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# Assessment of Smoke Emission by Diesel Light Passenger Vehicles in Gwalior City, India

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***Abstract***

*The number of vehicles on the highways in Gwalior, a growing city in central India, has been increasing. Most of these vehicles run on diesel, which has led to higher pollution levels. The smoke from diesel vehicles has become a major problem, affecting both the air we breathe and people's health. Emission's control has become the major driving force in the development of diesel engines, because the use of conventional fossil fuels can cause climate changes, which might lead to ecological disasters in certain areas. In recent years, various methods have been adopted to meet the increasingly stringent exhaust emission standards of vehicles. Improving diesel engines has made reducing emissions a top priority because burning of fossil fuels damages the environment and drives climate change. The production of toxic gases from fossil fuels, such as carbon dioxide ($CO_2$) and particulate matter (PM), harms the environment and our health. Vehicle exhaust has long been considered a significant source of anthropogenic particulate matter (PM) emissions. Particulate matter emissions from diesel engines have been shown to be harmful to both the environment and human health. For many years, lowering these emissions has been a top scientific focus and a cause of regulatory concern. Hence, the smoke emission was analyzed for the different diesel vehicles in Gwalior City.*

**Keywords:** Emission, smoke, diesel vehicle, particulate matter, human health, $CO_2$

## INTRODUCTION

The diesel engine is the most efficient type of power source among all types of internal combustion engines. Today, emission's control has become the major driving force in the development of diesel engines, because the use of conventional fossil fuels can cause climate changes, which might lead to ecological disasters in certain areas. In recent years, various methods have been adopted to meet the increasingly stringent exhaust emission standards of vehicles [1]. Vehicle exhaust has long been considered a significant source of anthropogenic particulate matter (PM) emissions [2, 3]. Particulate matter emissions from diesel engines have been shown to be harmful to both the environment and human health. For many years, lowering these emissions has been a top scientific focus and a cause of regulatory concern. Engine particulate is made up of accumulated organic matter that has been converted from the gas phase and carbonaceous soot, which is the product of fuel pyrolysis that occurs in the combustion chamber's fuel-rich, high-temperature areas. Even if total particulate mass or particle size is currently a controlled emission from automobiles, carbonaceous soot measurement on its own serves as a valuable indicator of engine combustion quality for scientific investigations [4]. Understanding the importance of estimation of the

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smoke emission by diesel engine, the current study was conducted. This will help to enable us to see where the current smoke emission of diesel vehicles stands.

## LITERATURE SURVEY

Giechaskiel *et al*. looked at how the ways of measuring vehicle exhaust emissions have changed over the years [5]. They focused on the latest tools used to measure the tiny particles in exhaust, such as filters, chemical analysis of those filters, and devices that detect light changes or measure exhaust particles electrically. The paper also compares how these tools work together, especially with the stricter emission standards being introduced. Finally, the review talks about what new tools and methods will be needed in the future to measure emissions from current and future vehicles.

The impact of adding Multi-Wall Carbon Nanotubes (MWCNTs) to biodiesel on engine performance and emissions was examined in a study by Ghafoori *et al*. A 20% biodiesel and 80% diesel mix (B20) were created by blending biodiesel, which was produced from leftover vegetable oil [6]. Using a unique technique, MWCNTs were added in small volumes to the biodiesel.

According to the findings, the gasoline containing MWCNTs performed better than either conventional diesel or biodiesel. Fuel consumption decreased by nearly 39%, but the engine's power and torque improved by 17 and 18%, respectively. Hazardous hydrocarbons (HC) and carbon monoxide (CO) emissions both decreased by 22 and 14%, respectively.

A study conducted by Prabu investigated a single-cylinder diesel engine's emissions, combustion, and performance using various fuel blends [7]. Three fuel types were the subject of the study: biodiesel with diesel mixed with it (B20), biodiesel with diesel and nanoparticles (B20A30C30), and biodiesel with nanoparticles only (B100A30C30). To guarantee equal mixing, the nanoparticles, alumina ($Al_2O_3$) and cerium oxide ($CeO_2$), were introduced to the fuel mixes at a concentration of 30 ppm using an ultrasonicator. To shed light on how to make diesel engines more ecologically friendly and efficient, the study sought to determine how the addition of nanoparticles affected engine performance and decreased emissions.

In a study by Rahim *et al*., they investigated how temperature affects the performance of diesel engines running on a 5% biodiesel blend [8]. Using a computer simulation, they modeled a four-cylinder diesel engine to observe how the engine performed when using this alternative fuel. The study provides useful insights into how temperature can influence the efficiency and emissions of the engine when biodiesel is used, helping to better understand the benefits and challenges of using biodiesel as a fuel option for diesel engines.

In their study, Basha and Anand examined the effects of various fuel blends on a diesel engine's operational efficiency and emissions [9]. Biodiesel, biodiesel combined with alumina nanoparticles, and jatropha biodiesel emulsion fuel: a mixture of 93% biodiesel, 2% surfactants, and 5% water, were all put to the test. At 25 and 50 ppm, nanoparticles were introduced.

The findings demonstrated that, in comparison to conventional biodiesel, the use of nanoparticles in the biodiesel emulsion enhanced engine performance and decreased hazardous emissions. For instance, the engine's Brake Thermal Efficiency (BTE) was 29% when using the fuel combined with nanoparticles at full load, while it was 24.9% when using ordinary biodiesel. Due to more efficient combustion, the gasoline containing nanoparticles had somewhat higher greenhouse gas emissions (such as $CO_2$). According to the research, incorporating nanoparticles into biodiesel can lower pollutants and increase engine performance.

A survey of the literature on smart cities emphasizes the concept of creating cities that offer smart solutions, a clean environment, a good quality of life, and necessary infrastructure. To increase the

 

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lifespan of old and trash cars and make them fit for use in smart cities in India and throughout the world, Singh *et al*. suggest renovating them [10]. The objective is to make effective use of the resources at hand, cut down on waste, and minimize pollution; all of which support the creation of ecologically responsible and sustainable smart cities.

Air pollution has worsened as Gwalior city expands rapidly, and traffic congestion intensifies. In addition to fine particulate matter, harmful chemicals such as sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_x$) have become more prevalent in the atmosphere. $SO_2$ levels were monitored using specialized air monitoring equipment (Envirotech APM 415 and 411) at four different locations throughout the city to track this pollution.

Ahmad and Sharma conducted a study between November 2013 and May 2014 to investigate how vehicular pollution affects the health of people aged 10 to 60 years in Gwalior [11]. The main goal was to measure the levels of vehicle emissions in the city and understand their effects on people's health.

This literature survey reviews earlier research on the increasing problem of air pollution in cities and highlights the need for more studies to explore the health risks caused by vehicle emissions.

## METHODOLOGY

### Study area

The study was conducted in the city of Gwalior. Gwalior is a historic city situated in Madhya Pradesh, India. The study site has been given Figure 1 indicating the route taken by light passenger vehicles. This route is a route with one of the heaviest traffic in the city.

### Sampling

The smoke emission sampling was done with the help of a modified form of Bosch type smoke meter. The smoke from the vehicle was allowed to be deposited on a filter paper attached to the Smoke meter. It was ensured that the vehicle was warmed up before the sampling was initiated. The smoke deposited on the filter paper was compared to the smoke evaluation chart based on the color or the darkness of the smoke color and the nearest reading on the smoke evaluation chart in Hart ridge smoke unit (HSU) was recorded. The chart contains the smoke level in different code units. In the Smoke evaluation chart, each 4 units in the chart is equivalent to 64 Hart ridge smoke unit (HSU).


**Figure 1.** Route taken by the light passenger diesel vehicles.
*(Source: Google earth)*

**RESULTS**

In the present study of smoke emission from small passenger diesel vehicle plying in Gwalior City, a total of 100 vehicles were monitored for the smoke emission with the help of a smoke meter with which smoke emitted were deposited on filter paper and the smoke deposited was compared to the smoke evaluation chart. The chart indicated the smoke level in different code units which was then calculated as 4 units in the chart was equivalent to 64 Hart ridge smoke units (HSU). The different code units as indicated by the different vehicles and their calculated emission values are indicated in Table 1. The data collected indicated that the vehicles showed a wide range emission covering from 3 to 9.5 in the reference chart. The study indicated that 9% of the vehicles emitted smoke of 9.5 units as per the smoke evaluation chart, 11% emitted 9 units, 13% emitted 8 units, 18% emitted 7 units, 17% emitted 6 units, 16% emitted 5 units, 11% emitted 4 units and 5% emitted 3 units (Figure 2). The corresponding emissions in HSU to the code units of the smoke evaluation chart of the vehicles are also given in Figure 3.

The study revealed that 79% of the vehicles were found to belong to the vehicle registration group of 2006–2010 which at the time of the study were 8 to 12 years old. 20% belong to 2011–2015 which were 3 to 7 years old and 1% belonging to 1986–1990 which was 18 to 22 years old and there were no vehicles in service for the groups of 1991–1995, 1996–2000 and 2001–2005 (Figure 4). The Semi Inter Quartile Range of the data revealed that the vehicle group with registrations from 2006–2010 contributed the highest in terms of emission as compared to other groups (Figure 5). To account for variations in the number of vehicles across different areas and eliminate any bias caused by these differences, the first quartile (Q1) and third quartile (Q3) were excluded from the analysis. This approach helps ensure a more accurate and unbiased representation of the data. This helps in analysis of only the range of the emission value and not considers the number of values.

The carbon particulates (mg/m$^3$) and Opacity in Filter Smoke Number (FSN) were also calculated using the conversion chart [5]. The graph of Carbon particulates and Opacity with reference to the emission of the vehicles in HSU indicated that with the increase in the emission of the vehicle, the carbon particulates (mg/m$^3$) increases, and the same trend is followed by Opacity (FSN) as shown in Figure 6.

**Table 1.** Emission of different vehicles with their Code units.

| No. of vehicles | Code unit | Emission (HSU) |
|---|---|---|
| 9 | 9.5 | 154.375 |
| 11 | 9 | 146.25 |
| 13 | 8 | 130 |
| 18 | 7 | 113.75 |
| 17 | 6 | 97.5 |
| 16 | 5 | 81.25 |
| 11 | 4 | 65 |
| 5 | 3 | 48.75 |

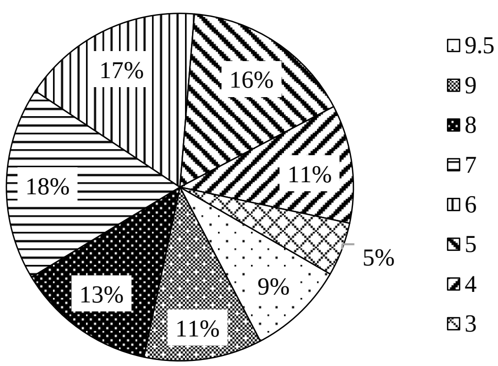


**Figure 2.** Percentage of vehicles and their emission.

 

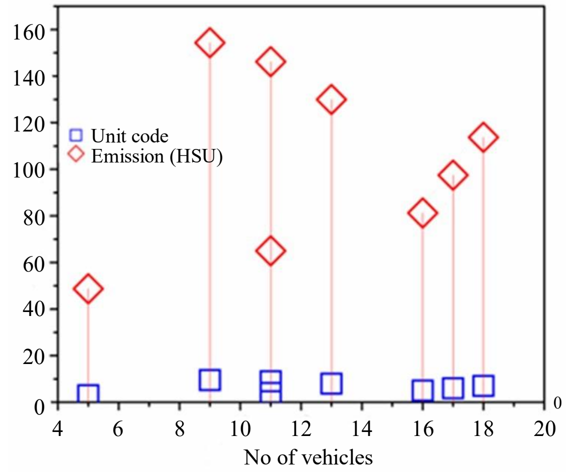


**Figure 3.** Emission code units and their emission.

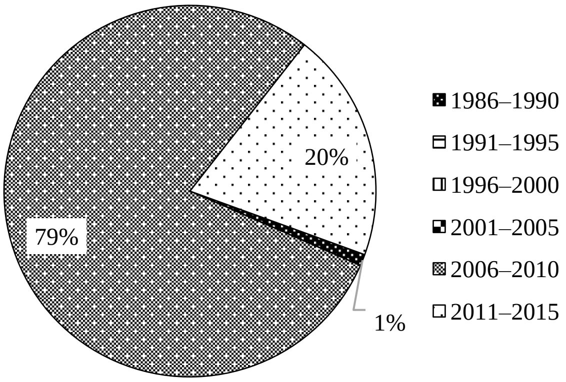


**Figure 4.** Vehicles and their registration group.

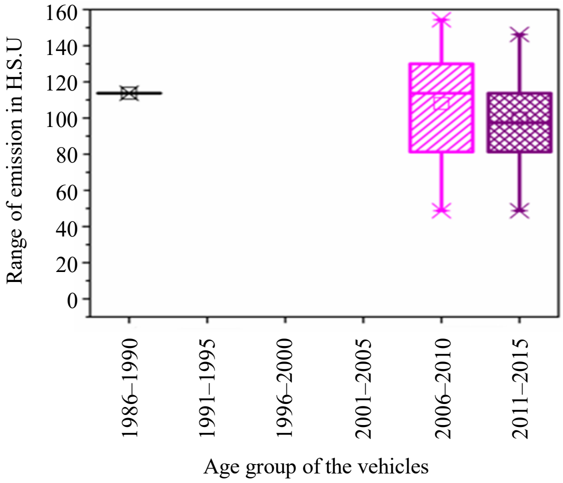


**Figure 5.** Quartile deviation of the different groups.

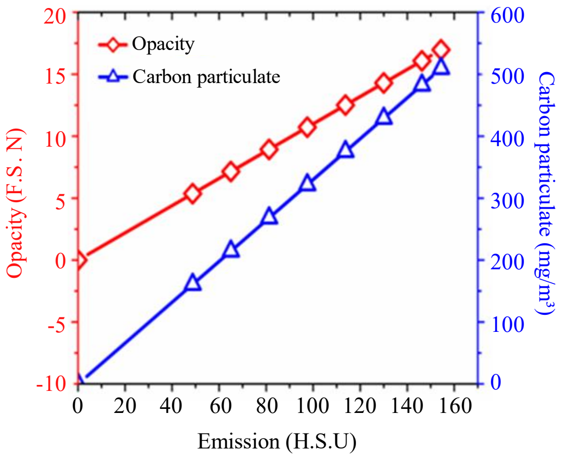


**Figure 6.** Graph of Carbon particulates and Opacity.

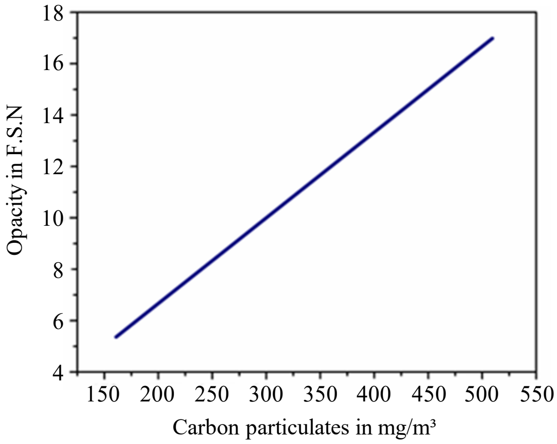


**Figure 7.** Correlation of carbon particulates and opacity.

The graph of carbon particulates (mg/m$^3$) against Opacity (FSN) also indicated that there is a positive correlation between the carbon particulate (mg/m$^3$) concentration and the Opacity (FSN) of the emitted smoke from the vehicle (Figure 7).

 

## CONCLUSION

In Gwalior, the rising number of diesel vehicles has resulted in a significant rise in pollution, with smoke emissions emerging as a significant issue. Particulate matter (PM) and carbon dioxide ($CO_2$), two dangerous pollutants produced by diesel engines, pollute the air, endanger human health, and fuel climate change. Stricter regulations for automobiles and better diesel engine technology are the results of a renewed emphasis on lowering these emissions. Action must be taken immediately to enhance air quality, conserve the environment, and protect human health, according to this report on smoke emissions from diesel automobiles in Gwalior.

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