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Role of biofuel and their binary (diesel–biodiesel) and ternary (ethanol–biodiesel–diesel) blends on internal combustion engines emission reduction

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ABSTRACT

Exhaust emission from transportation sector affects the human health. It is the main contributor to degrade the air quality. Biofuel is promising alternative to maintain both human health and environment quality better by reducing harmful emission from biofuel runs diesel engines. This study explores the global and Australian greenhouse gas (GHG) emission scenario along with the contribution of transportation sector to the GHG emission in Australia. Besides, the world biofuel standard with the target and mandate taken by the government of different countries to use biofuel are also discussed in the paper. This review indicated that engine emission is dependant on some factors such as engine operating condition, biofuel types, blending etc. Both biodiesel–diesel and ethanol–biodiesel–diesel blending plays a significant role in reducing the exhaust gas emission such as carbon monoxides (CO), hydrocarbons (HC), particulate matter (PM). But ethanol–biodiesel–diesel and biodiesel–diesel blends produce higher carbon dioxides emission, which is absorbed by the crops and considered as lower net CO_2 emission. Finally, about 5–10% of ethanol with 20–25% biodiesel can be added with petro-diesel effectively and efficiently to reduce global GHG emission, thus to maintain environment and human health better.

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1. Introduction

Air is the nectar in life and without air life is not sustainable. But air is polluting due to the noxious gases and particulate matter of highly toxic substances that are dangerous for health. It is very important to maintain the good quality of air as an adult male normally breathe 10.8 m^3 of air per day [1]. The air we inhale every day is mainly comprised of 78% nitrogen and 21% oxygen and small amount of suspended particles that are presents in the air have vast impact on human health [2].

Rapid growth of the number of vehicle industry in the world has resulted in increase of exhaust emissions to the environment. Vehicular emissions such as particulate matter (PM), hydro carbon (HC), carbon dioxides (CO_2), carbon monoxides (CO) and nitrogen oxides (NO_x) are hugely responsible for the air quality deterioration [3]. Two main internal combustion engine types such as petrol engine and diesel engine contribute to degrade the air quality in the urban environment [4].

About 22% global GHG (greenhouse gas) emissions come from the transportation sector due to the increasing demand of vehicles as shown in Fig. 1 [5,6]. The fast emission growth was driven by emissions from road transport sector which increased by 52% since 1990 and accounted for three quarters of transport emission in 2011 [6]. The International Energy Agency (IEA) forecasts that the emissions of carbon dioxide (CO_2) from transport sector will increase by 92% between 1990 and 2020 and it is estimated that 8.6 billion metric tons carbon dioxide will be released to the atmosphere from 2020 to 2035 [4]. Fig. 2 shows the top 10 CO_2 emitter countries in the world [7]. It has been also reported that, an increase in average global temperature by 2 °C will result in death of hundreds of millions of people [8].

Transportation system has a great importance for social and economic development of any country. The rising issue for transportation sector is the energy which mainly fulfilled by gasoline and diesel fuel. Globally 1.1% in average energy consumption is increased in the transportation sector every year. The transportation sector accounts for the largest share (63%) of the total growth in world consumption of petroleum and other liquid fuels from 2010 to 2040 [9].

It is very urgent to find out alternative fuels for transportation sector as this sector is emitting higher GHG emission and contribute to the rapid growth of global oil demand. [2]. Recently, attention has been drawn to develop cleaner alternative fuels from renewable sources to reduce the harmful emission to air and to reduce the dependency on the petro-diesel fuel [10].

Biofuels are considered as a cleaner fuel for internal combustion engines in the transportation sector due to their renewable property and reduction of fossil CO_2 discharge which significantly contributes to the global climate changes [11,12]. The most feasible cleaner fuel for vehicles being considered globally is biofuel such as biodiesel and ethanol [3]. Ethanol is produced from a number of crops such as potatoes, sugarcane, grains, corn and sorghum etc. [13]. On the other hand, biodiesel is produced from vegetable oils, recycled waste vegetable oils, and animal fats [14–16]. However, there are many technical barriers for the direct use of ethanol in diesel fuel due to the properties of ethanol, including low cetane number, poor solubility in diesel fuel in cold weather and lower flash point. Biodiesel can be mixed with both ethanol and diesel; using biodiesel as an emulsifier ethanol and diesel can be blended together and can be used as biodiesel–ethanol–diesel blends in diesel engines [17]. This paper presents a comprehensive review on the potential reduction of worldwide IC engines emission using biofuel, biofuel development and the targets and policies set by governments of different countries, overview of emission scenario and the contribution of transportation sector to CO_2 emission in Australia. A large number of literatures from highly rated journals in scientific indexes are reviewed including the most recent publications to provide the information to the researchers, policy makers and those who are interested on biofuel.

2. Overview of Australian emission scenario

Australia's emissions were in 580 Mt CO_2-e and 586 Mt CO_2-e in the year of 1990 and 2000 respectively. It is estimated to reach 685 Mt CO_2-e and 801 Mt CO_2-e in 2020 and 2030 respectively, taking consideration of pre-existing energy efficiency and renewable energy measures. Projected emissions growth to 2020 is dominated by direct combustion and fugitive emissions linked to the production of energy sources, particularly export demand for Australian LNG and coal. Emissions from direct combustion and fugitives continue to grow, associated with continued demand for Australia's energy resources [18]. The level of growth within the direct combustion and fugitives sectors is more moderate than the preceding decade. Table 1 and Fig. 3 show the projected emissions trend 1990–2030 in Australia.

3. Contribution of transportation sector to CO_2 emission in Australia

The transport sector covers emissions from the direct combustion (or end-use emissions) of fuels by road, rail, domestic aviation and domestic shipping. It has been reported that there were 13.9 million petrol powered vehicles registered in 2014 accounting for 78.8% of the total vehicle fleet Australia wide. In comparison, there were 3.3 million diesel powered vehicles accounting for 18.5% of the fleet. It is to be noted that in last five year period from 2009 to date, the number of Passenger vehicles and Light Commercial vehicles registered with diesel fuel increased by 103.6% and 65.4% respectively [19]. Transport emissions were 91 Mt CO_2-e in 2012, contributing 15% of Australia's total domestic emissions [18]. Within the transport sector, road transport is the largest subsector contributing 84% of all transport emissions in 2012. Emissions from transport sectors are projected to reach 99 Mt CO_2-e in 2020 and 106 Mt CO_2-e in 2030. Road

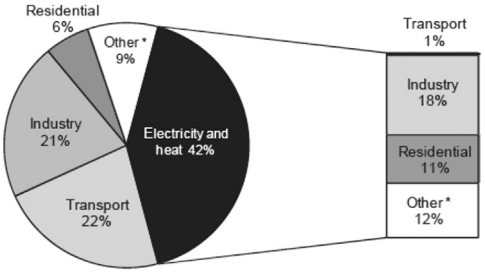

Fig. 1. CO_2 emission by sectors [5,6].

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