Air Pollution and its remedies through Bio-diesel

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Abstract – *The present paper gives complete idea on the pollution statistics after industrial revolution and the increased use of fossil fuels. Keeping in mind about the current global energy crisis, global warming and adverse effect on human health due to the emission hazards emitted from the petro diesel vehicles. Therefore global interest is generated to find out a substitute to the current pilot fuel. Bio-diesel has attracted interest in recent times due to its oxidation characteristics and environmental benefits. Bio-diesel obtained from straight vegetable oil through a process known as base catalyse Transesterification process. In this process the reversible reaction between the triglyceride of vegetable oil and methanol in presence of base catalyst (KOH) to produce glycerol and methyl ester. The methyl ester produced in this process is then blended with bio-diesel in various proportions before use in a diesel engine. Utilization of bio-diesel increases the life of the engine along with reduced emissions.*

Key Words: Bio-diesel, Transesterification, Pollution, energy.

1. INTRODUCTION

Fossil fuels are fuels formed by natural resources such as anaerobic decomposition of buries dead organism[1-3]. Fossil fuels contain high percentage of carbon including petroleum, coal and natural gas. Fossil fuel range from volatile materials with low carbon: hydrogen ratios like methane, to liquids like petroleum to non-volatile materials composed of almost pure carbon[4].

2. TYPES OF FOSSIL FUELS

There are three types of fossil fuels: coal, oil and natural gas.

- COAL - Coal is mainly used to produce electricity. Most of the coal is transported to power plants where it's burned to make steam. The steam turns turbines produce electricity[1].
- OIL - Oil, also called petroleum is the major energy source. On the contrary, crude oil is the type of petroleum that occurs naturally.
- NATURAL GAS - Natural gas is odorless when is mined from beneath the Earth's surface, with the added smell for the recognition during leakage of gas.

3. FOSSIL FUELS AS ENERGY

Fossil fuels are a great source of energy because they originate from living things. The plants and trees uses sunlight to make food from carbon dioxide and water, by process called 'photosynthesis' and energy gets stored in the plants and animals that eats the plants. The dead plants and animal matter sinks into the water and remains buried with much of their substances intact and the energy within them is further transformed.

4. POLLUTION STATISTICS

Air pollution is one of the major factors in the deterioration of the atmosphere. Introduction of different particulates and pollutants are responsible for the death and damage to all the living organisms on the plant[4]. Before the industrial revolution the main source of air pollution were volcanoes, wild fire and burning of biomass but since the advent of fossil fuels there has been a huge spike in the percentage concentration of the pollutants in the atmosphere. The main by-products of burning fossil fuels are as follows.

- Carbon Monoxide
- Carbon Dioxide
- Sulphur Dioxide
- Nitrogen Oxide
- Lead
- Particulate M

4.1 Carbon monoxide (CO)

The Global increase in the industrial activities and the use of fossil fuels has resulted in an unprecedented increase in the levels of carbon monoxide in the air[5]. Once in the atmosphere carbon monoxide reacts with the carbon dioxide by the reaction with hydroxyl radical (OH). Hydroxyl radical is responsible for breaking down and removing the greenhouse gases. With the increase in the amounts of CO its reactions with (OH) also increases leaving less hydroxyl radical available for the breaking down of the greenhouse gases[3].

Following maps were made by the NASA satellite MAPS. It measured the distribution of the carbon monoxide in the lower atmosphere.

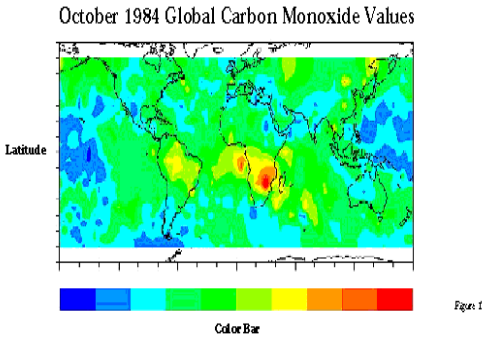


Chart-1 Global carbon Monoxide values October 1984

Large concentrations of carbon monoxide can be seen above South America and Central Africa which are produced by the burning of the biomass.

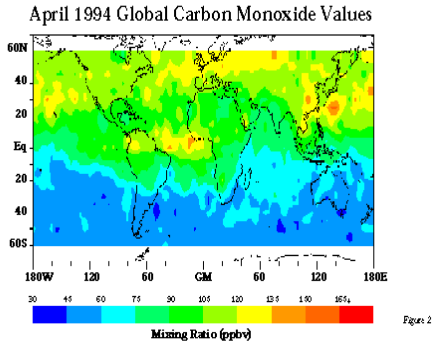


Chart-2 Global carbon Monoxide values April 1984

In this picture the concentration of carbon monoxide is relatively high in the northern hemisphere; this is because of the extensive burning of the fossil fuels and establishment of numerous industries[2].

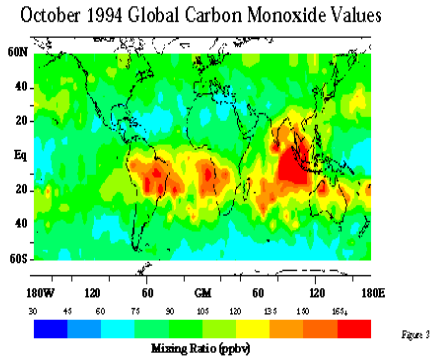


Chart-3 Global carbon Monoxide values October 1994

Relatively higher values of CO were measured above the entire southern hemisphere. These changes can be attributed to the unchecked exploitation of the fossil fuels and an increased global demand for natural resources due to overpopulation.

4.2 Carbon Dioxide (CO2)

Carbon is the most important element for all life forms in this planet. Carbon flows from on organism to another in different forms carrying energy, information and vital nutrients, providing all the living organisms with the functions to help them survive. This exchange of carbon between different life forms is known as "The Carbon Cycle" [5]. Besides that Carbon based compounds like carbon dioxide, carbon monoxide and methane are responsible for maintaining the average temperature of the earth. They trap a wide range of energy from the sunlight including the infrared radiations.

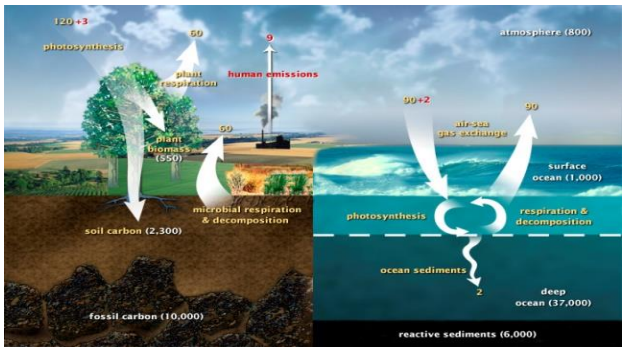


Chart-4 Carbon Cycle

The extensive use of fossil fuels has resulted in a rise in levels of carbon dioxide throughout the globe. The average concentration of carbon dioxide is 400 ppm (parts per million) and it is steadily increasing. This has a direct effect on the earth's average temperature which is increasing as well causing random changes in weather patterns[6].

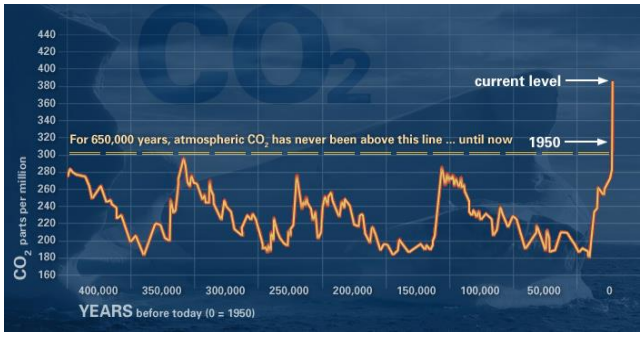


Chart-5 Concentration of carbon dioxide in ppm

5. CAUSES OF AIR POLLUTION

Air pollution is caused by both human and natural reasons. Natural causes of air pollution include volcanic activity, wind erosions, forest fires, natural radioactivity etc. Air pollution had existed long before the modernization of society but it became significant only after the discovery of fossil fuels. Following are the main reasons for air pollution:

5.1 Industrial emissions

The beginning of the fossil fuel era was marked by the establishment of numerous industries. These industries are run mainly on the fossil fuels. The chemical energy that is stored in the fossil fuels is converted into the heat energy and is than utilized for various purposes. The incineration of fossil fuels emits various greenhouse gases. Every year over 10 million tons of toxic waste is released in the atmosphere by these industries [6]. These emissions can be condensed by converging towards more environment friendly sources of energy.

Chart-6 Industrial Pollution

5.2 Burning fossil fuels

Transportation has become a very important part of our global trade structure. Cars, trucks, planes, ships and other transportation vehicles burn a lot of fuel in order to work. Emissions from these vehicles contain both primary and secondary pollutant[7]. Burning of fossil fuels releases approximately 21.3 billion tonnes of CO_2 in atmosphere every year. This problem is difficult to manage because humans depend heavily on these vehicles for the transportation of goods and people.

Chart-7 Automobile pollution

6. EFFECTS OF AIR POLLUTION

6.1 ACID RAIN

When the suspended pollutants in the air chemically react with the atmospheric moisture it creates acidic compounds. Burning of fossil fuels releases sulphur dioxide (SO2) and nitrogen oxides (NOx) into the atmosphere. These chemical gases react with water, oxygen, and other substances to form mild solutions of sulphuric and nitric acid. Winds spread these acidic solutions across the atmosphere. When acid rain reaches Earth, it flows across the surface in runoff water, enters water systems, and sinks into the soil [7].

Chart-8 Effect of acid rain

6.2 Eutrophication

Rain carries the chemical compounds and deposits them into rivers lakes and ponds[7]. This boosts the algae growth in that water body. The algae use up all the available oxygen and blocks the incoming sunlight making it unsustainable for any marine life. These phenomenon is called eutrophication.

Chart-9 Eutrophication

6.3 Ground level ozone

Without ozone layer it would have been impossible for life to proliferate in this planet but when in ground layer Ozone is detrimental to human health. Chemical reactions involving nitrous oxide and VOC (Volatile Organic Compounds) in presence of sunlight create Ozone[2].

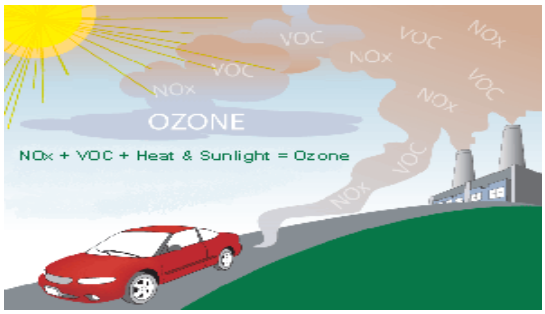


Chart-10 Ozone depletion

6.4 Effect on health

Air pollution causes an array of health related problems including lung cancer, asthma, heart related problems, acute respiratory infections in children etc. People living in cities with higher air pollution index are prone to such illnesses. According to WHO reports more than 7 million people died worldwide due to air pollution[8].

Chart-11 Effect of pollution on health

7. PREVENTIVE MEASURES

Most of the electricity that we used today is produced by the burning of the fossil. By practicing activities as simple as turning off the light when not in use and adopting energy efficient method you indirectly reduce the consumption of these fossil fuels and hence decrease the amount of pollutants entering the atmosphere [1]. To shift our dependency on the fossil fuels in a large scale following methods should be implemented.

7.1 Solar cells

A solar cell is a device which is used to convert the sunlight directly into electricity by photo-voltaic effect. Solar cells can act as a viable source of energy in areas where the climate is hot throughout the year. Only problem with the implementation of this technology in large scale is that its initial cost is very high[6]. As of 2017 India's total solar produced energy capacity is 9.57 Gigawatts.

Chart-12 Solar power plant

7.2 Wind turbines

Wind turbines are used to convert the winds kinetic energy into electrical energy. This technology is mostly applied in the coastal areas where the climate is mostly windy. The major drawback of this method is that it can be implemented only on the areas where the climatic requirements are fulfilled. Estimates suggest currently the potential utilization of wind energy is almost 65000 Megawatt[6].

Chart-13 Wind turbines

7.3 Bio fuels

Bio Fuels are an eco-friendly alternative to the fossil fuels. They are made by contemporary biological processes such as anaerobic digestion. Anaerobic digestion is a process where microorganisms are used to break down biodegradable materials in absence of oxygen [8]. Wild plants like Mahua and some other species are potential sources for production for bio-diesel.

Chart-14 Jatropha seeds

7.4 Bio-gas

Bio-gas is a mixture of certain gases with methane as its main component[9]. It is combustible and can be implemented for various tasks. It can be used as cooking gas or to produce electricity. Along with that it is also very cheap, reliable and environment friendly [1-3].

Chart-15 Mini Bio-gas plant

8. VARITIES OF SEEDS SUITABLE FOR EXTRACTION OF ALTERNATIVE FUEL

Demand for edible oils for food has increased tremendously and usage of edible oil for bio-diesel production will be quite expensive so commonly non-edible plant oils such as Jatropha and soap nut will be used significantly for bio-diesel production[10].

8.1 TYPES OF OIL:

There are two types of oils that is edible oils and non-edible oils[11]. Example of edible oils are such as sunflower, soybean, palm oils and various others. The main disadvantages of edible oil is higher viscosity, lower volatility, the reactivity of unsaturated hydrocarbon chains whereas Jatropha oil and waste cooking oil are more readily available than edible oils. Jatropha have several advantages as a renewable feedstock because it is non-edible and can be grown on marginal lands and the seeds contain about 30% oil.

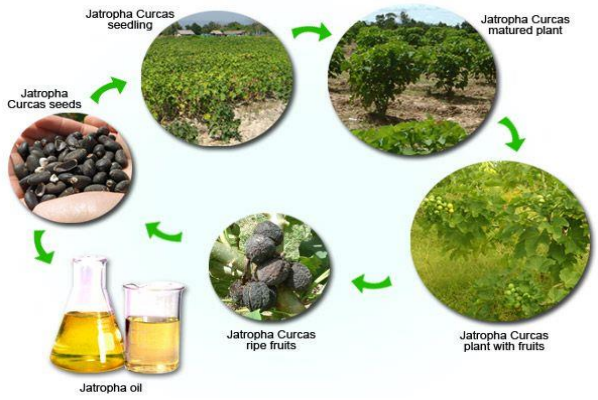


Chart-16 Bio-diesel production cycle

8.2 BIO-FUEL

Bio-fuels are fuels derived from biomass. Biomass has traditionally been used as fuel for energy production in the form of wood, charcoal or animal waste. Ethanol and bio-diesel are the most widely used liquid bio-fuels[12].

8.3 BIO-DIESEL AS A FUEL

Bio-diesel is a form of diesel fuel manufactured from vegetable oils, animal fats or recycled restaurant greases. It is safe, biodegradable and produces less air pollutants than petroleum-based diesel. **Bio-diesel** can be used in its pure form(B100) or blended with petroleum diesel[1].

8.4 BIO-DIESEL AS A REPLACEMENT TO DIESEL

Bio-diesel is a diesel fuel derived from organic sources. It is an alternative fuel to petroleum diesel fuel. It is a clean burning fuel[5]. It is nontoxic, biodegradable, produces 60% less carbon dioxide than petroleum based diesel fuel.B10 blend is 10% bio-diesel,90% petroleum diesel,B100 represents pure bio-diesel while B5 represents 5% bio-diesel and 95% petroleum and so on. Using bio-diesel as an alternative fuel may reduce global warming.

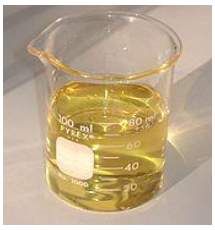


Chart-17 Bio-diesel seeds and oil

9. BIO-DIESEL PRODUCTION

It is the process of producing bio-fuel, bio-diesel through chemical reactions (transesterification and esterification).This process involves vegetable oil or animal fats reacting with alcohol (methanol or ethanol).The alcohol used should have low molecular weight[7]. Ethanol is used because of its low price but methanol is used for performing the reaction. This process can be catalyzed using acid or base. Base catalyzed transesterification is mostly preferred because of its low reaction time and less price of the catalyst used. Alkaline catalyzed transesterification is not used due to high sensitivity to water and free acids present in the oil.

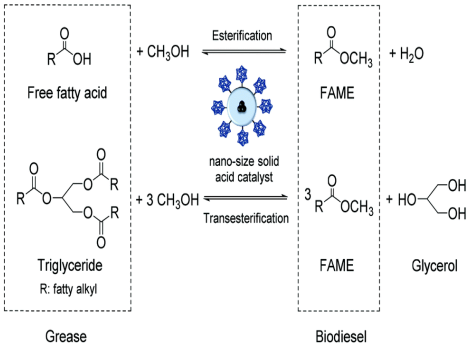


Chart-18 Transesterification reaction

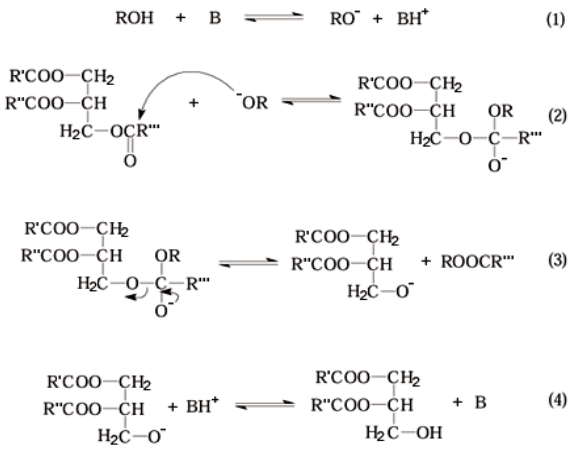
9.1 PROCESS STEPS

- **FEEDSTOCK PRETREATMENT-** The feedstock oil used in the production consists of yellow grease (recycled vegetable oil),virgin and tallow. The recycled oil is then processed to remove the dirt, charred food and water. Water must be removed especially because during base catalyzed transesterification water causes triglycerides to hydrolyze giving salts of fatty acids (soaps) instead of producing bio-diesel[1]l.

- **DETERMINATION AND TREATMENT OF FATTY ACIDS-** The cleaned feedstock oil is then titrated with the standardized base solution to determine the

carboxylic acid concentration in the oil. The carboxylic acid is further esterified into bio-diesel or glycerids or removed by neutralization[12].

- **REACTIONS-** In base catalyzed transesterification reaction between lipids(fats oil) and alcohol to produce bio-diesel and co- products.



Scheme 6. Mechanism of the base-catalyzed transesterification of vegetable oils.

Chart-19 Reaction cycle

- **PRODUCTION PURIFICATION-** After the reaction takes place in between the feedstock oil and alcohol (methanol or ethanol) we get the final product bio-diesel and along with that co-product is also obtained such as glycerol, soap, excess of alcohol, water. Soap can be removed or converted into acid, water is also removed from the fuel. Methanol can be removed by distillation and is reused[11].

10. ADVANTAGES AND DISADVANTAGES OF BIO-DIESEL

- **ADVANTAGES**

1. Bio-diesel is non-toxic and safe to handle and can be safely used while driving on the road.
2. Bio-diesel is economically beneficial for use as it is being manufactured on a local basis, there is no need to import oil.
3. There is no need of engine modifications. However, the ten percent bio-diesel should be filled up and blended as it may be a bad idea of running it on 100% bio-diesel.

- **DISADVANTAGES**

1. Bio-diesel is considered by many people that it grows mold and it's also another serious disadvantage. The main solution in this problem is on using it while fresh and nice.
2. People may experience almost 25% of decreased power if the used bio-diesel is measured not in the exact quality. The main solution to this problem is to make use of the most dependable and high quality fuels from reliable and trusted manufacturers.

11. ENVIRONMENTAL IMPACT OF BIO-DIESEL

- **GREENHOUSE GAS EMISSIONS-Carbon dioxide** is one of the major greenhouse gases. Although the burning of bio-diesel produces carbon dioxide emissions similar to those from ordinary fossil fuels, the plant feedstock used in the production absorbs carbon dioxide from the atmosphere when it grows and the process is known as photosynthesis which allows it to store energy from sunlight in the form of sugars and starches. After the biomass is converted into bio-diesel and burned as fuel the energy and carbon is released back into the atmosphere.

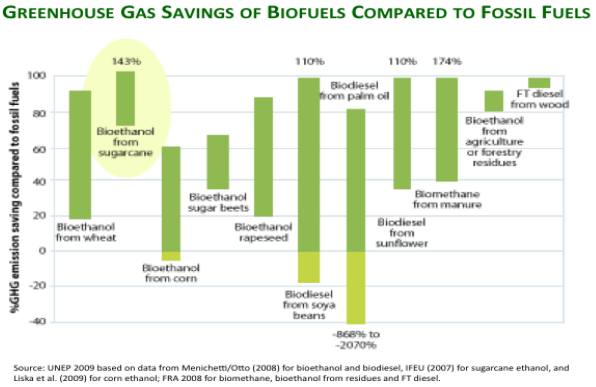


Chart-20 Bio-fuel savings

- **POLLUTION-**Bio-diesel can reduce the direct tailpipe emission of particulates, small particles of solid combustion products on vehicles car sulfur (< 50ppm) diesel. Bio-diesel has a higher Cetane rating than petrol diesel, which can improve performance and clean up emissions compared to crude petro diesel(with Cetane lower than 40).Bio-diesel contains fewer aromatic hydrocarbons: benzofluoranthene(56% reduction),Benzo pyrenes(71% reduction).

- **BIODEGRADABLE IN AQUATIC ENVIRONMENT-** As bio-diesel becomes more widely used, it is important to consider how consumption affects water quality and aquatic ecosystems. The presence of bio-diesel can increase the rate of diesel biodegradable via co-metabolism. As the ratio of bio-diesel is increased in bio-diesel/diesel mixtures, the faster the diesel is degraded.

- **CARBONYL EMISSIONS-**It is generally recognized that using bio-diesel results in a substantial reduction in regulated gas emissions. The results found out to be such that carbonyl emissions of formaldehyde, acetaldehyde, acrolein, acetone, propionaldehyde and

butyraldehyde were higher in bio-diesel mixtures than emissions from pure diesel. Bio-diesel use results in higher carbonyl emissions but lower total hydrocarbon emissions, which may be better as an alternative fuel source.

12. APPLICATIONS OF BIO-DIESEL

- Bio-diesel can be used as home heating oil in domestic and commercial boilers.
- B100 is such a good solvent that it can clean dirty or greasy engine or other machine parts. Also, bio-diesel makes an awesome bike chain degrease/lubricator. Bio-diesel can also be used as an industrial solvent for metal cleaning, which is advantageous due to its lack of toxicity or environmental impacts.
- Bio-diesel naturally has less than 15ppm sulfur concentration anyway, and adding just 1 to 2% bio-diesel can restore the lubricity to diesel fuel.
- Bio-diesel can reduce the exceedingly toxic products designed for paint removal. Bio-diesel can also be used to remove adhesive residues, like those left by duct tape.

13. CONCLUSION

Bio-diesel is an environmentally safe, low polluting fuel than petroleum based diesel. Using of bio-diesel as an alternative to petroleum diesel in order to keep control over global warming. Due to rapid depletion of fossil fuels bio-diesel has been planned to be used as substitute in future, it should also serve to reduce and maintain the price of automobile fuel. The under and unexploited vegetable oil are good sources of bio-fuel and our country is endowed with many such plants. Research is being carried out now to convert vegetable oil into bio-diesel in huge amount through biotechnological processes. In future, hoping for a wide range of usage of bio-diesel in our country.

References:

[1] G. Hemanth, B. Prashanth, Nayan Benerjee, Tuhin Choudhuri, Mrityunjay, "Dual fuel mode operation and its emission characteristics in diesel engine with Producer gas as primary fuel and Jatropha bio-diesel as pilot fuel",International journal of mechanical engineering and technology, Volume 8, Issue 4, pp:138-147, April 2017.

[2] Prashanth, B., Saiteja,R., Sunil Kumar,B.Swarup Kumar Nayak., 'Performance Characteristics of a four Stroke Single Cylinder Diesel Engine Fueled with Waste Cooking oil and Diesel Blends", Proceedings of International Conference on Emerging Trends in Mechanical Engineering(ICETIME-2016).pp:747-751, 2016.

[3] Nayak, C., Pattanaik,B.P.,Nayak, S.K. Effect of preheated Jatropha oil and Jatropha Oil methyl ester with producer gas on diesel engine performance, Volume 9,Issue 1,2014,pages 1709-1722.

[4]A.M. Namasivayam, T. Korakianitis, R.J. Crookes, K.D.H. Bob-Manuel, J. Olsen .Bio-diesel, emulsified bio-diesel and dimethyl ether as pilot fuels for natural gas fueled engines Appl Energy, 87 (2010), pp. 769–778

[5] A.K. Agarwal, K. Rajamanoharan .Experimental investigations of performance and emissions of Karanja oil and its blends in a single cylinder agricultural diesel engine Appl Energy, 86 (2009), pp. 106–122.

[6] Nayak,S.K.,Behera,G.R.,Mishra,P.C.Physio-chemical characteristics of punnang oil and rice husk-generated producer gas,Volume 39,Issue 3,! February 2017,Pages 291-298.

[7] Nayak,S.K.,Mishra,P.C.,Behera,G.R.2017.Experimental Investigation on dual-fuel engine utilization waste cooking oil and producer gas. Energy Sources ,Part A:Recovery, Utilization and Environmental Effects. Article in press, Pages 1-8.

[8] A. Boretti ,Advantages of the direct injection of both diesel and hydrogen in dual fuel H_2ICE Int J Hydrogen Energy, 36 (2011), pp. 9312–9317

[9]Nayak,S.K.,Mishra,P.C.,Kumar,A.,Behera,G.R.,Nayak,B.Experimental investigation on property analysis of karanja oil methyl ester for vehicular usage.Volume 39,Issue 3,1 February 2017,Pages 306-312.

[10] K. Mu'azu, A. Mohammed-Dabo, S.M. Waziri, A.S. Ahmed, I.M. Bugaje Development of mathematical model for the esterification of *Jatropha curcas* seed oil JPTAF, 4 (3) (March 2013), pp. 44–52

[11] Nayak,S.K.,Mishra,P.C.Investigation on jojoba bio-diesel and producer gas in dual-fuel mode.Volume 38,Issue 15,2 August 2016,Pages 2265-2271.

[12] Nayak,S.K.,Mishra,P.C.Emisiion from utilization of producer gas and mixes of jatropha bio-diesel Volume 38,Issue 14,17 July 2016,Pages 1993-2000.