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An Investigation Into The Utilisation Of Biodiesel Fuel For The Purpose Of Assessing Roadworthiness: A Study Conducted In Hong Kong

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1. Abstract
Because of the upcoming adoption of new emission rules, the automotive industry is working diligently to develop new engine management systems and pollution control technologies. This is because of the fact that the restrictions are about to be implemented. In the year 1992, this idea was conceived with the European Regulation for Heavy-Duty Diesel Vehicle Emissions Limits serving as the main source of inspiration. It is Euro-I. The Euro-II standard was first established in the year 1996, while the Euro-III standard was put into effect in the year 1999. As new energy sources and technologies become available, it is anticipated that more stringent requirements were imposed in the years 2005 (Euro-IV) and 2008. (The Euro-V). Overly high levels of emissions from autos are often the result of improper vehicle maintenance upkeep. When it comes to detecting high emitters within a fleet of vehicles that are presently in operation, inspection, and maintenance (I&M) programmes are the most reliable way. In addition, civic and vocational education are necessary for the promotion of safe driving practices and the increase of employment rates in the field of "automobile maintenance and repair." shop for Over in Japan and the United States, "Diesel vehicles, regardless of whether they are new or old, are subject to comparable restrictions in the majority of states in the United States; however, testing procedures vary." An emission and noise standard has been set by the Hong Kong Police Department (HKEPD) for all cars operating in the city. The yearly inspection and testing of emissions is also a component of "Projects in Instruction and Management," which is a project that aims to prevent the spread of smoke. Emissions from automobiles, trucks, and buses that are presently on the road are monitored and assessed based on fleets.

Keyword: E*missions exhaust systems, Pollution control technology, Biodiesel Fuel, Automotive industry.*

2. Introduction
There are around 7 million people living in Hong Kong, which has a population density of more than 500,000 vehicles. Due to the limited availability of natural resources in Hong Kong, the majority of the raw materials and consumer products that are used in the city are imported from other countries, especially China. Singapore's airports and container terminals are able to manage an annual cargo volume of more than 200 million metric tonnes **(Nandha, 2021).** This is a result of Singapore's strategic position at the crossroads of Asia and the Pacific, as well as its closeness to China. Since the 1980s, the rapid growth of the transport industry has had a significant influence on a number of different industries, including fossil fuels, the expansion of road networks, and the construction of infrastructure **(Gouran, 2021).**
For the same reason that they are a significant source of air pollutants in other industrialised cities throughout the globe, vehicle emissions are a major source of air pollutants in Hong Kong. These emissions have substantial effects for both the environment and human health. For instance, particulate matter (PM) and nitrogen oxides (NOx) are responsible for contributing to respiratory disorders in people as was as the damage of the environment. Concerns about air pollution have been voiced by the general public as a result of the fact that densely populated streets and high-rise buildings in urban areas impede air circulation and ventilation capabilities. As a result of inadequate circulation and ventilation, the pollutants in the air that are trapped by vehicle emissions may rapidly accumulate to levels that are lethal. A number of measures have been put into place by the government of the Hong Kong Special Administrative Region (HKSAR) throughout the course of the last few years in order to lessen the impact of emissions from automobiles and to cut down on emissions that are environmentally dangerous. In addition to more stringent emission rules, these programmes included a tax rebate for cleaner fuels, incentives for exhaust after treatment technology, and other such measures. Both the legislation governing low emission technologies and the pilot projects that have been implemented have garnered considerable support and shown some beneficial results. Although this is the case, the vast majority of them have not been successful in improving energy efficiency or reducing fuel use in any substantial manner. As a consequence of this, they provide only a marginal influence on the air quality and energy efficiency of Hong Kong **(Uchocki, 2021).**

3. Background
With seven million residents and more than 500,000 vehicles, Hong Kong is a wealthy and densely populated city **(Cican, 2020).** Due to its limited natural resources, Hong Kong is totally dependent on mainland China and other nations for its food, clothes, and other basic needs. The region's state-of-the-art airports and container terminals allow for the yearly flow of over 200 million tonnes of goods, capitalising on its position as both an Asian hub and a gateway to China. The

development of fossil fuels, transportation networks, and infrastructure has been under tremendous pressure to meet the high demand for dependable service brought about by the industry's rapid expansion since the 1980s.
Vehicle emissions of air pollutants, such as particulate matter (PM) and oxides of nitrogen (NOx), contribute to human respiratory ailments and environmental damage in Hong Kong and other industrialised cities worldwide." **(Shahabuddin, 2020)** Problems with air pollution have been brought to light due to factors such as increased traffic in cities and the proliferation of tall buildings, which cut down on natural ventilation. Accumulating dangerous levels of air pollution from vehicle emissions is possible in enclosed spaces with inadequate ventilation and air movement. In the last several years, Hong Kong's economy has grown substantially.
Several programmes have been launched by the Hong Kong Special Administrative Region (HKSAR) government to reduce automobile emissions of dangerous substances. Some of these measures were monetary incentives for the installation of exhaust after-treatment equipment, tighter pollution restrictions for vehicles, and tax incentives for the use of cleaner fuels. These rules have broad backing, and trial projects using low-emission technologies have shown encouraging outcomes thus far. Most of them, nevertheless, have failed to improve efficiency or reduce fuel use. In general, they do nothing to improve air quality or reduce energy costs in Hong Kong.
Annual petroleum use has soared in the last few decades, and the motor fuel business is now dominated by petroleum-based fuels like petrol and diesel. In light of growing worries about global warming, resource loss, and environmental damage, a number of alternative fuels have been created **(Krishania, 2020).** Nonetheless, most people only recognise a small number of them. over instance, biodiesel's use has been on the rise in both the US and Europe over the last decade. Vegetable oils, animal fats, and waste lipids may all be used to make it; therefore, it doesn't need any nonrenewable resources during manufacture. Biodiesel is an eco-friendly fuel that reduces pollutants and greenhouse gas emissions while also contributing to a more diverse energy market.

4. Purpose of the research

Car companies are working on improved pollution control technologies and engine management systems in light of the "new emission standards" that were recently implemented. In 1992, this concept was developed to establish limits on emissions from heavy-duty diesel vehicles' tailpipes as part of the European Regulation (Euro-I) **(Tabatabaei, 2019).** The Euro-II and Euro-III standards, built on top of this standard, were introduced in 1996 and 1999, respectively. As a result of innovations in power generation and technology, stricter standards are expected to be implemented in 2005 (Euro-IV) and 2008 (Euro-V). Cars that aren't well-maintained can contribute significantly to pollution levels. Any fleet of operational vehicles may benefit greatly from inspection and maintenance (I&M) programmes, which are the gold standard for detecting high emitters. Encourage proper vehicle maintenance and "boost" the auto repair industry with the help of civic education and vocational training. Despite differences in testing procedures, both new and used diesel vehicles are subject to comparable laws in the US and Japan. Every vehicle in Hong Kong is required by law to comply with the city's strict pollution and noise regulations. Programmes for inspection and maintenance also include measures to reduce smoke and conduct annual emission testing **(Ahmet, 2020).** The levels of exhaust pollutants are tracked in all operational vehicle fleets. Legislatively mandated restrictions like this not only cut down on exhaust pollution but also save a ton of power thanks to "improved" combustion.

5. Literature Review

As of right now, petrol and diesel are the two types of motor fuel that are utilised the most often, and the amount of petroleum that is used annually has increased dramatically over the course of various decades **(Zhang, 2020).** It is anticipated that this pattern will continue. In response to the growing concern over the depletion of fossil fuels, the protection of natural resources, and the preservation of the environment, a wide range of recently produced fuels have been developed. Nevertheless, only a select handful are permitted for broad usage. The use of biodiesel has been widespread in both Europe and the United States for more than a decade, and its popularity is only expected to continue to grow. Ingredients such as vegetable oils, animal fats, and even lipids that have been used in the past are examples of feedstocks that may be utilised. Biodiesel, on the other hand, may contribute to the diversification of energy sources, the reduction of air pollution, and the reduction of emissions of greenhouse gases **(Zhang, 2020).** Although biodiesel and petroleum diesel are often used interchangeably, there are significant differences between the two in terms of their physical and chemical properties. The alterations that have taken place have a direct impact on the variations that occur in engine performance, the behaviour of exhaust emissions, and fuel economy. The great majority of the research that has been conducted on biodiesel has been conducted on an engine dynamometer, which does not adequately represent the real emissions of an in-service vehicle fleet under varied power needs. However, biodiesel has been the topic of a number of studies.
When it comes to deciding whether or not biodiesel will be brought into the local fuel market, roadworthiness has emerged as a crucial factor. The truth is that dynamometer testing does not reveal the impact that biodiesel has on the compatibility and durability of engine components. According to the findings of earlier studies, biodiesel has a number of negative effects on the operation of engines. These negative effects include, among other things, the destruction of certain kinds of

elastomers, the loosening of deposits, and the diminishment of engine oil. The inherent limitations of biodiesel may be solved by raising the quality of the biodiesel and by utilising suitable materials to replace the affected areas in the fuel system. This is despite the fact that biodiesel has inherent downsides **(Guercio, 2021).** Because of this, the general people may continue to consume biodiesel without suffering any adverse effects.

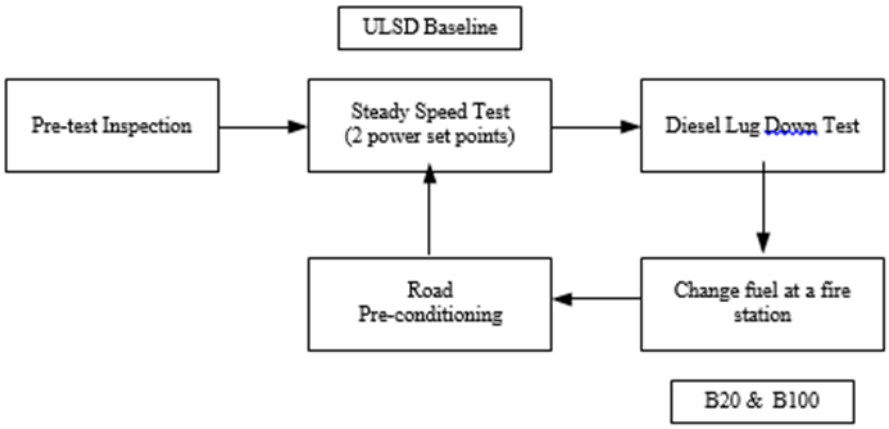
6. Research Questions

1. What are the "impacts of various biodiesel fuels and their fuel blends on vehicular exhaust" emissions?
2. How much roadworthiness matters?

7. Research Methodology

The decision was taken to "start with an ultralow sulphur diesel (ULSD)," which is a kind of diesel fuel that is derived from petroleum and has just 0.01 percent sulphur out of its total weight composition. When compared to low sulphur diesel, which contains 0.035 percent sulphur, the usage of Ultra Low Sulphur Diesel (ULSD) results in an immediate reduction in particulate matter (PM) and sulphur oxide (SOx) emissions. When it comes to packed city traffic, ULSD is a better option than other options because of these benefits. The year 2000 marked the beginning of the implementation of ULSD, which was made possible with the assistance of the government of the HKSAR. In an effort to promote fuel, tax deductions were provided. At the present time, ultra-low sulphur diesel (ULSD) is the only statutory motor diesel fuel in Hong Kong, and it is easily accessible at all of the city's petroleum stations.
Three different types of biodiesel fuel were put through their paces during this investigation: Biodiesel A, Biodiesel B, and Biodiesel C. Despite the fact that Biodiesel B was produced locally, Biodiesel A and C were imported into Europe. Waste lipids were used in the production of all three biodiesel products, with the exception of the second biodiesel. A comprehensive fuel analysis was performed on each and every one of the fuels in order to verify that they were following the Hong Kong biodiesel standards.

8. Conceptual Framework of the Study



9. Results

The performance of two automobiles (R1 and R2) and four different biodiesel fuels was compared.
The results are tallied up in Table below. Even though the cars' maximum engine power was relatively stable across the measurement period, switching to plain biodiesel resulted in significant decreases in smoke opacity (R1: -81%, down from 26 HSU to 5 HSU and R2: -56%, decreased from 24 HSU to 11 HSU). It was observed that the smoke opacity of R1 decreased with time when biodiesel was used. Furthermore, the ultimate ULSD emission test results were significantly lower than the starting levels. This finding suggests that both biodiesel fuels had a purifying impact on the test cars' engines, leading to less polluting emissions.

R1					
Test Date	24-Sept-01	24-Sept-01	24-Oct-01	11-Dec-01	18-Dec-01
Test Fuel	ULSD	Biodiesel A B100	B10 Biodiesel A	B10 Biodiesel A	ULSD
FAS Smoke Level (HSU)	28	8	5	4	13
DLD Maximum Engine Power (kW)	46	45	46	48	50
DLD Maximum Smoke Level (HSU)	26	6	5	4	18
R2					
Test Date	17-Aug-01	17-Aug-01	18-Sept-01	18-Oct-01	5-Nov-01
Test Fuel	ULSD	Biodiesel B	Biodiesel B	B10 Biodiesel B	B100 B100
FAS Smoke Level (HSU)	26	11	12	13	44
DLD Maximum Engine Power (kW)	45	44	43	45	45
DLD Maximum Smoke Level (HSU)	24	11	11	10	21

10. Research Design

At a speed of fifty miles per hour, the air-cooled eddy current power absorption unit (PAU) that is included inside the Clayton Industries model ECCT500108 chassis dynamometer has the capacity to produce a maximum of five hundred horsepower. Two opacity metres were used to assess the smoke opacity of tailpipe emissions. These metres were the SPX Dieseltune model DX230 (for the dynamometer test) and the Lucas model YDA309 (for the on-road emission test). In order to monitor the speed of the engine during the on-road emission test, AVL model 490 engine tachometers were used. Furthermore, Luca's type YDA133 tachometers were utilised during the dynamometer test. In order to detect carbon monoxide and nitrogen oxide emissions, a chemical cell combustion analyzer (model IGD Tocsin 310) manufactured by Richard Oliver Ltd. was used. On the other hand, a Beckman Industrial Model 400A FID non-heated HC analyzer was designed to measure hydrocarbon emissions.

In-house testing of vehicle performance is possible via the use of a chassis dynamometer emission testing equipment that is fully automated. For the purpose of controlling the system, which mimics driving traces that are precise and reproducible, a computer console is used. It makes it possible to test the vehicle in a way that has been set. Since 1999, the government of the Hong Kong Special Administrative Region (HKSAR) has been using this cutting-edge technology in order to run the Smoky Vehicle Control Programme. To this day, more than one hundred thousand automobiles have been tested using this approach.

11. Data Analysis

It was proposed that firemen at a nearby fire station replace the fuel while emissions were being measured using a chassis dynamometer. This was part of a complete testing schedule that was being carried out. During the test run, the whole process was carried out in order to verify and assess the effectiveness of the suggested method.

The first dynamometer testing process was changed to two-power steady speed tests when it was discovered that the tyres were slipping during the start-up run. This was done in order to more precisely represent the situations that are encountered while driving in the real world. Two distinct power set-points, twenty percent and fifty percent of the engine's rated output were used in order to replicate operations under varying levels of demand.

This testing could not be "finished in a single day" because "inter-day and" day-to-day fluctuations were evaluated to ensure the validity of the test methodologies and the stability of the instrument. This was due to the fact that the time and effort required in this testing was significant.

12. Discussion

A comprehensive analysis was conducted to determine the feasibility of using biodiesel as a vehicle fuel in Hong Kong. Biodiesel fuel did not quickly degrade the engine system, according to road tests measuring emissions and durability. It was also done to examine whether engine components may be affected by biodiesel blends. The dimensional test, tensile test, and bursting test were three of the criteria used to examine the physical properties of biodiesel blends using four different fuel hoses. Using biodiesel has the potential to reduce emissions of greenhouse gases, a major factor in the issue of climate change. Biodiesel is a practical way to reduce diesel use each year, which is important due to environmental concerns and the "depletion" of fossil fuels.

13. Conclusion

In order to assess whether or not biodiesel might be used as a fuel for motor vehicles in Hong Kong, a substantial amount of study was carried out. According to the results of roadside emission and durability tests, biodiesel fuel did not harm the engine system in a short amount of time. Using four distinct gasoline hoses and three criteria, including dimension, tensile, and bursting tests, research was carried out to investigate the physical characteristics of biodiesel mixes.

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