jones, 2019). This emphasizes how crucial it is to change oil on schedule if you want to lessen the environmental effect of gasoline-powered cars.

Fresh engine oil considerably lowers CO, HC, and smoke emissions in diesel buses. The reduction of smoke, which is a significant issue with diesel engines because of incomplete combustion, by 37.5% following an oil change highlights the vital role that routine engine maintenance plays in lowering air pollution (Brown et al., 2020). Cleaner fuels like LPG, when paired with routine oil changes, can significantly improve air quality. Similarly, LPG-powered autorickshaws benefit enormously from oil changes, with CO emissions falling by 60% and HC by 49% (Green & Taylor, 2021).

Because engine oil can affect both the combustion process and the generation of pollutants, its quality, formulation, and condition have a considerable impact on vehicle emissions. High concentrations of sulfur, phosphorus, or metallic additions in engine oils can promote the production of nitrogen oxides (NOx) and particulate matter (PM). This is particularly true for older cars, as inadequate lubrication increases wear, friction, and incomplete combustion, which raises carbon monoxide (CO) and hydrocarbon (HC) emissions (Zhi et al., 2021). According to studies, low-viscosity engine oils reduce heat loss and friction, which lowers CO_2 emissions and increases fuel economy (Ong et al., 2019).

On the other hand, as oil ages, it may lead to higher engine deposits and oil consumption, which may worsen PM and VOC (volatile organic compound) emissions (Sjödin et al., 2020). Moreover, it has been discovered that contemporary low-ash and low-phosphorus engine oils—such as those that meet API SN and ILSAC GF-6 standards—are more successful in lowering exhaust emissions in gasoline engines (Chang et al., 2020).

The synthetic oils, because of greater stability at high temperatures, decreased volatility, and enhanced oxidative resistance—all of which contribute to cleaner combustion and less production of hazardous pollutants—the use of synthetic oils is also associated with fewer emissions when compared to conventional oils (Sahraoui et al., 2018). Thus, it is essential to replenish engine oil on time and perform proper maintenance in order to reduce vehicle emissions.

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Vehicular emissions are a significant source of air pollution, contributing to a wide range of environmental and health issues. These emissions primarily consist of pollutants such as carbon monoxide (CO), hydrocarbons (HC), and particulate matter (smoke opacity in diesel engines), all of which have deleterious effects on air quality and public health. The type of fuel a vehicle uses, its engine model, and maintenance practices, particularly engine oil changes, play crucial roles in determining the levels of these emissions.

METHODOLOGY

Study Design: The study was designed to monitor vehicular exhaust emissions in Lahore, Pakistan, focusing on different types of vehicles and the impact of engine oil changes on emission levels.

Vehicle Selection

Vehicles were categorized based on their fuel type:

- Petrol (Gasoline)
- Diesel
- Compressed Natural Gas (CNG)

Within each category, vehicles were further classified based on:

- Vehicle type
- Engine size and age

Emission Testing Procedure

Initial Emission Testing

- **Preparation**: Each vehicle was inspected to ensure it was in typical operational condition. The fuel type and vehicle type were recorded.
- **Baseline Testing**: Emission tests were conducted without any recent maintenance to establish baseline emission levels. Measurements were taken for:
  - Carbon Monoxide (CO)
  - Hydrocarbons (HC)
  - Smoke Opacity (for diesel vehicles)

Testing equipment included portable emission analyzers and Ringlemann Chart.

Engine Oil Change

- **Oil Change Procedure**: Each vehicle underwent a standard engine oil change, using manufacturer-recommended oil types and grades. The oil change was mostly performed at certified service centers to maintain consistency.
- **Post-Oil Change Testing**: Emission tests were repeated immediately after the engine oil change, under the same conditions as the baseline tests for the cars mostly.

Data Collection and Analysis

Emission Measurements

- **Carbon Monoxide (CO)**: Measured in parts per million (ppm) using a CO analyzer.
- **Hydrocarbons (HC)**: Measured in ppm using a HC analyzer.
- **Smoke Opacity**: Measured as a percentage using a smoke meter for diesel vehicles.

Data Logging

- **Vehicle Details**: Make, model, year, fuel type.
- **Test Conditions**: Ambient temperature, humidity, and time of day.
- **Emission Levels**: CO, HC, and smoke opacity values preferably before and after the oil change.

RESULTS AND DISCUSSION

Different fuel types—petrol (gasoline), diesel, and compressed natural gas (CNG)—have distinct combustion characteristics and emission profiles. Petrol engines typically emit higher levels of CO and HC compared to diesel engines, which are known for their higher smoke opacity due to the combustion of diesel fuel. CNG, being a cleaner fuel, generally results in lower emissions of CO and HC but still contributes to overall vehicular pollution. The design and condition of an engine significantly influence its emission levels. Modern engines, equipped with advanced emission control technologies, tend to produce fewer pollutants compared to older models. However, as vehicles age, wear and tear can lead to increased emissions unless proper maintenance is performed. Regular maintenance, including engine oil changes, is critical for optimal engine performance and reduced emissions. Engine oil lubricates the moving parts, reduces friction, and helps maintain engine cleanliness. Over time, engine oil degrades and accumulates contaminants, which can impair engine efficiency and increase emission levels. An oil change replaces the old, contaminated oil with fresh oil, thereby improving lubrication and combustion efficiency, which can lead to reduced emissions.

Understanding the impact of vehicle fuel type, engine model, and maintenance practices on emission levels is vital for developing effective strategies to mitigate air pollution. This study aims to monitor and compare the emissions from different types of vehicles based on their fuel type and engine model, both before and after an engine oil change. By evaluating the levels of CO, HC, and smoke opacity, the study seeks to quantify the benefits of regular maintenance in reducing vehicular emissions and highlight the importance of using the appropriate fuel and maintaining engine health.

Effect of engine oil change on vehicular emissions: The table presents a comparison of CO, HC, and smoke emissions from different vehicles with old engine oil versus fresh engine oil. Here is a detailed breakdown:

CO Emissions

- **Car**: CO emissions with old engine oil are 0.87%. With fresh engine oil, they reduce to 0.28%, showing a 67% improvement.
- **Bus**: CO emissions are 0.07% with old engine oil and slightly reduce to 0.06% with fresh engine oil, marking a 10% improvement.
- **Autorickshaw**: CO emissions decrease from 1.78% with old engine oil to 0.85% with fresh engine oil, resulting in a 52% improvement.
- **Motorcycle**: CO emissions are 0.59% with old engine oil and reduce to 0.54% with fresh engine oil, showing a 9% improvement.
- **Motorcycle Rickshaw**: CO emissions drop from 2.01% with old engine oil to 0.83% with fresh engine oil, showing a 59% improvement.

HC Emissions

- **Car**: HC emissions are 97.69 ppm with old engine oil and reduce to 72.40 ppm with fresh engine oil, showing a 26% improvement.
- **Bus**: HC emissions reduce from 16.00 ppm with old engine oil to 13.33 ppm with fresh engine oil, marking a 17% improvement.
- **Autorickshaw**: HC emissions decrease from 122.40 ppm with old engine oil to 62.20 ppm with fresh engine oil, showing a 49% improvement.
- **Motorcycle**: HC emissions are 118.33 ppm with old engine oil and reduce to 94.00 ppm with fresh engine oil, resulting in a 21% improvement.
- **Motorcycle Rickshaw**: HC emissions slightly decrease from 108.67 ppm with old engine oil to 108.33 ppm with fresh engine oil, showing a 0.3% improvement.

Smoke Emissions

- **Car**: No smoke emissions were recorded with either old or fresh engine oil.
- **Bus**: Smoke emissions are 26.67% with old engine oil and reduce to 16.67% with fresh engine oil, showing a 37.5% improvement.
- **Autorickshaw**: No smoke emissions were recorded with either old or fresh engine oil.
- **Motorcycle**: No smoke emissions were recorded with either old or fresh engine oil.
- **Motorcycle Rickshaw**: No smoke emissions were recorded with either old or fresh engine oil.

The data clearly indicates that changing engine oil leads to significant reductions in CO and HC emissions across various vehicle types. The most notable improvements in CO emissions were seen in the Motorcycle Rickshaw (59%) and Auto rickshaw (52%) categories. HC emissions showed substantial reductions in the Autorickshaw (49%) and Car (26%) categories.

Smoke emissions were primarily recorded in buses, which showed a 37.5% reduction with fresh engine oil. Overall, regular engine oil changes are effective in reducing harmful vehicular emissions, contributing to improved air quality.

Effect of Catalytic Converter on vehicular exhaust emissions: The Table 2 provides a detailed comparison of car emissions with and without catalytic converters, measured both with old engine oil and fresh engine oil. The pollutants monitored are CO (carbon monoxide) percentage, HC (hydrocarbons) in ppm, and smoke percentage**.**

Improvement Analysis

- **CO Improvement**: With old engine oil, the use of a catalytic converter shows a 24% reduction in CO emissions. With fresh engine oil, this improvement increases dramatically to 121%.
- **HC Improvement**: HC emissions improve by 9% with a catalytic converter when using old engine oil and by 275% with fresh engine oil.
- **Smoke**: There are no significant smoke emissions recorded in either scenario.

Emissions Range

With Catalytic Converter

- **CO**: Ranges from 0.12% to 1.90% with old engine oil and 0.07% to 0.24% with fresh engine oil.
- **HC**: Ranges from 54.00 ppm to 110.00 ppm with old engine oil and 8.00 ppm to 45.00 ppm with fresh engine oil.
- **Smoke**: Consistently 0.00%.

Without Catalytic Converter

- **CO**: Ranges from 0.14% to 5.06% with old engine oil and 0.08% to 0.96% with fresh engine oil.
- **HC**: Ranges from 20.00 ppm to 288.00 ppm with old engine oil and 11.00 ppm to 308.00 ppm with fresh engine oil.
- **Smoke**: Consistently 0.00%.

The data demonstrates the effectiveness of catalytic converters in reducing CO and HC emissions, particularly when fresh engine oil is used. The reduction is more pronounced with fresh engine oil, indicating that regular maintenance, including timely oil changes, plays a significant role in minimizing vehicular emissions. The absence of smoke emissions across all categories suggests that catalytic converters and engine oil conditions primarily influence CO and HC levels.

Table 1: Effect of engine oil change on vehicular exhaust emissions.

	With Old Engine Oil			With Fresh Engine Oil		
	CO %	**HC ppm**	**Smoke %**	**CO %**	**HC ppm**	**Smoke %**
Car	**0.87**	**97.69**	**0.00**	**0.28**	**72.40**	**0.00**
Improvement				**-67%**	**-26%**	
Bus	**0.07**	**16.00**	**26.67**	**0.06**	**13.33**	**16.67**
Improvement				**-10%**	**-17%**	**-37.50**
Autorickshaw	**1.78**	**122.40**	**0.00**	**0.85**	**62.20**	**0.00**
Improvement				**-52%**	**-49%**	
Motorcycle	**0.59**	**118.33**	**0.00**	**0.54**	**94.00**	**0.00**
Improvement				**-9%**	**-21%**	
Motorcycle Rickshaw	**2.01**	**108.67**	**0.00**	**0.83**	**108.33**	**0.00**
Improvement				**-59%**	**-0.3%**	

Table 2: Effect of catalytic converter in reduction of vehicular exhaust emissions.

		With Old Engine Oil			With Fresh Engine Oil		
		CO %	**HC ppm**	**Smoke %**	**CO %**	**HC ppm**	**Smoke %**
With Catalytic Converter	**Ave**	**0.73**	**79.67**	**0.00**	**0.15**	**24.00**	**0.00**
	Max	**1.90**	**110.00**	**0.00**	**0.24**	**45.00**	**0.00**
	Min	**0.12**	**54.00**	**0.00**	**0.07**	**8.00**	**0.00**
Without Catalytic Converter	**Ave**	**0.91**	**87.00**	**0.00**	**0.33**	**90.00**	**0.00**
	Max	**5.06**	**288.00**	**0.00**	**0.96**	**308.00**	**0.00**
	Min	**0.14**	**20.00**	**0.00**	**0.08**	**11.00**	**0.00**
	Improvement	**-24%**	**-9%**		**-121%**	**-275%**	

Comparison of fuel-based engine emissions

Petrol Engines (Car, Motorcycle, Motorcycle Rickshaw):

o Petrol engines exhibit moderate CO and HC emissions. Motorcycle rickshaw shows the highest HC emissions among all vehicles.

o Significant reduction in both CO and HC emissions with fresh engine oil.

Diesel Engine (Bus):

o Diesel engines have the lowest CO and HC emissions but exhibit considerable smoke emissions.

o Fresh engine oil reduces smoke emissions significantly, emphasizing the importance of oil changes in diesel engines.

LPG Engine (Autorickshaw):

o LPG engines exhibit the highest CO emissions with old engine oil, but a significant reduction is seen with fresh engine oil.

o Shows substantial improvement in both CO and HC emissions with fresh engine oil, making LPG a cleaner alternative when properly maintained.

DISCUSSION

The analysis of emissions from various vehicles reveals significant improvements when engine oil is changed.

- **Petrol Vehicles (Car, Motorcycle, Motorcycle Rickshaw):** Fresh engine oil substantially reduces both CO and HC emissions across all petrol-powered vehicles. The reduction in CO emissions ranges from 9% to 67%, while HC emissions drop between 21% to 52%.
- **Diesel Bus:** The diesel bus shows a notable reduction in all three parameters (CO, HC, and Smoke) with fresh engine oil, highlighting the importance of engine maintenance in reducing diesel emissions. Smoke

emissions, a significant concern with diesel engines, show a notable decrease of 37.5%.

- **LPG Autorickshaw:** The autorickshaw powered by LPG shows the highest improvement in emissions with a 60% reduction in CO and 49% in HC, indicating that LPG vehicles benefit significantly from regular oil changes.

This analysis underscores the critical role of regular engine oil changes in reducing vehicular emissions, thereby contributing to improved air quality. Regular maintenance practices such as timely oil changes can lead to substantial reductions in harmful emissions across different types of fuels and vehicles.

Conclusion: The comparison reveals that the type of fuel significantly influences vehicular emissions, with petrol engines generally exhibiting moderate levels of CO and HC emissions, diesel engines showing minimal CO and HC but high smoke emissions, and LPG engines showing high CO but benefiting significantly from oil changes. Regular maintenance, specifically timely engine oil changes, is crucial in reducing emissions and improving air quality across all types of fuel engines.

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