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DEVELOPMENT OF METHODOLOGY FOR VEHICLE EMISSIONS MODELING

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ABSTRACT - The issue of poor air quality in Sri Lanka is a pressing concern for public health and the environment. To address this issue, a novel methodology for vehicle emissions modeling is developed, focusing on identifying sources and effects of emissions through comprehensive data analysis. The methodology involves collecting emission data from vehicle emission test companies, and transforming it into annual datasets for analysis. The R language is used to facilitate the analysis, enabling advanced statistical methods like descriptive statistics and correlation analysis. Data visualization tools are employed to present insights clearly and comprehensively. The study aims to contribute to the existing body of knowledge by introducing a novel approach to vehicle emissions modeling in Sri Lanka, highlighting unique aspects of the methodology and new data sources. The findings will serve as the foundation for policy recommendations to effectively manage emissions, impacting Sri Lanka's environmental policies and air quality management strategies.

Keywords: Emission, Vehicle Emission, Big data, R Language, CO_2

1. INTRODUCTION

Transportation is a critical aspect of modern society, enabling people and goods to move quickly and efficiently. However, vehicles are a significant contributor to air pollution, with harmful emissions such as carbon monoxide (CO), carbon dioxide (CO_2), and hydrocarbons (HC) released into the atmosphere. In Sri Lanka, the increasing number of vehicles on the roads is becoming a major concern for the environment and public health [1]. In Sri Lanka, road transportation generates the most greenhouse gas (GHG) emissions of any mode of transportation additionally ambient air pollution is responsible for 7800 fatalities annually [2]. However, Sri Lanka does not have a proper tool to measure and manage emissions, which is crucial for effective policymaking. This study focuses on vehicular emission analysis using big data in Sri Lanka. The main objective of this research is to identify the emission level of vehicles and provide policy recommendations, study Sri Lankan vehicle emission data, collect, clean, understand and analyze data, and provide policy recommendations using existing tools to manage the emission. The study uses the equation provided by Karunathilaka et al. (2018) [3] to quantify the emission masses using Vehicle Emission Test (VET) data. The equation considers the volume of diluted exhaust gas, the density of the pollutant, and the concentration of the pollutant in the exhaust gas.

2. MATERIALS AND METHODS

2.1. Data

For this research, vehicle registration data can be collected from the Department of Motor Traffic (DMT) or Revenue License data. Collect vehicle emission data, there are two different methods: getting area emission data or getting individual vehicle emission data from vehicle emission test companies. Between the two methods, collecting emission data from testing companies is the best method in the other hand collecting data

from individual vehicles can be used to validate the process. VET companies keep data more accurate and organized. Those testing companies hold roughly around 6 million entries per year, which makes them big datasets. Therefore, these data can be used for analyzing vehicle emissions in Sri Lanka. VET data was

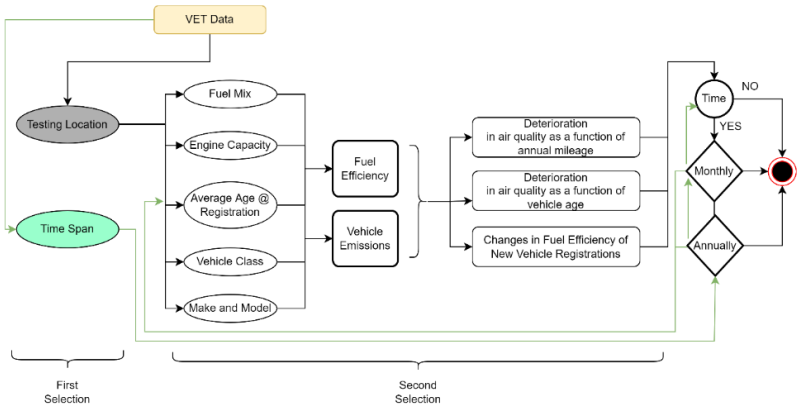

Figure 1. Data Collection Process

collected through two existing VET companies in Sri Lanka which are CleanCo, and Laugfs.

Figure 1 visualizes the data collection procedure and its criteria and how the selection process for the analysis will be done. The data cleaning process involves several steps to ensure the accuracy and consistency of the collected data. The first step is to obtain the Vehicle Emission Test (VET) dataset, which contains information on the emission of pollutants from vehicles in Sri Lanka. The dataset is initially in Excel format and requires several modifications. The headers in the dataset are edited to make them more descriptive, and excess columns are removed. Blank cells are replaced with 'NA' to make the dataset consistent. The modified dataset is then saved in .csv format, with separate files created for each quarter and year. The next set of data-cleaning steps is carried out using the R language. The separate .csv files for each quarter and year are read separately using R, and the 24 files for each year are combined to create a whole year's dataset. The dataset is then edited to make it more interpretable. The resulting dataset is then used for the analysis. To ensure the accuracy of the data, a sample dataset of 3000 entries is created, containing random 1000 entries from each year, for further analysis. The data cleaning process ensures that the dataset is consistent and accurate, which is essential for the subsequent analysis.

2.2. Methodology

An existing equation used to quantify the CO_2, CO, and HC mass for this research, that equation is been described here. [3], [4]

$$Mi = Vmix * Qi * Ci \quad \text{(Karunathilaka et al., 2018)} \qquad (1)$$

- Mi = Mass emission of the pollutant i (CO, CO_2, HC) in g/l.
- Vmix = Volume of diluted exhaust gas expressed in m^3 per 1liter and corrected to normal conditions 293K and 101.33 kPa.
- Qi = Density of the pollutant i in kg/m^3 at normal temperature and pressure (293 K and 101.33 kPa).
- Ci = Concentration of pollutant i in diluted exhaust gas expressed in ppm or (v/v) % and corrected by the amount of the pollutant i contained in the dilution air.

Table 1. CO_2 Mass Calculation Example for Diesel

Diesel - CO_2 (Mi = Vmix * Qi * Ci)				
K_Avg	Vmix	Qi	Ci	Mi
2.3	15.81	1.842	2.011	134.6980791

Table 2. CO_2 Mass Calculation Example for Petrol

Petrol - CO_2 (Mi = Vmix * Qi * Ci)				
AccCO_2	Vmix	Qi	Ci	Mi
15.45	9.03	1.842	15.45	256.9839

Table 1, and 2 show the example mass calculation process of diesel vehicle and petrol vehicle. "Vmix" provides the volume of diluted exhaust gas expressed in m^3 per 1lite of fuel either diesel or petrol. When determining "Ci" for diesel vehicles it is calculated using "K average" and for petrol vehicles "Ci" determine directly using "Accelerated CO_2" [3], [4].

For this research, the following steps will be taken to analyze the data:

- Data cleaning to remove or correct any errors, inconsistencies, or duplicates in the data.
- Descriptive statistics describe the data in terms of measures such as mean, median, mode, standard deviation, and variance.
- Correlation analysis to identify the relationships between variables in the data.
- Data visualization to present the data in a graphical format for better understanding.

The methodology presented in this study provides a comprehensive framework for the analysis of vehicular emissions using big data. The data cleaning steps, and the data preprocessing techniques implemented were effective in ensuring data quality and integrity. The results of the methodology can be presented in terms of data distribution by vehicle types and by province. This provides valuable insights into the contribution of different vehicle types and regions to the overall emissions.

3. CONCLUSION

The study highlights the importance of managing vehicular emissions, particularly in developing countries like Sri Lanka, where there is a lack of proper tools to measure and manage emissions. The use of big data and advanced analytical tools like R can provide valuable insights into vehicular emissions and help policymakers make informed decisions to reduce the environmental impact of transportation.

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