HEALTH EFFECT OF EMISSION FROM ELECTRIC AND BIO-DIESEL VEHICLES – A REVIEW

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ABSTRACT

The transport vehicles have been using the internal combustion engine for many decades. The internal combustion engine is used because of their high reliability. The transport sector plays a vital role in the country’s economy. It is estimated that about 90% of the transportation sector uses fossil fuels. With the increasing industrialization, there will be a shortage of fossil fuels. Every year there is an increase in the energy demand by 2%, stated by International Energy Agency Report. There would be 39% increase in the greenhouse gas emission by the year 2030 from fossil fuels. With the rising concern about climate change and the increasing amount of toxic emissions, manufacturers of the car are getting aware and are shifting towards less polluting vehicles or green vehicles. Biodiesel is also gaining interest and is being preferred because of its continued availability, emission characteristics showed that biodiesel have low CO emission. With addition of ethanol the emission of CO further decreases but NO\textsubscript{x} emission increases. NO\textsubscript{x} decreased with jatropha methyl ester & 50% turpentine oil. On the other hand use of electric vehicle or hybrid electric vehicle would also decrease the emission by 51% but would increase the load on power grid by 3% for every 30% penetration. Which would increase the emission/air pollution from the thermal power plant. Emission in the human body can cause illness, increase the death of can be hazardous to the health of humans. This paper gives a review of the emissions from biodiesel and electric vehicles and the health effects.
Key words: Electric Vehicle, Bio-diesel, Health effect, NOₓ, CO.

INTRODUCTION

The transport vehicles have been using the internal combustion engine for many decades. Internal combustion engine is used because of their high reliability. The transport sector plays a vital role in the country’s economy. The transport fleet mainly uses fossil fuels for their working. The major use is petrol and diesel in the fleet. It is estimated that about 90% of the transportation sector uses fossil fuels. With the increasing industrialization, there will be a shortage of fossil fuels. The energy resources are less in amount and accessibility to the resources are difficult. Theses fuels produce a lot of emissions. The emissions are CO, HC, NOₓ & greenhouse gases. Every year there is an increase in the energy demand by 2%, stated by International Energy Agency Report (Aaron et al., 2018). There would be 39% increase in the greenhouse gas emission by the year 2030 from the fossil fuels (Kamalesh et al., 2015). The rising emission for the vehicles has made us think about the alternative fuels and hybridization of the vehicles. There is an immense need to curb the fuel crisis. Fossil fuel emissions can lead to problems related to health, respiratory issue (asthma).

With the rising concern about climate change and the increasing amount of toxic emissions, manufacturers of the car are getting aware and are shifting towards less polluting vehicles or green vehicles. Hybrid and electric vehicles are green vehicles and alternate fuels. Japan was the first country to introduce a hybrid electric vehicle commercially. In the year 2015, the penetration of the hybrid electric vehicle in the Japanese houses were 9.8%, reported by the Ministry of Internal Affairs and Communication (Mitsutsugu, 2019). The Chinese government also showed interest in developing the electric vehicle, because of the rising pollution and because of which the Chinese government changed their policy (Ang et al., 2018).

Fire, Volcanoes etc releases different types of pollutants to the environment. But the major cause of air pollution in the environment is because of anthropogenic activities. Many
industries and vehicles release air pollutants which causes a lot of harm to the environment and human health. Air pollutants in the human body can cause illness, increase the death of can be hazardous to the health of humans (Marilena et al., 2008).

**BIODIESEL**

Biodiesel is generally produced from vegetable oils or animal fats by the process of transesterification. Rudolf Diesel (1858-1913) was the one who originated the use of vegetable oil to be possibly used as engine fuel. He was the one who ran the primary engine with vegetable fuel (E. Sadeghinezhad et al., 2013). It is being preferred because of its continued availability, emission characteristics and the limited resources and increasing demand for petroleum increases the demand for biodiesel. It is growing popularity as an alternative fuel because of its environmental and profitable benefits. An essential source of energy is the vegetable oils. But the oils can create many problems in the engine components. The different molecular structure, volatility and the higher viscosity are the reasons for the engine component problems (P. McCarthy et al., 2011). Vegetable oils can be obtained from various sources. Glyceride is the vegetable oil can be considered as an alternative for diesel fuel. They have very less sulfur and aromatic polycyclic compound in the exhaust emission and have good heating power. As these oils are produced from plants when they are burnt they produce recyclable carbon dioxide (Mustafa et al., 2008). The higher cetane number of biodiesel is because of the long chain fatty acids with 2–3 double bonds. The oxygen content is around 10-11% oxygen by weight. Because of these characteristics the emission of particulate matter, carbon monoxide and hydrocarbon is reduced in the biodiesel. However, the NOx emission is more by 11% in the biodiesel (S. Rajesh et al., 2008). Micro algae biodiesel are the newly emerging field because of the derivation of high potential bio-diesel. Though the biodiesel has lower HHV (higher heating value) than petroleum fuels but it is higher than coal. Micro algae have the advantage of being environment-friendly thought the production cost of this biodiesel
is double the cost of petroleum oil (A.Avinash et al., 2015). In recent years the use of nanomaterials has gained popularity. The nanomaterials used in the diesel enriches the diesel fuel property. It helps in the completion of the combustion process. It also helps in the reduction of pollution and gives better engine performance. In some research papers, diesel fuel were mixed with water in different volume concentration. Triton X-100 surfactant was used to in the diesel fuel to stabilize the water. 0.9 vol% water sample slowed the decrease in pollution (Ehsanollah et al., 2018).

**ELECTRIC VEHICLE**

The Electric vehicle was first constructed by Frenchman Gustave Trouvé in the year 1881. He built a tricycle which was powered by 0.1-hp DC motor and a lead acid battery. The weight of the vehicle and including the drive was 160 kg. Morris and Salom’s Electrobat were the first electric vehicle commercially. Both the car was installed with a 1.5 hp motor. Almost after 18 years the first hybrid electric vehicle was reported, Paris Salon show in 1899. Pieper’s was a parallel hybrid electric vehicle with an electric motor and a gasoline engine which was air cooled. The gasoline engine used to charge the battery of the vehicle while coasting and standstill. The motor used to work when power was required more than the engine power. In the year 1997, Toyota took the initiative to develop and commercialize hybrid electric vehicles and released Prius sedan. The civic hybrid was brought out by Honda (Mehrdad et al., 2009). Electric vehicles and hybrid electric vehicles are solutions for reducing pollution from the vehicle exhaust. It has also been observed that the registration of electric vehicles and the hybrid electric vehicles is increasing day by day. Energy efficiency was improved and low pollution was reported from the hybrid electric vehicle from the previous work (Alberto et al., 2018). But the conventional vehicles are cheaper than electric vehicles and hybrid electric vehicles. The Indian government have invested in renewable energy sources like wind energy and solar energy and wants to increase their infrastructure. National Mission on electrical
mobility was launched, which helps in creating a demand of about 5 to 7 million electric vehicles (two-wheeler, light vehicles, buses and commercial vehicles by 2020 (Anu et al., 2015).

**AIR POLLUTION**

Gaseous pollutants contribute to air pollution and the burning of fossil fuels are the main reason. NO₂ are formed when ozone reacts to NO. The smell of NO is very bad. Generally, nitrogen dioxide that is formed in the atmosphere are either because of lightening or are produced by water, soil and plants. However, the formation of nitrogen oxide naturally or in this way only contributes to 1% of the total NO in our atmosphere. Vehicles using fossil fuels contribute to almost 80% of the nitrogen oxide in the atmosphere. Nitrogen dioxide is also produced by the power stations which are run by coal, metal refineries and other manufacturing industries. Most of the NO is formed because of fossil fuels. Formation of NO₂ is shown in equation 1. NO is very important to understand as it is the major contributor to the formation of photochemical smog. Nitrogen oxide is mainly formed by the burning of fossil fuels. In a research, it was found that the NO₅ emission due to the vehicles at traffic congestion in the year 2006 was 39.59 x 10⁴ tons, which increased to 43.68 x 10⁴ tons by the year 2010 and by 2015 the emission of NO₅ was 49.19 x 10⁴ tons. From 2006 to 2015 there is an increase of 24.24% in the emission of NO₅ (Zhuang et al., 2019 & Rafael et al., 2020).

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2NO + O_2 \rightarrow 2NO_2
\]

\[
NO + O_3 \rightarrow NO_2 + O_2 \quad (1)
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When there is incomplete combustion CO is formed. It is formed because of the incomplete oxidation process. Amount of Air fuel mixture defines the CO formation. Generally, during the start of the engine, the engine requires a rich mixture. During that time the formation of CO is more because enough air is not available for conversion of carbon to CO₂. Even in the condition of less swirl, insufficient swirl or large diesel droplet size the CO is formed (Ibrahim et al.,
Whereas SO$_2$ is formed when burning of fossil fuels which contains Sulphur. Therefore, air pollution has a different composition and varied time of exposure which leads to different effects in human health. Different human impact can range from difficulty in breathing, cancer, Nausea and skin irritation. It has also been observed that the air pollution effects the newborn infants and children the most (Marilena et al., 2008).

**BIODIESEL AND ITS TYPES**

**Jatropha Oil**

Jatropha Curcas L. is a large shrub or small tree. The tree can be tall up to 5-7m which belongs to Euphorbiaceae family and has a life of 50 years. Jatropha oil is an excellent source of biodiesel. The plant leaves have 4-6 lob, 10-15cm in width and length and are smooth. The Jatropha curcas seeds are used for the production of Jatropha oil. The jatropha plants can be grown in the wastelands. Jatropha plants seeds can give about 40% oil. The oil is extracted from the seed by manual ram press. The manual ram press can extract about 60-65% oil (W.M.J. Achten et al., 2008 & Jungmin et al., 2019). It was observed that the Jatropha oil improves the brake power, specific fuel consumption and brake thermal efficiency. 100 % biodiesel blend had lower HRR-max. Jatropha has a higher viscosity, which leads to inferior atomization. The production of CO, HC and NO$_x$ was less compared to conventional diesel fuels (Chetankumar et al., 2019).

**Karanja Oil**

Karanja is also known as Pongamia pinnat. It is a plant which grows abundantly along the riverbanks & coastlines. The plant requires very less land for the growth but it requires ample sunshine overhead in the initial stage. In India, the plant could be found from Kanyakumari to the Himalayan foothills. The seedcases of Karanja plant are shaped elliptical and contain only one seed. The size of the pods is 2-3cm in width and 3-6cm in length, with a thick wall. The seeds are inside the pods, size of the seed varies between 10-20mm and are brown in colour.
The oil output of the seed is about 29-39%. As di-ketone pongamol and karanjin toxin are present in the karanja oil, it makes it non-edible oil. The annual yield of karanja is about 2-4 t/hector/year (Rupesh et al., 2017). Karanja is a non-edible oil and has a promising feedstock. It was seen that the Karanja oil had similar properties to diesel and could be grown on wasteland easily. The karanja plant can yield about 96% biodiesel by transesterification. The karanja oil has been treated by transesterification for the use as biodiesel (Shubham et al., 2019). The cetane no of 100% Karanja oil was found to be 50.8 whereas the mineral diesel oil is found to be 51.2 (Sanghoon et al., 2017). The biodiesel at higher load and engine speed showed lower CO emission. The hydrocarbon and NO\textsubscript{x} emission was higher when compared to conventional diesel at lower loads and engine speed. Increase in emission by 20.73% was observed by the use of Karanja. Increasing the combustion temperature, boosting combustion phasing, the difference in oxygen content of the biodiesel and the difference of the chemical composition of diesel and biodiesel are the reason for the NO\textsubscript{x} emission (Atul et al., 2014 & Pankaj et al., 2019).

**PALM OIL**

Elaeis guineensis, the fruit of the palm tree gives two different types of oil. When the palm fruit is mesocraped, palm oil is obtained. The outer pulp of the fruit comprises of Kernels, which becomes a source of palm kernels oil. The two different oils are derived from the same fruit but have different properties & characteristics. C16:0 and C18:1 fatty acid are rich in palm oil (Oi-Ming et al., 2012). Figure 1 shows the palm mill conventional system. The production of palm oil requires a lot of natural resources such as water and forest land. But the production of the palm oil conduces to a lot of pollution to
Nutrients from the fertilized fields were leached. Acidifying compounds were from the mills and fiber combustion in the boilers were the reason for smog precursors (Kanokwan et al., 2017). Indonesia is the largest producer of palm oil. The combined heat and power of the conventional palm oil mills are 2.0 MPa and 350°C steam. The boiler efficiency is low to about 70%. The biodiesel plant receives its raw material i.e the crude palm oil from the palm oil mill. Co-product glycerol is also produced from the plant where biodiesel is the main product (Fumi et al., 2019). It is one of the maximum oil-producing plant, Palm oil. The palm tree is suited for grown in India because of its tropical climate (S. Senthilkumar et al., 2015). Palm oil with diesel in a combination of B30 showed lower NOx at 10% EGR. But particulate matter were always less than 100 nm (Jun et al., 2020).

**COCONUT OIL**

Coconut oil, Jatropha and palm oil are the main components of the biodiesel source in Asia (H.G. How et al., 2014). Coconut oil is available in large quantity in Asia. It is low in cost and is a non-edible oil. Coconut oil has short chain length (C12 & C14) unlike other natural oils, this reduces the viscosity in the biodiesel (Ting et al., 2016). The high amount of saturated fatty acids in coconut biodiesel made it have a lower flame temperature than diesel (Changhwan et al. 2016). Coconut has free fatty acid percentage of 12.8%(lauric acid), having 25.5 mg KOH/g acidic value in the oil. The oil has a brown colour. The oil is prepared by transesterification which is a chemically reversible process, also known as alcoholsysis, this removes all the water.
molecules. The viscosity of the triglyceride is reduced by this process. Coconut oil has a high viscosity and low volatility same like the vegetable oils (Piyanuch et al., 2010 & Azeem et al., 2019). Because of these atomizing and mixing the oil with air is difficult, cannot be used directly in the diesel engine. Coconut biodiesel have a high quantity of lower molecular weight methyl ester (M.Habibullah et al., 2014). The tropical eastern region is the native for coconut. Coconut is mainly grown in central and south America, throughout the Asian continent and some parts of Africa. Coconut palm tree can produce 75 fruits in a year (João et al., 2010).

**MORINGA OIL**

Oleifera tree belongs to the sub-Himalayan regions of northwest India family. It is grown in Arabia, Pacific, Caribbean island, south Asia, Africa and South America. Mainly the oil is distributed in Cambodia, Tanzania, Philippines and Central & North America. This plant has the capacity to tolerate soil pH, poor soil condition and rainfall varying between 23-300 cm/year. 33-44% w/w vegetable oil could be produced from the moringa plant. The oleic acid content in the moringa oleifera oil is more than 70%. It is being used in effleurage process and possesses resistance to oxidative degradation. This biodiesel has the highest cetane number. The cetane number is about 62.12, determined by Waukesha CFR F-5, with a varying density between 860kg/m3 to 900kg/m3 (G.Kafuku et al., 2010). The biodiesel can be prepared by the oil without any wastage. Transesterification of moringa oil to biodiesel by the use of 1 wt. % KOCH3 catalyst (Samuel et al., 2019). The MO seeds contain 39%(wt%) oil and fatty acids. The oil contains about 19% saturated fatty acids and unsaturated fatty acids of 81%. It was also seen that 98 wt% in methyl esters were also found (Jhosianna et al., 2010).

**SOYBEAN OIL**

Victoria was the first to produce Soybean commercially in the year 1980. Soybean is a crop which grows in irrigated summers. The crop suits climate which is high in temperature and longer days. It is mainly used in the meal of stock feed industries and for oil extraction. Soybean
is produced in large quantity in Brazil. Cultivation of 35 million hectares in the year 2017/18 (Rogério et al., 2019). The yield of soybean oil is more than the yield of sunflower oil. The comparison shows that yield of soybean to sunflower is 2,668 kg/ha & 1500 kg/ha respectively. Soybean contains only 18% oil compared to sunflower oil which contains 26% oil. In the production of the soybean oil, nearly no nitrogen is used. To produce 1000kg of soybean oil 5556kg of soybean is required. Net loss in energy is 8% (David et al., 2005). The oil has high brake specific fuel consumption, because of lower heating value, compared to diesel about 10.2% lower. This biodiesel blend showed lower CO and HC emission because of the presence of oxygen atoms in the fuel (D. Subramaniam et al., 2013) but NOx emission are higher (Medhat et al., 2019).

**TYPES OF ELECTRIC VEHICLES**

**BATTERY ELECTRIC VEHICLES**

When an internal combustion engine is replaced by electric motors which are powered by a battery in a vehicle, are known as Battery Electric vehicle. The battery of the battery electric vehicle is charged by connecting it into a charging spot when the vehicle is idle. There are many advantages of the battery electric vehicle, firstly they are less polluting and do not harm the environment and secondly, they are highly efficient and could be charged in the night so that the car could be used in the day time. The only main disadvantage of battery electric vehicle is their high initial cost, and it is the main barrier between the customers. Cost of battery would decrease with technological evolution, as shown in figure 2. The customers have range anxiety. They think the trip would not be completed in one charge and the time required for charging the vehicle also takes time, unlike conventional vehicle in which one does not have to worry about the range. The range of anxiety is accelerated with a lower number of charging infrastructure. The range of the cars and the capacity of the battery are not linear. Many other factors reduce the efficiency of the battery. The batter of the BEV plays a vital role in the cost
of the vehicle. According to the International Energy Agency, the battery price of the BEV should be less than USD 300/kWh, of the BEV are to be made popular. Battery management system is an important component in the BEV. The main function of the BMS is to determine the state of charge, remaining useful life and state of health of the battery. BMS also helps the battery to run in a safe, undamaged and efficient way. The motor used in the BEV is also important. Mainly DC motor is suitable for EV. They are simple in use, the control system is simple and least costly. AC motor can also be used, as they are less expensive but the electronics used are expensive and complicated (Amin et al., 2017).

**HYBRID ELECTRIC VEHICLE**

**SERIES HYBRIS ELECTRIC VEHICLE**

When a small internal combustion engine is added to an electric vehicle, it becomes a hybrid electric vehicle. The internal combustion engine helps in balancing the energy shortage form the battery electric vehicle. Because of the simple structure of the series hybrid electric vehicle as shown in figure 3, it is primarily used in heavy commercial vehicles. There are many advantages of a series hybrid
electric vehicle. The torque is from a single motor (source), which becomes simpler to control the speed. Mechanical decoupling between the driven wheel and the internal combustion engine. HEV has a simple structure, easy packaging and drivetrain control. Whereas conversion of energy is two times, induces energy loss. Torque source for the wheels is only the traction motor (Mehrdad et al., 2009).

**PARALLEL HYBRID ELECTRIC VEHICLE**

Through a mechanical coupling the electric motor and the internal combustion engine both can power the wheel individually. Mechanical coupling could be a single axle, pulley belt, gear box or sprocket-chain. As a mechanical coupling (mechanical coupling hybrid drivetrain) is being used, engine operating condition cannot be fixed. But as there is less conversion of power, therefore the power loss is less unlike Series hybrid electric vehicle. Both the engine and the motor can supply power to the wheel therefore the losses are less as depicted in figure 4. And as there is no generator like the Series-HEV the structure is simpler and compact. Because of these advantages the parallel-HEV are preferred in the passenger vehicles (Mehrdad et al., 2009 & Yimin et al., 2006).
SERIES–PARALLEL HYBRID ELECTRIC VEHICLE

Disadvantages of both series-HEV and parallel-HEV are overcome in the series-parallel hybrid electric vehicle (Yimin et al., 2006). The planetary gear system is used in Series-Parallel Hybrid electric vehicle as shown in figure 5. It is used to decouple the engine speed from the wheel.

The engine, motor and the planetary gear make the series flow of power as shown in figure 6. Motor works in the opposite direction of the torque, it is generating power. Engine speed is divided to reach the generator and the other to the drivetrain as depicted in figure 7. When the generator is positive, it works to provide power to the wheels. The famous series-parallel architecture that became famous was the Toyota Hybrid System, allowing all power demand
and gave a good performance. For off-road vehicles, series-hybrid architecture is fresh. The engine is at its highest operating region giving best efficiency by the control strategy, depending on the battery state of charge and power request. HEV mainly operate on charge sustain mode (Mehrdad et al., 2009 & Yiming et al., 2012).

Figure 6: Planetary gear system (Mehrdad et al., 2009)

Figure 7: Series-parallel hybrid electric powertrain block diagram

PLUG-IN HYBRID ELECTRIC VEHICLE

Plug-in hybrid electric vehicles have similar architecture and components like the conventional hybrid-electric vehicle depicted in figure 8. In both the vehicles IC engine and electric motor drivetrain are connected to each other, and are connected to the road. PHEV has an additional charging port extra than the HEV, which helps PHEV to charge and stock energy when connected to a charging point. PHEV have fuel energy and battery energy which can be used
individually or together. This system helps the PHEV to driven with lower emissions, better efficiency, low cost and high performance than the HEV. Plug-in electric vehicle different power management modes: 1. Electric Vehicle Mode 2. Internal Engine Mode 3. Charge Depleting Mode 4. Charge Sustaining Mode, switching between the modes can be automatic or dependent on the driving condition. PHEV have batteries or regenerative which are used to store energy. PHEV has a power management task, which monitors the battery state of charge. But replacing the battery is very costly, and is a potential component of vehicle lifecycle cost. It is estimated that the battery has a life of 10 years or 161,000 to 210,000 km (Yiming et al., 2012 & Thomas et al., 2009).

![PHEV outline](https://example.com/figure8.png)

**Figure 8: PHEV outline (Thomas et al., 2009)**

**EXHAUST EMISSION ANALYSIS**

The exhaust gas temperature of the coconut biodiesel blend showed at 100% throttle the 15% coconut biodiesel blend showed the maximum exhaust temperature which was about 3.33% more than 100% Diesel exhaust temperature. But in the case of 8-% throttle condition, the maximum exhaust temperature was observed for CB15 having 5.96% higher temperature than 100% diesel fuel. It was also observed that the coconut biodiesel blend had low CO emissions
for both 100% and 80% throttle as shown in figure 8. CO$_2$ emission at 100% and 80% throttle at 2200rpm showed that CO$_2$ was more by 4.56% for 15% coconut biodiesel blend and even in the case for NO$_x$ emission (A.M Liaquat et al., 2013). Hydroxyl compounds solution-in-diesel emulsion, glucose solution-in-diesel emulsion, synthetic bio-oil-in-diesel emulsion and aldehydes solution-in-diesel emulsion was used to experiment the engine performance and the emission. It was observed that the exhaust gas temperature of the emulsion fuel and the diesel fuel did not have much difference with the engine load. The low exhaust temperature was because of the higher emulsion viscosity and because of which there were low-quality injection and incomplete combustion. CO emission increased with the engine load, because of at high load the fuel-rich mixture is more. CO is formed because of the incomplete combustion but in the case of biofuels the CO formed is less because the fuel is rich in oxygen. The NO$_x$ emission was increased for all test fuels with the increase in the load (Xingzhong et al., 2018 & K.A. Abed et al., 2019). The 50% Jatropha methyl ester and 50% turpentine oil emitted low NO$_x$ emission during the ideal condition, because of shorter combustion duration and ignition delay is high. Lower NO$_x$ was reported with pine oil and kapok methyl ester oil. It was also observed that the NO$_x$ emission was decreasing with increasing break Power (Pankaj et al., 2017 & A.K. Jeevanantham et al. 2020). The level of CO emission in dual fuel operation in which one fuel

![Figure 8: CO$_2$ and NO$_x$ relation with throttle (A.M Liaquat et al., 2013)](Error! Reference source not found.)
is natural gas and the other is biofuel is higher. The CO is converted to CO\textsubscript{2} because of incomplete combustion, low gas temperature and shortage of air (N. Panneerselvam et al., 2015). By changing the nozzle axis location CO was found to be low and NO\textsubscript{x} emission was more at high engine speed. Which was caused by the higher cylinder peak temperature (Amin et al., 2015). Use of Bio-fuel blend with methanol showed a increase in CO\textsubscript{2}, CO, NO\textsubscript{x} emission and suggested the use of Bio-fuel blends with alcohol as a substitute for conventional diesel fuel (S. Thiyagarajan et al., 2020). In another situation, the mixture of 20% biodiesel in 80% diesel helped in reduction of CO\textsubscript{2} by 12.6% & hydrocarbon by 11% in the city of Bangkok (Manjula et al., 2009). NO\textsubscript{x} emission from the cottonseed oil is higher than n-butanol or diethyl ether because the later oils have high cetane number & higher heating value. n-butanol or diethyl ether have low CO emission than cottonseed biodiesel blend and pure cottonseed oil (D.C. Rakopoulos, 2013 & Dimitrios et al., 2015). In another case it was seen that the NO\textsubscript{x} emission increased with the increase in heat release and the combustion, NO\textsubscript{x} was maximum at 100% load with 100% biodiesel. Emission was almost 17% higher than Diesel could be seen in figure 9. NO\textsubscript{x} emission was low with the addition of n-butanol to the biodiesel blend, lower temperature caused by the high latent heat of evaporation (S. Senthur et al., 2017). Sunflower oil blend and cottonseed oil blend showed NO\textsubscript{x} emission to be higher than diesel

![Figure 9: NO\textsubscript{x} variation with different biodiesel blend and load (S. Senthur et al., 2017)](image-url)
fuel, cottonseed biodiesel blend exhibited higher NO\textsubscript{x} emission. The HC produced form the Cottonseed biodiesel was higher than all other oils, but overall the biodiesel blends (cotton and sunflower) had higher HC emission than diesel (C.D. Rakopoulos et al., 2008). Bio-hydrogenated diesel was produced from fatty acid methyl ester and palm oil fatty acid distillate. They had a negative GHG emission because CO\textsubscript{2} was absorbed by the palm oil plants during cultivation of the plants. The palm trees are a CO\textsubscript{2} sink. Greenhouse gas emission from Bio-hydrogenated diesel by fatty acid methyl ester production was low than palm oil fatty acid distillate. Bio-hydrogenated diesel by fatty acid methyl ester production required 1.77kg of crude palm oil whereas Bio-hydrogenated diesel by palm oil fatty acid distillate required 44.44kg of crude palm oil in both cases there is 1kg of Bio-hydrogenated diesel (Bulin et al., 2017). When using cottonseed biodiesel 50% and ethanol 50% it was seen that the CO emission increased at lower loads with increasing ethanol content but in the case of NO\textsubscript{x} it was observed that the with an increase in ethanol the NO\textsubscript{x} emission reduces. Ethanol increased atomization by increasing viscosity (B. Prbakaran et al., 2018). In another case, soybean biodiesel was studied and was seen that 100% biodiesel had higher NO\textsubscript{x} emission, 19.2% more NO\textsubscript{x} emission (Suresh et al., 2018 & Suresh, 2020). Linseed Methyl Ester biodiesel was compared with base diesel and was observed that the biodiesel had low CO emission than base diesel. The diesel had 1.64% more CO emission. The hydrocarbon emission was lower than diesel for the Linseed Methyl Ester biodiesel (Narath et al., 2019). With the increase in biodiesel, the NO\textsubscript{x} emission also increases. cottonseed or sunflower biodiesel blend oils showed an increase in NO\textsubscript{x} emission with an increase in the Biodiesel blend (D.C. Rakopoulos, 2012).

Many different types of hybrid vehicle were studied. Greenhouse gas emission was reduced by 8% during the off-peak charging pattern. When Dutch grid was used for charging the electric vehicles in Greenhouse gas emission was 33-77 g Km\textsuperscript{-1}. Emission, when compared to conventional cars, was 51-78% lower. 30% penetration of electric vehicles would increase 3%
of the electricity demand. If the electricity is generated by natural gas then there would be 0 g km\(^{-1}\), but in the case of coal-based power plant, the GHG emission would be 155 g km\(^{-1}\) (Oscar et al., 2011). In another case, an experiment was conducted to test the fuel economy and emission of hybrid vehicles. The hybrid vehicle was found to produce less CO\(_2\) in city drive than highway (Georgios et al., 2008 & Hüseyin Turan Arat, 2019). Goods vehicle driven by Electric drive were estimated to reduce the CO\(_2\) emission. Predictions were made about the market share of the hybrid electric vehicles, 82% stock of hybrid electric vehicle and 65% of battery and fuel cell vehicles. Even if maximum hybridization was carried out, by 2050 diesel and gasoline vehicle will account for 52% of the energy consumption. CO\(_2\) emission would be reduced by 55.8% tank to wheel, by the battery electric vehicle and hybrid electric vehicle (Juan et al., 2012). The CO, NO\(_x\) & PM2.5 was reduced by 1500, 33.9 & 7.2 Gg yr\(^{-1}\) by the incursion of the electric vehicles by 20.6 million vehicle fleet in Taiwan. Electric vehicles were mainly charged by the thermal power plants which increased the NO\(_x\) by 20.3Gg yr\(^{-1}\). Electric vehicles would improve the Surface concentration of NO\(_x\) and CO by 3.3 ppb, 260 respectively annually, but the SO\(_2\) would be increased. CO\(_2\) emission was low as shown in figure 10 and CO\(_2\) emission from electricity grid is lower than diesel emission as shown in figure 11 (Nan et al., 2016). In Brazil the impact of an electric
Figure 10: Diesel vehicle and Electric Vehicle Carbon Dioxide emission (Nan et al., 2016)

Figure 11: EV and Diesel CO₂ emission when shaped by Emission factor (Nan et al., 2016)

vehicle. Even if the transport fleet is made electric the electricity consumption of 40 million MWH. 2% increase in electricity with 10% electric car addition every year (Marcos et al., 2014). In the case of the electricity mix, 0.25 kg CO₂/kWhel and 50 g CO-2/km were analyses for time-dependent average electricity mix and controlled charging strategy of the electric vehicle respectively. But in the case of marginal electricity mix the emission was 0.55 kg CO₂/kWhel & 110 g CO₂/km for the uncontrolled charging of the electric vehicles. In the case were the countries are dependent on the thermal power plant for the generation of electricity CO₂ emission would not meliorate significantly (Partick et al., 2015). Even when electric vehicles and conventional vehicles were compared the CO₂ emission 4.6 times higher in the conventional vehicles. It was also expected that the electric vehicles will pollute more than diesel vehicles if the electric matrix exceeds 1.05 kg CO₂/hWh. The value is 13 times more than 2016 value in Brazil (Eduardo et al., 2017).

In Brazil, the engine powered vehicle was replaced by electric vehicle and the analysis revealed that if 75% taxi fleet were gradually substituted with the electric engine by 2030, 3100 tons of CO₂ would be reduced if the taxi is running for 200km a day. In another case, if the taxi fleet is running for more than 400km a day the reduction in CO₂ would be around 3800 tons of CO₂ to 4200 tons of CO₂ (Ana et al., 2018). In Japan, the road fright vehicles were analyzed and were noted that the tank to wheel CO₂ emission would be boiled down from 98 to 47 Mt-CO₂/year for the period 2012-2050.

With the use of Hybrid electric vehicles, fuel cell electric vehicles, zero-emission vehicles & battery electric vehicles the Well to wheel CO₂ emission could be reduced to 5.3, 27.6, 29.5, 43.9% respectively when compared to the base value. It was also stated that BEV and FCEV
diffusion could reduce tank to wheel CO$_2$ up to 55.8% by 2050 (Juan et al., 2012). Where many European countries are diffusing electric vehicle into the fleet to decarbonize. But many European countries like Netherland, UK and Germany have power generation plants which produce more pollution (Lluc et al., 2016). Estimations were made that Europe would have 2 million charging points by 2017. 3% would be rapid charging points of the 2 million (Jaroslaw et al., 2017). Battery electric vehicle use in Sweden created 7-9 g CO$_2$eq/km, 169-234 g CO$_2$eq/km was emitted by electric vehicles in Latvia whereas the average emission in Europe was 65-89 g CO$_2$eq/km. Plug-in hybrid electric vehicle at 88% state of charge showed more of NO$_x$, NH$_3$, CO$_2$ and CO emission than full state of charge. PHEV show different functioning at different SOC (R. Suarez et al., 2016). Real driving and laboratory results were different for hybrid electric vehicle and conventional vehicle. Hybrid electric vehicle had 44-100% more consumption than lab and 30-82% for a conventional vehicle. Hybridization of vehicle powertrain would not bring any welfare to air quality (Yuhan et al., 2019). In the Italian cities, it was observed that vehicle which complies with the Euro 4 norms had emission 10 times higher in the real condition. Electric vehicle had 12% lower CO$_2$ emission when compared to the conventional vehicle in the case of life cycle assessment of CO$_2$. CO$_2$ emission from the electricity generation plant by the different fuels were Gas (1.489 kg/kW h), municipal solid waste (0.897 kg/kW h), biogas (0.432 kg/kW h) are depicted in figure 12 (T.Donateo et al., 2015).
Electricity used by the electric vehicle in Scandinavia and Germany produced about 3-17 MtCO₂ based on Electricity System Dispatch model for the year 2030. Emission for burning fossil fuels would be around 29-136 Mt CO₂. 15g CO₂/km would be for the passenger electric vehicle when given supply from the electric generation plant. By the year 2050, very low CO₂ emission would be allowed do investment in the wind power and thermal power (using CCS lignite co-fired with biomass) would be used to generate power for the EV (M. Taljegard et al., 2019). Mild hybrid vehicle reduced the GHG emission very slightly, but the heavy hybrid vehicle is expected to reduce the GHG emission more. An electric vehicle with 100km range has the lowest GHG emission but the electric vehicle with 200 & 300 km range have higher GHG emission than the heavy hybrid vehicle as shown in figure 14 (Amin et al., 2017).

**Figure 12:** CO₂ emission in the Italian power generation plants (T.Donateo et al., 2015)

**Figure 14:** GHG emission (Amin et al., 2017)

**HEALTH EFFECT OF VEHICULAR EMISSION**

Air pollution affects human health in different ways and different degrees. Many pollutants affect the respiratory and cardiovascular system directly. There is an increase in mortality, impaired pulmonary function and morbidity because of the high level of SO₂ and suspended
particulate matter. (Aayush et al., 2018). It was observed that the vascular constriction was boosted through pollutants. Even when the body is exposed to air pollution it leads to brachial artery vasoconstriction. This type of problem was seen in adults with smoking and non-smoking habits. But exposure to Air pollution resulted in a change in heart rate variation and blood pressure (Ubiratan et al., 2005). In a study in Delhi, India showed that the respiratory-related problems increased when the air pollution increased and the numbers of emergency admission also increased in number. In Delhi, the eye irritation, headache and skin irritation increased because of the increase in air pollution (SA Rizwan et al., 2013). PM and NO2 increase would lead to inflammation in the airway (Frederick et al., 2008). Respiratory problems escalated in the children’s with exposure to low- NOx (Guy et al., 2010). NOx emission in another paper resulted in health damage (Denise et al., 2005). A study in china on electric vehicles showed that the increase in electric vehicles will increase the CO2 emission and will, in turn, increase the mortality risk (Shuguang et al., 2012). Direct relation with respiratory problem and NO2 was found and relation with asthma was found to increase with the exposure to NO2 exposure. In the case of CO, it leads to headache and deaths (Tze-Ming et al., 2007).

CONCLUSIONS

As fossil fuel was being used till now for running the vehicles. It was estimated that 90% of the transportation sector is dependent on fossil fuel. Fossil fuel is limited and the burning of the fossil fuel generates a lot of emissions, it has become necessary to shift to other alternatives to power the transportation sector. Alternate fuel such as biodiesel are being used in different parts of the world. Even electric vehicle and hybrid electric vehicle are gaining popularity. Electric vehicles are no polluting vehicles but to charge the electric vehicles, we need electricity, which is being generated by the power plants and power plants which use fossil fuels to generate energy. So burning biodiesel or driving a EV or HEV would also result in polluting
the environment and damaging the human health. Following conclusions were drawn from the review:

- CO₂ emission by coconut biodiesel blend were 4.5% more than conventional diesel and even in the case for NOₓ emission. NOₓ emission from the cottonseed oil was higher than n-butanol or diethyl ether because the later oils have high cetane number & higher heating value. NOₓ emission also increases with increase in blend ratio.

- Bio-hydrogenated diesel was produced from fatty acid methyl ester and palm oil fatty acid distillate. They had a negative GHG emission because CO₂ was absorbed by the palm oil plants during cultivation of the plants.

- In the case of electric vehicles, the emission when compared to conventional cars was 51-78% lower. But with every 30% penetration of electric vehicles, electricity demand would increase by 3%. GHG emission by thermal power plant would be 155 g km⁻¹, NOₓ would increase by 20.3 Gg yr⁻¹ and under maximum hybridization CO₂ would reduce by 55.8%

- Pollutants affect the respiratory and cardiovascular system directly. There is an increase in mortality, impaired pulmonary function and morbidity because of the high level of SO₂ and suspended particulate matter.

It can be inferred that with introducing electric vehicles into the fleet will decrease the emission, drastically. Biodiesel is an alternate to conventional fuel but has high NOₓ emission which is harmful to human health. The emission from the thermal powerplants will somehow result in damage to the health of humans and will affect the environment. In the case of using electric vehicles, electricity should be generated from a renewable source of energy so that the emission could be controlled and the health impact is less. More importance should be given on the development of alternate fuels, which could help in generating electrical power and be used in vehicles and is safe for human health.
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