Fuel consumption and CO_2 emissions from passenger cars: Statistics and Analysis

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Abstract

This paper aims at investigating the types of passenger cars and their impacts on pollution. The results are determined based on the car specifications and carbon emissions. Modes of transportation have grown significantly in the last ten years. Cars are the most used vehicles worldwide. Transportation contributes the most to pollution. However, a variety of new car models that can reduce pollution are now available. I chose this UK data set that focuses on car models, fuel efficiency, and emissions. From 2000 to 2013, this study used data analytics, statistical analysis, and visualizations to uncover insights into how and which cars were causing the most pollution. These results were obtained using R, Python, and SQL. According to the findings, petrol is the source of the most pollution. As a result, appropriate steps must be taken to reduce the use of gasoline and find alternatives. In this research paper, we look further into the meaningful insights discovered through the analysis, discuss the study's limitations, and outline the important findings.
Keywords: Fuel efficiency, Vehicles, Carbon emissions, Energy

Introduction

Particularly in developing countries where the use of vehicles is growing, carbon emissions are rising. By 2050, there could be 2.5 to 3 billion vehicles on the planet, up from the current 850 million (Global Fuel Economy Initiative (GFEI), 2016). Ninety percent of this growth is anticipated to occur in developing and post-industrial nations (Global Fuel Efficiency initiative - State-of-the-World-report, 2016). The global fleet's greenhouse gas emissions are expected to triple because of these countries' stagnant average vehicle fuel economy. The growth of CO_2 emissions in the transportation sector is the highest of any sector, according to the International Energy Agency (IEA) of 2013. Around the world, transportation accounts for more than 50% of oil consumption, and it accounts for almost all the recent and anticipated growth in oil consumption. By 2050, there will be three times as many vehicles on the planet as there are now, and the transport sector is growing more quickly than any other sector globally. Controlling the fuel energy demand and greenhouse gas (GHG) emissions has become a global concern due to the rapid growth in vehicle population, particularly private passenger vehicles. Thus, a major component of the global development agenda is promoting fuel efficiency and lowering carbon dioxide (CO_2) emissions. Automobiles also emit methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons from leaking air conditioners in addition to carbon dioxide (CO_2). These gases emit fewer emissions than CO_2, but because they have a higher global warming potential (GWP) than CO_2, they can still have a significant impact. Although, some recent studies suggest that electric vehicles may be the answer to emission issues, Fernández (2018) discovered that the production of electric cars at the power plant level and the production of the electricity used to power their batteries pollute the environment. However, using renewable energy sources to generate electricity, such as wind, solar, and geothermal energy, as well as altering social customs, may reduce transportation emissions.

Since then, the EU has been working to further reduce CO_2 emissions and fuel use from passenger cars, with mandatory, fleet-average, and mass-dependent targets of 95 g/km by 2021. A manufacturer can be fined between €5 and €95 per gram of excess CO_2 per vehicle sold if they don't follow the rules. Over the past ten years, this policy has significantly altered the average official CO_2 emissions and the key characteristics of European passenger cars. This is a direct result of engine downsizing for both diesel and gasoline engines and has been accompanied by a decrease in average engine capacity despite the apparent increase in engine power. Despite its importance for vehicle energy consumption, mass has consistently remained between 1300 and 1400 kg. However, there is debate over the veracity of these CO_2 figures and whether they are representative of actual CO_2 and fuel consumption. The maintenance of a clean environment has grown in importance in society. Vehicle and motorcycle emissions are some of the pertinent environmental issues that need to be addressed. As a result, reducing motor vehicle pollution is crucial for preventing climate change. It is believed that environmental emissions are proportional to the amount of fuel used by a vehicle. Fuel consumption, which can be defined as the amount of fuel used per unit distance, is the reciprocal of fuel efficiency. The vehicle is said to be more economical the lower the fuel consumption value. Although there is a lot of research on the environmental emissions produced by transportation systems, it is confirmed that variables like driving habits, vehicle design, and traffic conditions have a big impact. When driving in the real world, overlooked factors like side winds, rain, and road grade may significantly affect fuel consumption. A vehicle's fuel efficiency is influenced by several variables, including its design, the surrounding environment, traffic patterns, and user and driver behavior.

In September 2017, the Worldwide Harmonized Light Vehicle Test Procedure (WLTP) took the place of the New European Driving Cycle (NEDC) test procedure for measuring the official fuel consumption and CO_2 emissions of new cars. By September 2018, all new cars (powered by an internal combustion engine) were required to comply with the WLTP test procedure. By providing model-specific values at the point of sale, the new testing regime seeks to provide a closer representation of "real-world" fuel consumption and CO_2 figures. Even though all tests will still be carried out in a lab, allowing for meaningful comparisons between cars, it differs from the previous procedure in several ways.

To have a better understanding of cars and the pollution they cause, this paper attempts to address key questions of concern. The following are the research questions-

1) *Which car manufacturer produces the most air pollution and noise pollution?*
2) *Which car model produces the most air pollution and noise pollution?*
3) *How are fuel costs and emissions related?*
4) *What are the characteristics of the car with low emissions?*

By finding a solution to these questions, we can raise awareness and discontinue the production of those models. By studying the dataset, one will gain an understanding of the characteristics of the car models and will be able to take the necessary steps to change the car's characteristics.

Literature review

Pollution is now a major concern worldwide. Although, there are many reasons for this, vehicles contribute a major part in creating pollution. The amount of CO_2 a car emits is directly related to the amount of fuel it consumes. A typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year. Road transport contributes about one-fifth of the European Union's (EU) total emissions of carbon dioxide (CO_2), the main Greenhouse Gas (GHG), 75% of which originates from passenger cars. Considering, the fuel consumption and CO_2 emissions of UK alone, published by the Vehicle Certification Agency (VCA), an Executive Agency of the United

Kingdom Department for Transport has given information of all the vehicles, including new and old cars, and their properties like fuel consumption, CO2 emissions, model, etc.

Several factors have been identified as contributing to the growing disparity between official fuel consumption and real-world driving conditions. Due to the variety of operating conditions, driver behavior, vehicle usage, and other external factors, it is unlikely that any test protocol, no matter how carefully designed, will be able to accurately capture the real-world performance of vehicles. As a result, there will always be a need to identify which factors influence emissions under real-world driving conditions and which are captured by vehicle certification tests to assess their impact on real-world fuel consumption.

In the research paper [1], Georgios Fontaras, has compared official fuel consumption conditions and real-world driving conditions. Through a qualitative perspective, he performed a Reality vs Certification gap estimation for an average 2015 passenger car. He explained the reasons and the assumptions considered for the official fuel conditions, that lead to a gap between them. Analyzation of potential influence of different factors on CO_2 emissions over real-world conditions compared to the official test value is done. Average CO2 emissions based on various factors of the car are determined. The NEDC-based procedure for CO_2 and fuel consumption measurement is considered.

Juliet Namukasa in [2] aimed at establishing the relationship between age, engine capacity, fuel type and fuel efficiency and carbon emissions. The finding showed a relation between a vehicle's age, engine capacity, vehicle category (Light Duty, Medium Duty, and Heavy Duty), and fuel efficiency and carbon emissions. Petrol vehicles had lower fuel consumption and emissions, whereas diesel vehicles had higher carbon emissions and fuel consumption due to increased engine capacity. Most of the fuel efficiency and carbon emissions research relies on survey data rather than panel data.

In [3], estimated GHG emissions from example journeys across the UK, comparing different modes of transport, and presents statistics on GHG emissions and air pollution on transport. The author considered three cases namely, indirect emissions, direct emissions, indirect effects. Map plots indicating CO2 emissions from transport by local authority, 2019; Percentage change in CO2 emissions from transport, 2005 to 2019 in UK are analyzed and plotted. ‘Emissions and mileage for cars, vans, HGVs and buses in 2019’ and change in emissions are produced as a table plot to give insights on the amount of CO2 emitted by cars.

Materials and Methods

This publicly accessible online dataset was obtained from the gov.uk, transport department of UK. This dataset contains information about the description of cars and fuel efficiencies like manufacturer, model, fuel type, noise levels(dB), carbon emissions(mg/km), engine power in Kw. The structure of the data obtained from the new test is one of the immediately noticeable differences. The terms "urban," "extra-urban," and "combined," which were previously used to describe test cycle driving phases for petrol/diesel cars, are no longer acceptable. The data is being expressed as "Low," "Medium," "High," "Extra-high," and "Combined" in their place. This dataset could be loaded into many tools more easily because it was obtained as a CSV file. Dataset consists of 5678 rows. This dataset contains data from 2000 to 2013 in UK alone. All information about all new cars currently on sale in the UK and used cars that were first registered on or after 1 March 2001.

Data cleaning was the first step, and Python was mainly used for this. The categorical values in the dataset contained a significant number of null values. To make the data easier to analyze and visualize, these data columns were removed. A few string values also needed to be changed due to misspellings and spaces between words in the variables. I was able to eliminate duplicate values by doing this. I began statistical analysis after the data had been cleaned. Python and RStudio both assisted me in creating analyses. To make visualizations and interpretations, I used R studio and Python. Oracle SQL Developer was additionally employed to analyze and extract some data from the dataset based on frequencies and percentages.

For the summary and visualizations of the dataset in Python, libraries like Matplotlib, Pandas, NumPy, etc. were used. Matplotlib for plotting the visualizations, Pandas is used to handle and analyze data, and NumPy for adding support for large, multi-dimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays.
Data analysis has been done using R programming and libraries like ggplot2, tidy verse, GGally, tinytex. ggplot2 for visualizations, GGally, a helper to ggplot2. I've created simple MySQL queries and shown the results.

Results

1) *Which car manufacturer produces the most air pollution and noise pollution?*

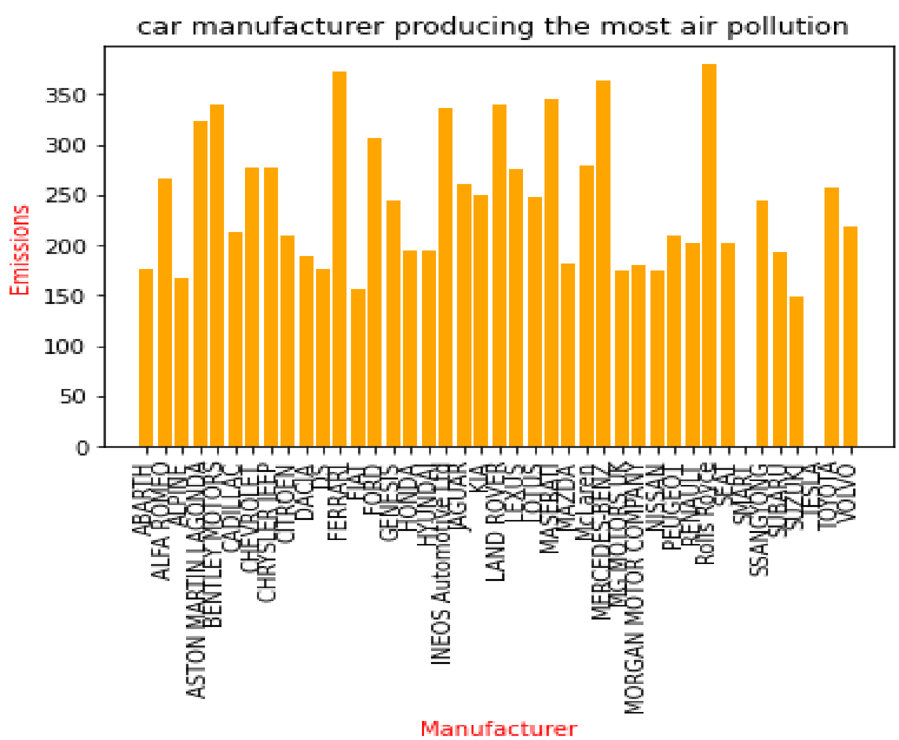


Fig.1- car manufacturer producing the most air pollution

	manufacturer	model	description
3969	Rolls Royce	Cullinan	Cullinan Black Badge
3967	Rolls Royce	Cullinan	Cullinan
738	FERRARI	812	812 GTS
3970	Rolls Royce	Cullinan	Cullinan Black Badge
3971	Rolls Royce	Dawn	Dawn
3973	Rolls Royce	Dawn	Dawn Black Badge Edition
3986	Rolls Royce	Wraith	Wraith Black Badge Edition
3968	Rolls Royce	Cullinan	Cullinan
735	FERRARI	GTC4	GTC4 Lusso
737	FERRARI	812	812 Superfast
739	FERRARI	Monza	Monza SP1
740	FERRARI	Monza	Monza SP2
3972	Rolls Royce	Dawn	Dawn
3980	Rolls Royce	Phantom	Phantom
3982	Rolls Royce	Phantom	Phantom Extended Wheelbase
2715	MERCEDES-BENZ	G-Class Model Year 2023	AMG G 63
2716	MERCEDES-BENZ	G-Class Model Year 2023	AMG G 63
3984	Rolls Royce	Wraith	Wraith

Fig.2-Table viewing the bar chart information

The above visualization is used to display the car manufacturers with respect to carbon dioxide emissions. I used bar chart to create this visualization. We can interpret that Rolls Royce manufacturer is causing the most air pollution of 380 mg/km. It is indeed surprising to see this.

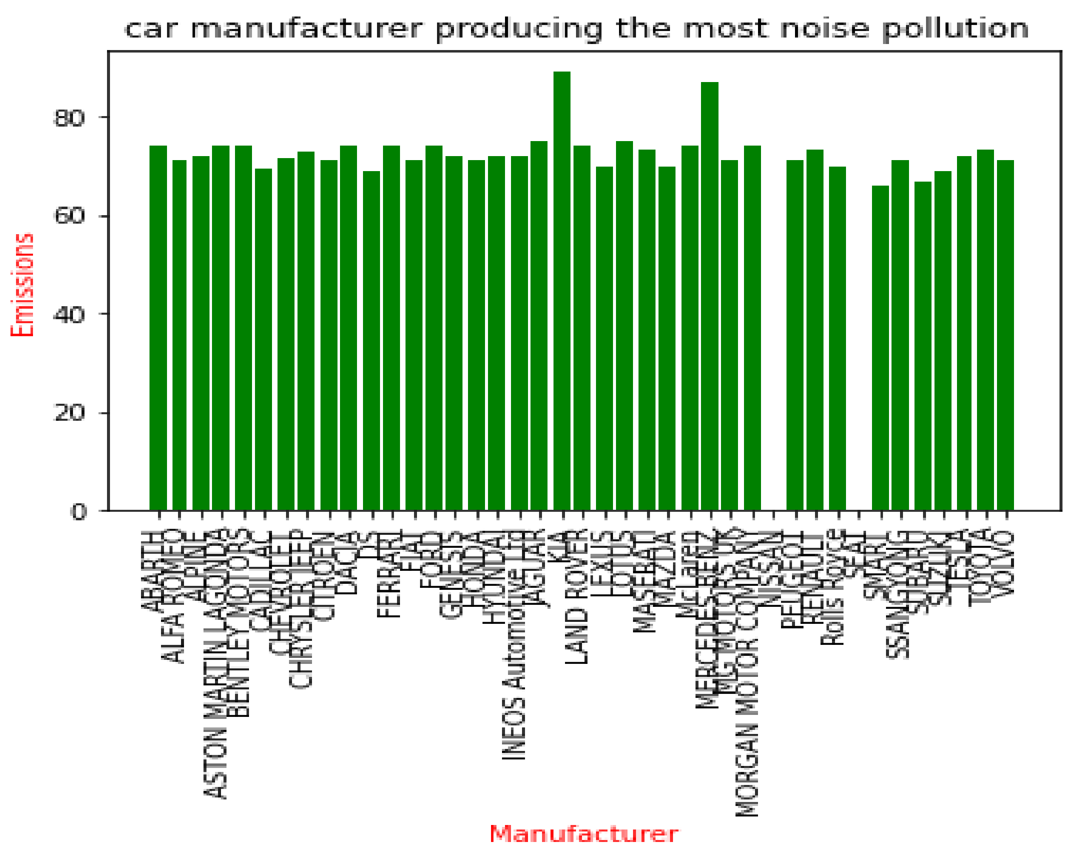


Fig.3- Car manufacturer producing the most noise pollution

The above visualization is used to display the car manufacturers with respect to noise levels. I used bar chart to create this visualization. We can interpret that Kia manufacturer is causing the most noise pollution of 89.2 db.

	manufacturer	model	description
1775	KIA	ProCeed MY22	'GT' 1.6 T-GDi 201bhp 7-speed auto DCT ISG
2755	MERCEDES-BENZ	GLE Coupe Model Year 2023	AMG GLE 53 4MATIC+
2756	MERCEDES-BENZ	GLE Coupe Model Year 2023	AMG GLE 53 4MATIC+
2765	MERCEDES-BENZ	GLE Estate Model Year 2023	AMG GLE 53 4MATIC+
2766	MERCEDES-BENZ	GLE Estate Model Year 2023	AMG GLE 53 4MATIC+
2763	MERCEDES-BENZ	GLE Estate Model Year 2023	GLE 300 d 4MATIC
2764	MERCEDES-BENZ	GLE Estate Model Year 2023	GLE 300 d 4MATIC
2757	MERCEDES-BENZ	GLE Coupe Model Year 2023	AMG GLE 63 S 4MATIC+
2758	MERCEDES-BENZ	GLE Coupe Model Year 2023	AMG GLE 63 S 4MATIC+
2769	MERCEDES-BENZ	GLE Estate Model Year 2023	AMG GLE 63 S 4MATIC+
2770	MERCEDES-BENZ	GLE Estate Model Year 2023	AMG GLE 63 S 4MATIC+
2777	MERCEDES-BENZ	GLS Model Year 2023	Maybach GLS 600 4MATIC
2778	MERCEDES-BENZ	GLS Model Year 2023	Maybach GLS 600 4MATIC
2801	MERCEDES-BENZ	V-Class MPV MY 2022	V 220 d extra-long
2802	MERCEDES-BENZ	V-Class MPV MY 2022	V 220 d extra-long
2803	MERCEDES-BENZ	V-Class MPV MY 2022	V 220 d long
2804	MERCEDES-BENZ	V-Class MPV MY 2022	V 220 d long
2805	MERCEDES-BENZ	V-Class MPV MY 2022	V 220 d Marco Polo

Fig.4-Table viewing the bar chart information

2) *Which car model produces the most air pollution and noise pollution?*

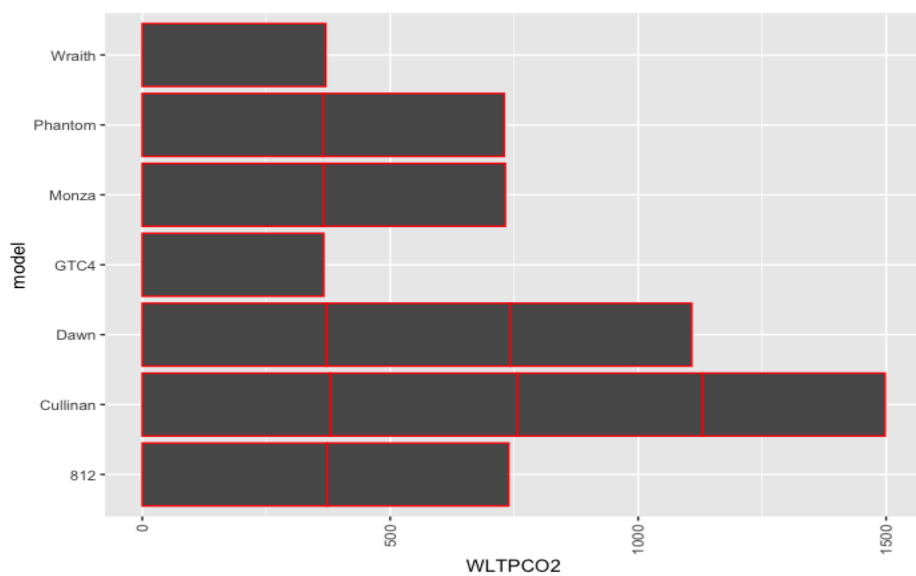


Fig.5- Car model producing the most air pollution

The above visualization is used to display the car models with respect to carbon emissions. I used bar chart to create this visualization. We can interpret that Cullinan model is causing the most air pollution.

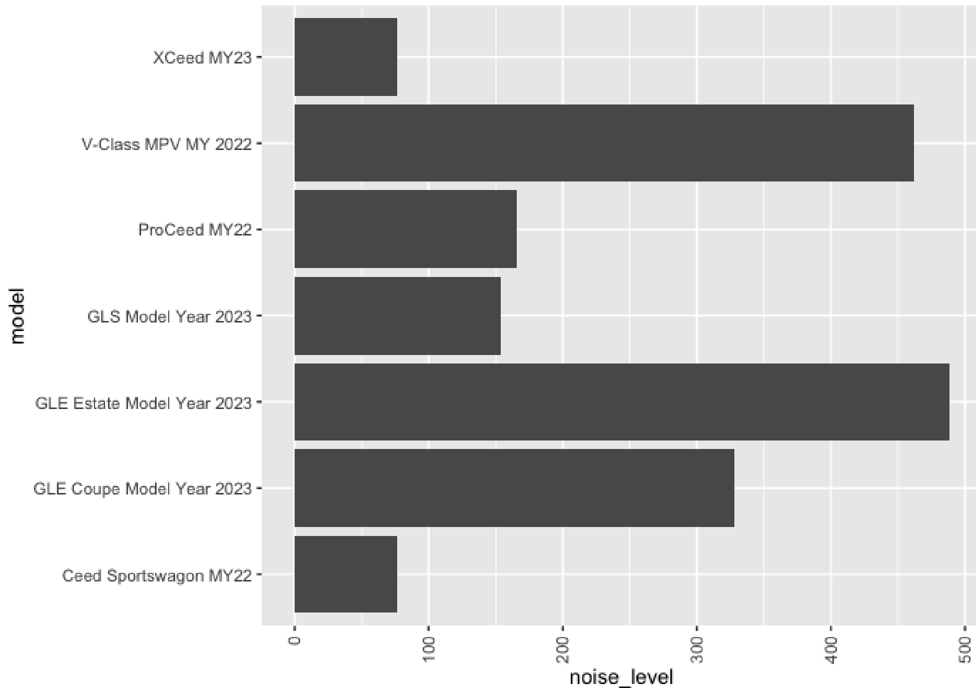


Fig.6- Car model producing the most noise pollution

The above visualization is used to display the car models with respect to noise levels. I used bar chart to create this visualization. We can interpret that GLE Estate model year 2023 model is causing the most noise pollution.

3) *How are fuel costs and emissions related?*

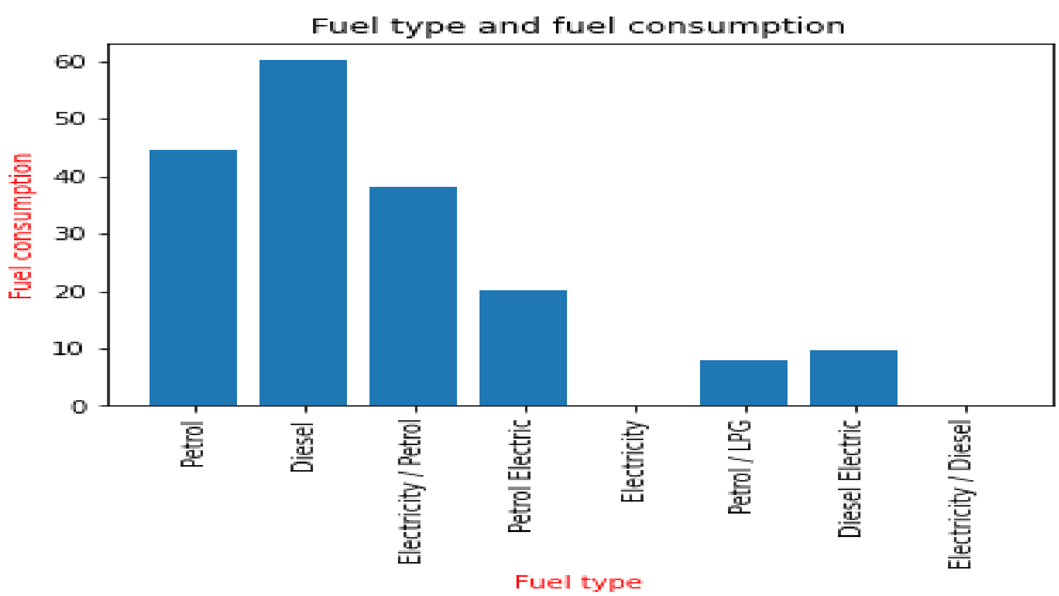


Fig.7- Fuel type v/s WLTP Metric Low fuel consumption

The above graph is created to display fuel type and its fuel consumption - WLTP_Metric_Low. This means that the fuel consumptions in urban areas are plotted above. This graph depicts that diesel consumption is more in urban areas.

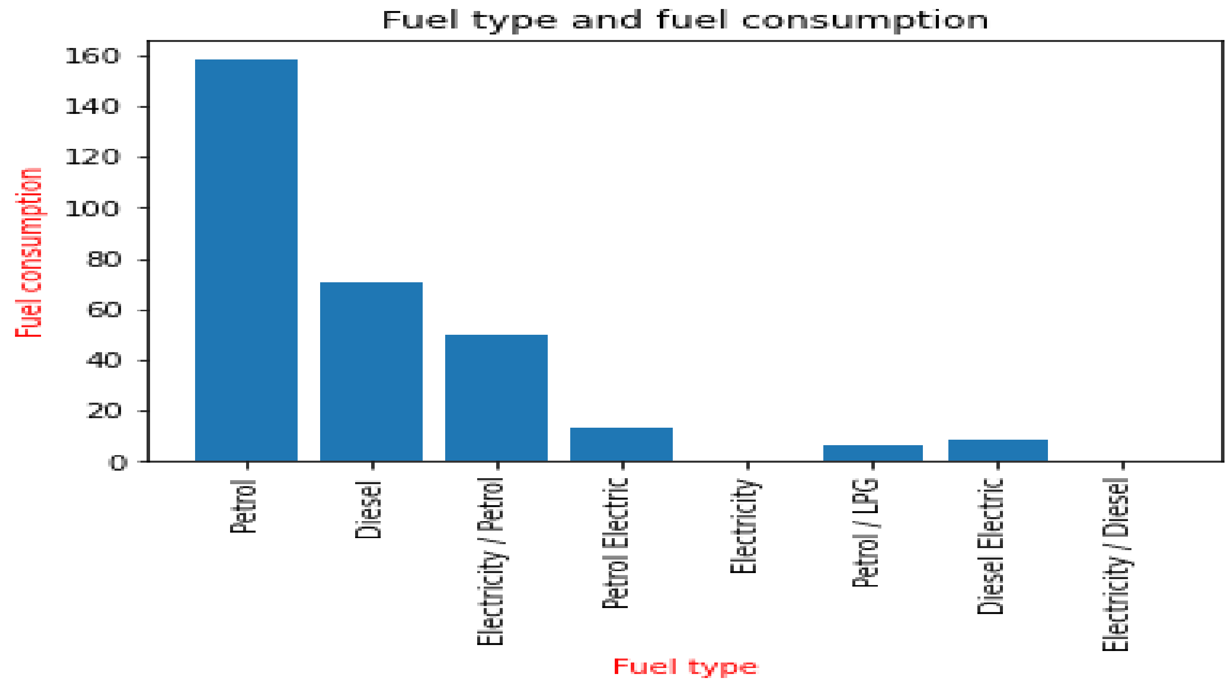


Fig.8- Fuel type v/s WLTP Metric Medium fuel consumption

The above graph is created to display fuel type and its fuel consumption - WLTP_Metric_Medium. This means that the fuel consumptions in Semi-urban areas are plotted above. This graph depicts that Petrol consumption is more in Semi-urban areas.

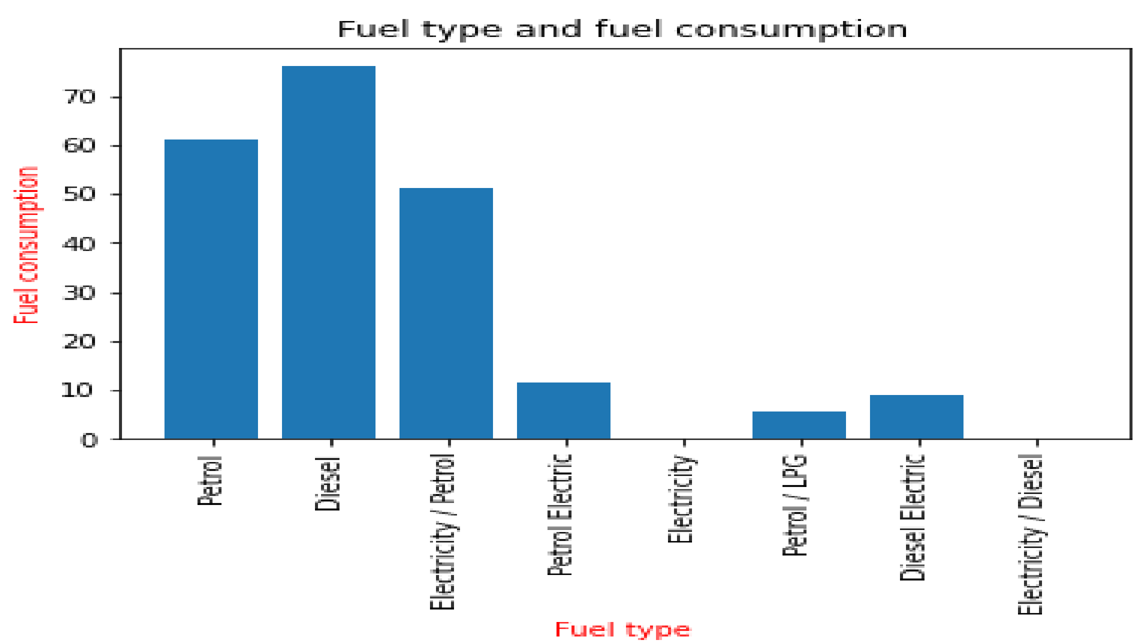


Fig.9- Fuel type v/s WLTP Metric High fuel consumption

The above graph is created to display fuel type and its fuel consumption - WLTP_Metric_High. This means that the fuel consumptions in Rural areas are plotted above. This graph depicts that Diesel consumption is more in Rural areas.

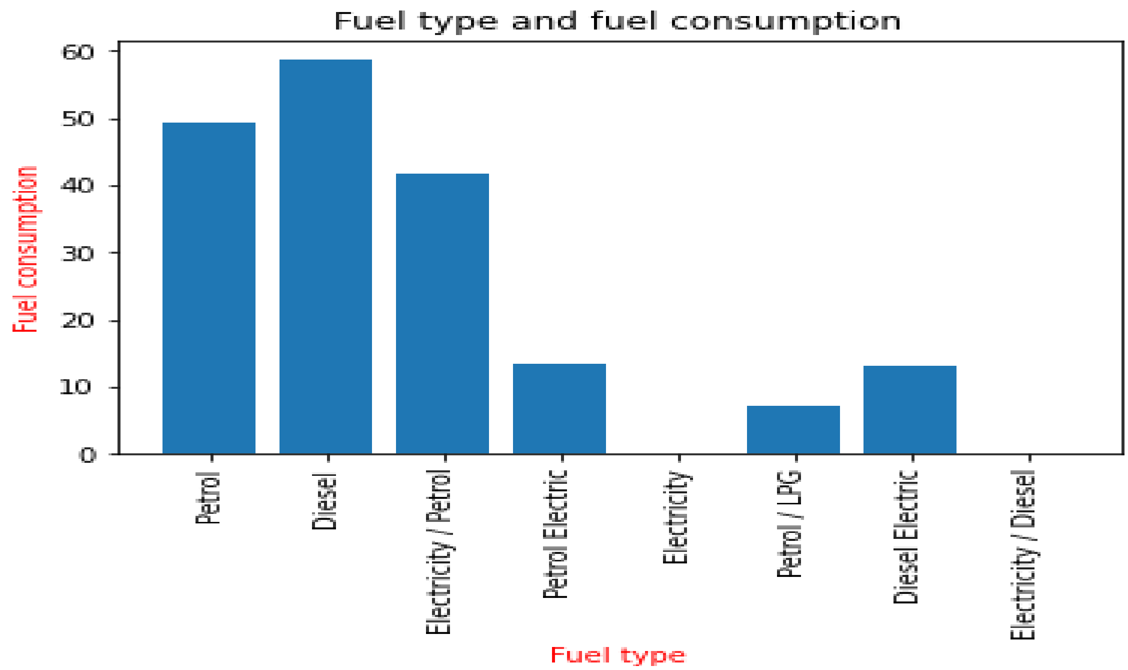


Fig.10- Fuel type v/s WLTP Metric Medium fuel consumption

The above graph is created to display fuel type and its fuel consumption - WLTP_Metric_Extra_High. This means that the fuel consumptions on highways are plotted above. This graph depicts that Diesel consumption is more in Rural areas.

From these above graphs we can understand that diesel consumption is more in all the areas.

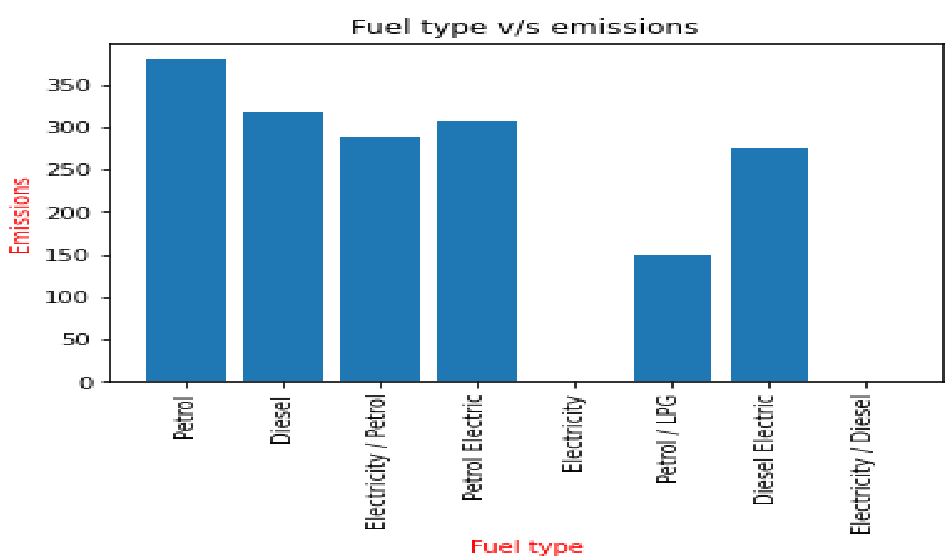


Fig.11- Fuel type v/s CO2 Emissions

The above graph displays fuel type and Co2 emissions as a bar chart. From this graph we can tell that Co2 emissions are more when fuel type is petrol. The next place goes to diesel. From the above graphs between fuel types and fuel consumptions, we can insist that Petrol is the major contributor of air pollution. As diesel is mostly used in many areas, Diesel is causing major pollution. As the diesel is the most common fuel type the diesel price must be low. Electricity and LPG are causing less pollution and the consumption of fuel is also less. Hence LPG must be provided to citizens at lower prices.

4) *What are the characteristics of the car with low emissions?*

```
> data <- df[with(df,order(WLTPCO2)),]
> data %>% select(manufacturer,WLTPCO2)
       manufacturer WLTPCO2
1828            KIA      25
1829            KIA      25
1830            KIA      25
4060           SEAT      30
4061           SEAT      30
4062           SEAT      30
4063           SEAT      30
4639          VOLVO      47
4640          VOLVO      47
4641          VOLVO      47
4642          VOLVO      47
4648          VOLVO      55
4650          VOLVO      56
4647          VOLVO      64
4649          VOLVO      64
123  BENTLEY MOTORS      75
115  BENTLEY MOTORS      82
2460          MAZDA      87
2461          MAZDA      87
2462          MAZDA      87
2463          MAZDA      92
4590         TOYOTA      92
4591         TOYOTA      92
4600         TOYOTA      92
4442         TOYOTA      94
4443         TOYOTA      94
4445         TOYOTA      94
4448         TOYOTA      94
```

Fig.12- Table view of manufacturer and carbon emissions in ascending order

The above table is created by ordering the dataset according to carbon emissions in ascending order. From the above table it’s clear that ‘KIA’ manufacturer has the lowest emissions.

```
> data <- df[with(df,order(WLTPCO2)),]
> y <- data %>% select(model,WLTPCO2)
> y
                          model WLTPCO2
1828               Sportage MY22      25
1829               Sportage MY22      25
1830               Sportage MY22      25
4060            Cupra Leon Hatch      30
4061            Cupra Leon Hatch      30
4062            Cupra Leon Hatch      30
4063            Cupra Leon Hatch      30
4639                  XC40, MY23      47
4640                  XC40, MY23      47
4641                  XC40, MY23      47
4642                  XC40, MY23      47
4648                  XC60, MY23      55
4650                  XC60, MY23      56
4647                  XC60, MY23      64
4649                  XC60, MY23      64
123           Flying Spur MY22.5      75
115               Bentayga MY21       82
2460                      Mazda2      87
2461                      Mazda2      87
2462                      Mazda2      87
2463                      Mazda2      92
```

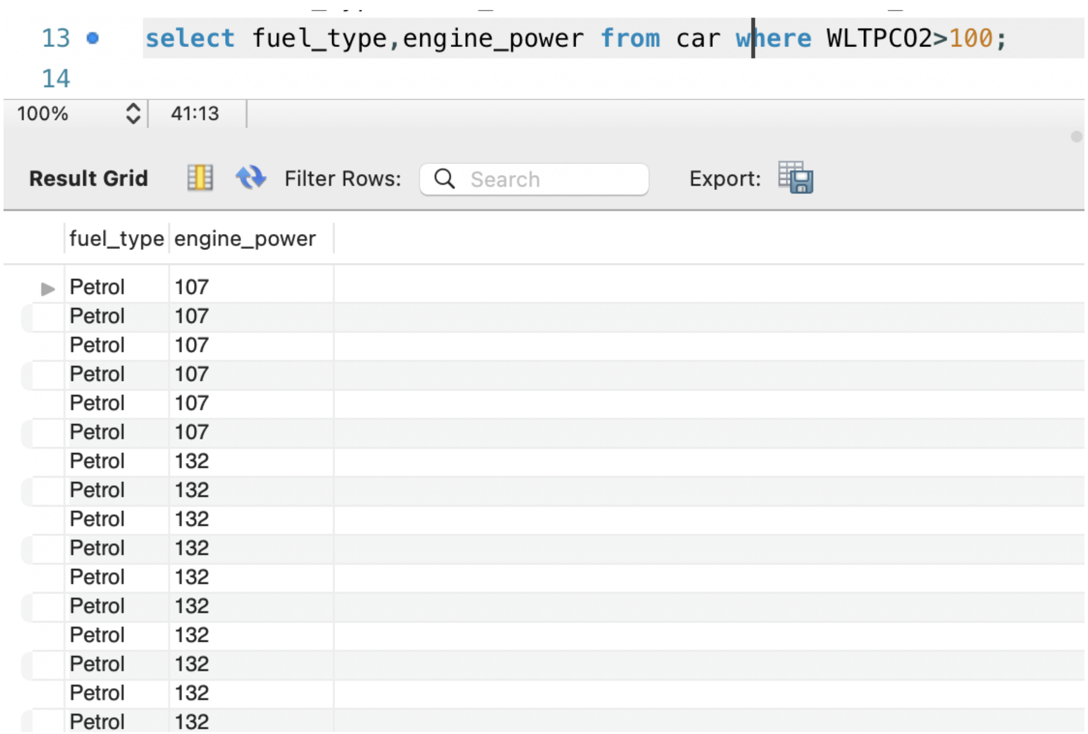
Fig.13- Table view of model and carbon emissions in ascending order

From the above table it's clear that 'Sportage MY22' model has the lowest emissions.
Similarly, "'GT-Line' 1.6 T-GDI 261 bhp PHEV" is the description, 'AT6' transmission, 'Automatic' gear, with '1598' engine capacity, 'Electricity/Petrol' fuel type, 'Plug-in Hybrid Electric Vehicle (PHEV)' power train are the characteristics that a car should have for to release less emissions.

manufactur...	model	description	transmission	gear	engine_capaci...	fuel_type	powertrain	engine_power	WLTP_metric_low	WLTP_metric_m
ABARTH	595	595 1.4 145 BHP Hatchback	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	107	10	7
ABARTH	595	595 1.4 145 BHP Hatchback	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	107	10	7
ABARTH	595	595 1.4 145 BHP Convertible	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	107	10	7
ABARTH	595	595 1.4 145 BHP Convertible	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	107	10	7
ABARTH	595	595 1.4 TJET 145bhp	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	107	10	6
ABARTH	595	595 1.4 TJET 145bhp	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	107	10	7
ABARTH	595	595 COMPETIZIONE 1.4 TJET 180bhp	SA5	Automatic	1368	Petrol	Internal Combustion Engine (ICE)	132	10	7
ABARTH	595	595 COMPETIZIONE 1.4 TJET 180bhp	SA5	Automatic	1368	Petrol	Internal Combustion Engine (ICE)	132	10	7
ABARTH	595	595 COMPETIZIONE 1.4 TJET 180bhp	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	132	9	6
ABARTH	595	595 COMPETIZIONE 1.4 TJET 180bhp Convert...	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	132	9	6
ABARTH	595	595 COMPETIZIONE 1.4 TJET 180bhp Convert...	SA5	Automatic	1368	Petrol	Internal Combustion Engine (ICE)	132	10	7
ABARTH	595	595 COMPETIZIONE 1.4 TJET 180bhp Convert...	SA5	Automatic	1368	Petrol	Internal Combustion Engine (ICE)	132	10	7
ABARTH	595	595 Competizione 180 BHP Convertible	SA5	Automatic	1368	Petrol	Internal Combustion Engine (ICE)	132	10	7
ABARTH	595	595 Competizione 180 BHP Hatchback	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	132	11	7
ABARTH	595	595 Competizione 180 BHP Hatchback	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	132	11	7
ABARTH	595	595 Competizione 180 BHP Hatchback	SA5	Automatic	1368	Petrol	Internal Combustion Engine (ICE)	132	10	7
ABARTH	595	595 ESSEESSE 1.4 TJET 180bhp Convertible	M5	Manual	1368	Petrol	Internal Combustion Engine (ICE)	132	9	6

Fig.14 – Table view for the SQL query

The above figure show the dataset after loading the data in SQL by importing the data and writing the SQL query. 'select * from car;' , query is used to display the table loaded into the SQL.



```
13 ●  select fuel_type,engine_power from car where WLTPCO2>100;
14
```

100% 41:13

Result Grid | Filter Rows: Search | Export:

fuel_type	engine_power
Petrol	107
Petrol	107
Petrol	107
Petrol	107
Petrol	107
Petrol	107
Petrol	132
Petrol	132
Petrol	132
Petrol	132
Petrol	132
Petrol	132
Petrol	132
Petrol	132
Petrol	132
Petrol	132

Fig.15 – Table view for the SQL query displaying fuel type and engine power

‘select fuel type, engine power from car where WLTPCO2>100;’ query is used to display the fuel types and engine power for those where engine power is greater than 100 Kw.

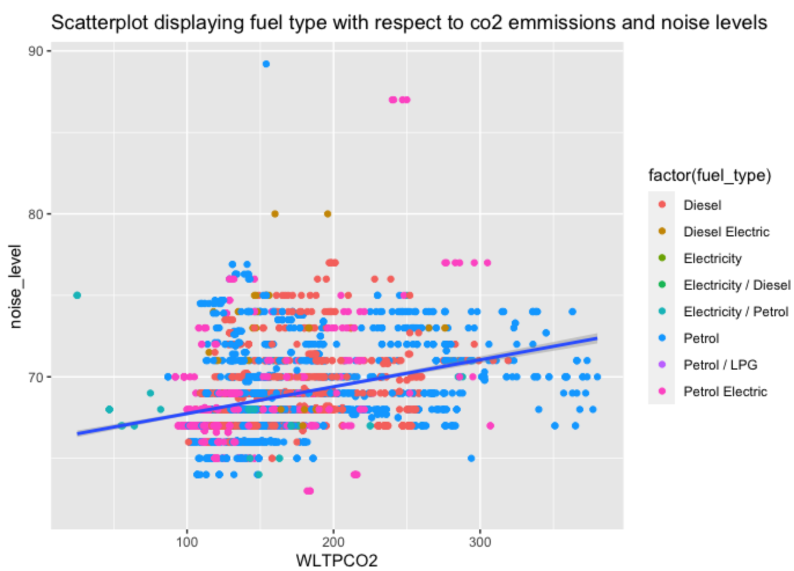


Fig.16-Scatterplot displaying fuel type with respect to co2 emissions and noise levels

The above graph is a scatterplot displaying fuel types considering noise level and carbon emissions. The graph provides us the following insights:

1) Electric provides more noise pollution
2) Petrol causes more carbon emissions

3) The carbon emissions increase with noise level

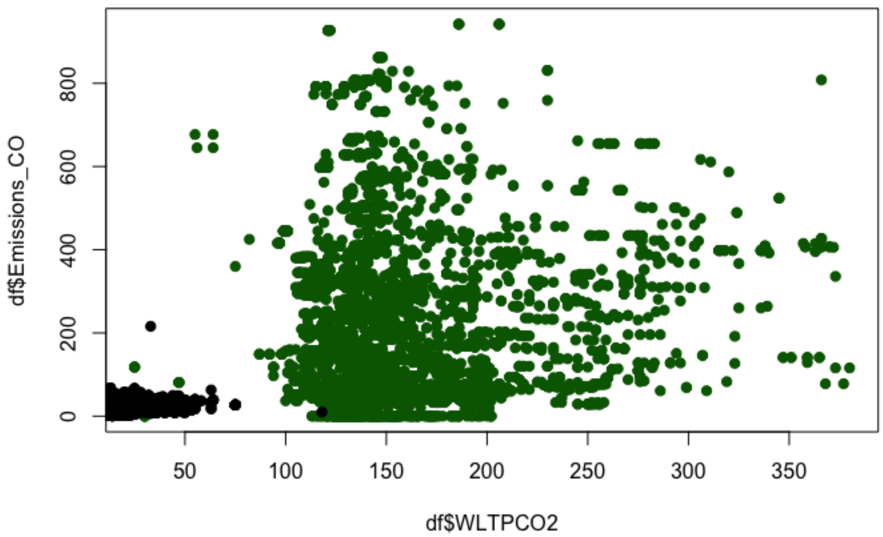


Fig.17-Scatterplot displaying different emissions

The above graph is a scatter plot of all the four emissions. They are

CO2 emissions [g/km]:

The main byproducts of burning gasoline or diesel for energy are carbon dioxide and water vapor. The most significant greenhouse gas causing climate change is carbon dioxide. A car will produce about its own weight in CO2 after 6000 miles.

CO Emissions [mg/km]:

Because carbon monoxide decreases the blood's ability to carry oxygen, less oxygen may be available to vital organs.

HC Emissions [mg/km]

The creation of ozone is aided by hydrocarbons. Some HCs have the potential to cause cancer and act as indirect greenhouse gases.

NOx emissions (mg/km)

Nitrogen dioxide (NO2) is created when nitrogen oxides react in the atmosphere, which can be harmful to health, especially for those who already have respiratory conditions. Additionally, NOx can harm vegetation and contribute to the formation of smog and acid rain.

The green points indicate carbon emissions whereas the black points indicate hydrocarbons and nitrogen dioxide emissions. The plot indicates that carbon dioxide and carbon monoxide emissions are more than hydrocarbons and nitrogen dioxide.

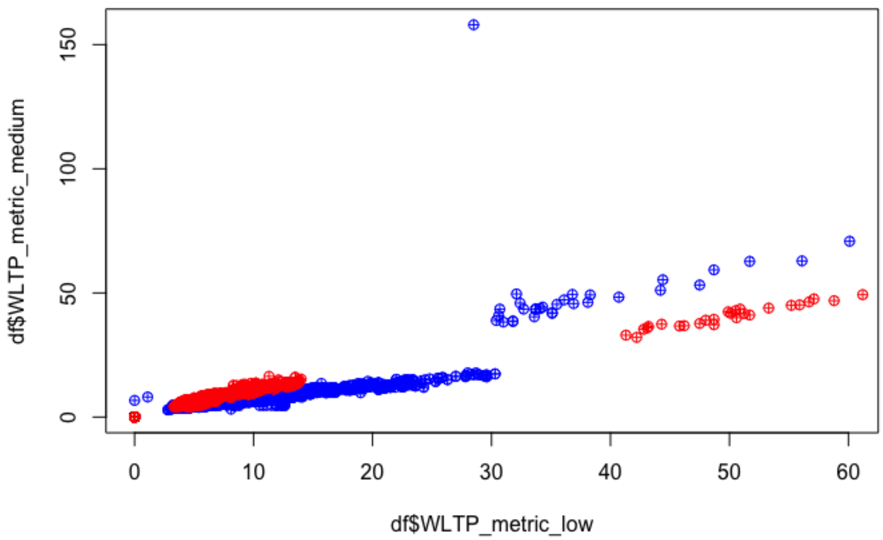


Fig.18-Scatterplot displaying different fuel consumptions

The above graph is a scatter plot of all the four Fuel consumptions. They are
W LTP Metric Low:
These are the fuel consumption values in urban areas according to WLTP.
W LTP Metric Medium:
These are the fuel consumption values in Semi-urban areas according to WLTP.
W LTP Metric High:
These are the fuel consumption values in Rural areas according to WLTP.
W LTP Metric Extra High:
These are the fuel consumption values in Highway areas according to WLTP.

The blue points indicate Urban and Semi urban areas whereas the red points indicate rural and highway areas. The above scatter plot indicates that there are more vehicles in urban and semi urban areas than in rural and highway areas.

Limitations and further research needed

I have faced many limitations while performing research. Firstly, the dataset is large and and consisted of errors. As the dataset is large cleaning the data was difficult. Secondly, different software's gave different outputs. I had to create and sort tables to compare the visualizations for the right answer.
In the 4 research questions, I didn't consider the noise pollution. Kia manufacturer has low carbon emissions but more noise pollution. Hence, one must conduct more research and analysis to determine the optimal car characteristics if they want to reduce the noise levels too.

Conclusion

Overall, this dataset gives us insights about the car specifications and requirements. It also mentions the emissions and noise levels from various models and manufacturers. The research questions are answered and gives us result that are beneficial for the society.

1) *Which car manufacturer produces the most air pollution and noise pollution?*

From the visualizations we can tell that ‘Rolls Royce’ and ‘Kia’ manufacturer is causing more pollution hence he should consider the factors that are leading to the more emissions and try to avoid them.

2) *Which car model produces the most air pollution and noise pollution?*

From the visualizations and interpretations, we can tell that ‘Cullinan’ ab ‘GLE Estate model year 2023’ models are causing more air and noise pollution. Proper measures can be taken for the models by trying to change the design or engine.

3) *How are fuel costs and emissions related?*

Diesel is the most common fuel used in many areas including rural areas. Hence, diesel is contributing to the most of carbon emissions. Although Diesel is mostly used, Petrol causes more pollution. LPG, Electricity led to less emissions. Hence, public must be made aware of this information and government measures must be taken to use the fuels that create less pollution.

4) *What are the characteristics of the car with low emissions?*

The characteristics, a car must have so that it produces less emissions are ‘Kia’ is the manufacturer. ‘Sportage MY22’ model has the lowest emissions, “'GT-Line' 1.6 T-GDI 261 bhp PHEV” is the description, ‘AT6’ transmission, ‘Automatic’ gear, with ‘1598’ engine capacity, ‘Electricity/Petrol’ fuel type, ‘Plug-in Hybrid Electric Vehicle (PHEV)’ power train are the characteristics that a car should have for to release less emissions.

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