

**The Potentials of Algae from Waste and Fresh Water as a  
Source of Biodiesel**

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**Abstract**

The demand and use for energy is increasing continuously due to industrialisation, desertification, cost of electricity, depletion of petroleum resources, human population and increasing commercial activities. The basic and traditional sources of energy has been petroleum resources, natural gas, coal, hydro and nuclear, however, the major disadvantage of using petroleum based fuel is atmospheric pollution due to greenhouse gas (GHG) emissions caused by inefficient burettes, hence inefficient indiscriminate burning of enormous amount of petroleum diesel has increased CO<sub>2</sub> level in the atmosphere which traps and prevent the heat from going to the outer atmosphere, thereby causing global warming. Algae were grown in waste and fresh water with NPK added to the tap water. The biodiesel was produced through the process of extraction, heating and transesterification. NaOH as a catalyst with methanol and hexane were added The result of this research revealed that 33% and 29% of was extracted from 11.5 grams 10.5 grams from the dry weight of algae from waste and fresh water respectively. It can be concluded from the result of this research that algae is a potential alternative source of biodiesel compared to oil from seeds. Biodiesel from algae is a perfect replacement or alternative

to petroleum diesel. This is because algae are found everywhere, easy to cultivate in a small pond and it is more effective than vegetable oil.

## **INTRODUCTION**

## **BACKGROUND OF THE STUDY**

Due to increasing awareness of the depletion of fossil fuel resources and environmental issues. Algae can be produced using fresh water resources (Jia et al,2010) or using saline and waste water (Clayton, 29 march 2008),because it has a high flash point (Dinh et al ,2009) it is degradable and relatively harmless to the environment if spilled(Demirbas,2011,Demirbas,2009). Biodiesel became more and more attractive in the recent years due to growing awareness regarding the depletion of fossil fuels and increased harmful emissions, efforts are being made to develop renewable green fuels like biodiesel and bioethanol from different waste/natural resources (Chakraborty et al.,2016). About 30 billion( $30 \times 10^9$ ) litres of fuel are utilised worldwide annually due to high demand and limitation posed by first generation biofuel (Ullah and Anyawu,2014). These problems has forced scientist to look for alternative sources of diesel fuel which is cheap, accessible and environmentally friendly. Petroleum diesel was identified as expensive, hazardous and a source of atmospheric pollution and greenhouse gases (GHG) emission, hence burning can cause an increase in carbon dioxide ( $\text{CO}_2$ ) level there by causing global warming (Ho et al, 2011).

The possible alternative to the petroleum diesel is biodiesel from any biological material, which is not in competition with food. 123.....10. The production of biofuel from algae gained more attention due to the fear of using crop and food-producing plants will affect human food demand besides, algae have 20% - 80% oil content that could be converted to kerosene oil and biodiesel. The diesel produced from algae is economically easy, different species such as tribonema, ulothrix and euglena have good potential for biodiesel production, more so gene technology can be used to enhance the production of oil and diesel content(Khan et al, 2017) . The oil press technique was identified to be simple and popular extracting about 75% of oil from the algae, the hexane solvent combined with the press method extracts about 95% of the oil from algae, while the supercritical method extracts 100% of the oil (Newman, 2008).The production of biodiesel from algae has the benefit of reducing carbon and nitrous oxide and other greenhouse gases emission that comes from fossil fuel. The process gives off pure oxygen and water vapour. To stop or reduce CO<sub>2</sub> emission is to fix biomass, through the process of photosynthesis ,because microalgae possess a greater capacity to fix CO<sub>2</sub> compared to C4 plants (Bhola et al,2014) The

greenhouse gas (GHG) emissions of carbon dioxide (CO<sub>2</sub>) contributes up to 68% of the total emissions (Ho et al, 2011). The most economical and environmentally friendly approach to overcoming the problem of fossil carbon dioxide emission would be to reuse the carbon dioxide through fixation in to biomass production like algae in a small pond. Carbon dioxide increases the growth of certain microalgae species it has the great capacity to fix CO<sub>2</sub> compared to C<sub>4</sub> plant. Microalgae can be propagated in an open race way pond or closed photo reactors. The potential use of microalgae after sequestration could include biodiesel production, fodder for livestock, production of colorant and vitamin (Bhola et al,2014).

Algae are found in kingdom plantae, sub-kingdom thallophyta, division phycophyta (algae). Different classes of algae include cyanophyta, phaephyta, rodophyta, euglenophyta, baccilariphyta, chlorophyta. Algae are unicellular or multicellular organisms that photosynthesis, but lack features such as leave, roots, seeds and flowers of higher vascular plant. Algae have wide ranging classification falling within several groups from plant through to protists (single celled organism) even bacteria (blue-green algae), they are commonly found in aquatic environment both fresh and

marine environment or even dry environment where they can live in symbiotic relationship with fungus as lichen. Many algal species move themselves through water column; while others float, attach themselves to object by means of an organ called hapteron in water or terrestrial environment. It is unknown how many species of algae in Nigeria and the world at large, but there are more than 3000 species of algae that have been reported so far, It was estimated that the 36000 known species comprised only 17% of the potential total number of algal species, making the total diversity of algae approximately 200,000 species worldwide (Madsen,2013),the various species of algae include spirogyra, microalgae, seaweed, e.t.c (Michael 2012). Algae can be grown in the dark in fermentation tank sustained by sugar rather than photo synthetically in the open.

Algae can be economically converted to solid fuel (dry and compressed), methane gas (anaerobic digestion) or liquid transportation fuel (fermentation) fuel such as ethanol and biodiesel (extraction) or used as animal feed, align extract or blue litmus ink from the plant. This research **thought it wise** to extract and esterify the algae oil to biodiesel to run diesel automobile, industrial machines and electricity generating plants

from algae. Biodiesel is equivalent to bio fuel made from renewable biological material such as vegetable oil or animal fats as well as algae. While there are numerous interpretation being applied to the term biodiesel, strictly speaking the term biodiesel refers to an ester or oxygenate made from oil and alcohol. Biodiesel is 100% a biological product.

Extracting or producing biodiesel from algae provide the highest net energy because converting oil into biodiesel is much less energy intensive than method of converting fuels such as ethanol, methanol, methane etc. this characteristic has made biodiesel the favourite end product from algae. The production of biodiesel from algae has the benefits of reducing carbon and nitrous oxide ( $\text{NO}_2$ ) and other greenhouse gas emission that comes from fossil fuel through industries, automobiles and other anthropogenic activities. The process gives off pure oxygen and water vapour. Light from concentrated solar panel is conducted in algae chamber via fibre optics once the algae grows to maturity it is harvested for conversion into biodiesel fuel, hence algae strain is not only useful for production of biodiesel but also waste treatment.

Biodiesel can be produced from vegetable oil, soybeans oil, and animal fat e.t.c. According to some estimate, the yield (per acre) of oil and hence biodiesel from algae is over 200 times the yield from the best performing vegetable oil. Below are the values of biodiesel that can be generated from plant sources;

In Louisiana (USA) algae is being harvested and turn into biodiesel by taking CO<sub>2</sub> from local industry and pumped into algae pond which are harvested every 3 to 5 days (Aquatic energy 2015). One acre of soya bean can produce one barrel of biodiesel in a year while algae produce between 1500 to 2000 barrels (EcoGeek 2008). It was reported that the largest possible source of suitable oil comes from oil crop such as rape seed, palm or soya bean. In U.K. rapeseed is the largest for biodiesel production ([www.esru.strath.ac.uk](http://www.esru.strath.ac.uk)) The problem associated with their production include oil quality and quantity and also the method used for their production in addition to general properties of oils taken from different natural species as well as talking of biodiesel production and utilization (Sreenath and Pai ,2018).

**Table 1: The yield per acre of oil and biodiesel from algae and plants sources**

| Plant sources | Quality of oil<br>(liters/acre)                   | Quantity of<br>diesel/barrel (Litters) |
|---------------|---------------------------------------------------|----------------------------------------|
| Corn          | 15                                                | -                                      |
| Soya bean     | 48                                                | 1 (159Litters)                         |
| Sun flower    | 102                                               | -                                      |
| Rep seed      | 127                                               | -                                      |
| Microalgae    | 1850 (Based on actual<br>biomass yield)           | 1500-2000                              |
| Microalgae    | 5000(based on<br>theoretical laboratory<br>yield) | -                                      |

Source: Aquatic Energy 2015, EcoGeek,2008

## **MATERIALS AND METHODS**

### **MATERIALS**

The materials and method involves the use of the following equipment and substances for the growth, extraction and transesterification of oil from algae to produce biodiesel.

Basin

Thermometer

Measuring cylinder 100mls

NPK fertilizer 250g

Mortar and pestle

Drying oven

Electronic precision balance (model 700, U.S. PAT.NO.2729.439).

Glass Petri dishes

Conical flask 100mls

Beaker 250mls

Thermostatic shaker

Gasoline

Hexane 40ml

Ether solution 40ml

NaOH 0.30g

28ml Methanol

Filter paper 12.0cm/funnel

water

## **METHODS**

### **METHOD OF GROWING ALGAE**

15 litres of waste water and tap water was collected from the drainage of the female's hostel University of Maiduguri in a basin and kept in the open for adequate sunlight in the experimental garden of the Department, of Biological Sciences, University of Maiduguri. Dibenedetto (2011) reported that aquatic biomass has long been cultivated in salty water or fresh waste. Stewart and Hesami (2005) reported that the capture of CO<sub>2</sub> produced by combustion of fossil fuel used in electric generation

can be achieved by amine scrubbing of the flue gases. This process may be costly and can be replaced by an option such as incomplete membrane separation, molecular sieves or desiccant absorption. 250g of NPK fertilizer was weighed on the electronic precision balance (Model 700, U.S. PAT. NO. 2729.439) and added to the tap water, with 60g of algae was added as inoculants (seed) to the tap water and allowed for some time to grow. Pitman et al (2011) suggested that waste water is a nutrient source, but cannot feed the algae directly unless it is processed by bacteria through anaerobic digestion or it can kill the algae. It was further suggested that the organic fertilizer from biogas digester can be used to grow algae but must be cleaned and sterilised. After then, 10 litres of water were added at regular interval to sustain minimum amount of water and moisture required for growth. Stecker (2002) reported that to produce one litre of algal biofuel manufacturers must use 3315 to 3650 litres of water or up to 123 billion litres for 39 billion litres of algal fuel. A thermometer was mounted to measure the daily temperature of the water.

## **METHOD OF PRODUCING BIODIESEL FROM ALGAE**

Various methods such as transesterification, blending, cracking, microemulsification and pyrolysis have been developed

to convert oils from biological sources into biodiesel that is comparable to diesel fuel. Trans esterification, by a number of consecutive reversible reactions is the most common method: triglycerides are converted stepwise to diglycerides, monoglycerides, and finally glycerol with the liberation of fatty acids methyl ester as biodiesel (Takisawa,et al,2014)The method or processes involved in the production of biodiesel from algae include the following stages.

### **EXTRACTION OF ALGAL OIL**

Two Petri dishes containing 50g of fresh algae was grounded in a mortar with a pestle and placed in an oven at a temperature 160°C for 10 minutes to dehydrate. 40mls each of hexane and ether solution were added to the grounded and dehydrated algae to bring out oil from the cells of the algae. Al-Iwayzy et al(2014) reported that the lipid extracted was heated to 48°C at the same time NaOH was added to 11mls of methanol and hexane. The mixture was kept in a beaker and allowed to stand and settle for 22 hours .The mixture was filtered using filter paper and funnel into a conical flask. The biomass was collected and weighed; the sample was heated to evaporate hexane and ether solution from the extracted oil. The oil from nuts and seeds is extracted

mechanically using presses or expelled, which can also be used for microalgae. The algal biomass should be dried before the process. The cells are broken down with a press to leach out the oil. About 75% of oil can be removed through this method and no special skills are required (Behera et al,2014).

### **TRANSESTERIFICATION**

A 0.30g of NaOH was dissolved in 28mls of methanol and stirred properly for 20 minutes; the mixture was used as the catalyst of the reaction. The catalyst was poured into the algal oil in a conical flask where the solution was put into the thermostatic shaker and was shaken for 3 hours with the solution kept for 16 hours to stand and settle. The oil can be obtained by various chemical methods such as transesterification acid catalysed methanolysis etc (Sreenath and Pai, 2018). Here the biodiesel and sediments were seen clearly and stratified. Biodiesel was separated using filter paper and funnel separator, where the biodiesel was washed by cold water bath and air dried by fanning and then stored in a bottle.

## RESULT AND DISUSSION

From the result presented in the table below (Table 1) oil was generated from both algae grown on waste water and tap water and subsequently used in biodiesel production. Bhakta and Ohnishi,(2015) reported that tremendous biomass growth of aquatic weeds in nutrients enriched aquatic environments up taking various pollutants has received considerable interest in applying as a potential feedstock for producing sustainable biofuel. This is compared to other crops like corn and soya bean algae produces more oil with other fuels like bio-oil, biodiesel, bioalcohol, biohydrogen and biogas which can be obtained after the liquid feed extraction (Fernandez, 2012). Algal biomass contains carbohydrate, protein and lipid/natural oil. The bulk of the natural oil is in the form of tricylglycerol which is the right kind of oil for producing diesel (Wen and Liao, 2014).In addition to the fuels algae has long been cultivated as a source of industrial chemicals like agar, algininate, carragenans and fucerellans or as food for human and animal feed. The lipid content of microalgae on a dry cellular weight basis usually varies between 20 and 40%, a lipid content as high as 85% has been reported for selected microalgal strain (Dibenedetto, 2011).

The vegetable oil content of algae can vary with growing conditions and species, but has been known to exceed 70% of the dry weight of algal biomass(Baliga and Powers, 2010).The loss in weight during the process of dehydration and extraction amounting to 3.8g and3.0g which could be attributed to volatile substances. About 33% and 29% of oil was extracted from 11.5g and 10.3g dry weight of algae grown on waste water and tap water respectively, while Vijayaraghavan and Hemanathan (2009) obtained a lipid content ranging from 41% to 49%, Murthy,(2013)obtained 101,249.2 litres/ha/yr. The dry weight constitute 43% and 45% of the fresh of algae plant from waste and tap water respectively.

**TABLE 1;** Table Showing Fresh and Dry Weight of Extracted Oil and Residue of Algae.

| Treatments    | Fresh weight(g) | Dry weight(g) | Extracted oil (g) | Biomass (g) |
|---------------|-----------------|---------------|-------------------|-------------|
| Waste water % | 25.5            | 11.5<br>56%   | 3.8<br>33%        | 6.5<br>26%  |

|           |      |      |       |       |
|-----------|------|------|-------|-------|
| Tap water | 23.0 | 10.3 | 3.0   | 5.8   |
| %         |      | 55%  | 29.1% | 23.2% |

Some species of algae have the ability to produce up to 60% of their dry weight in the form of oil. The 26% of the total biomass constitute the left over biomass after extraction of oil. This can be compressed into solid biofuel or digested anaerobically to produce biogas (methane). The main obstacle to commercial production of biodiesel is its cost and feasibility characteristics, they can be grown in fresh water or synthesised using ocean water or waste water, they are degradable and relatively harmless to the environment if spilled (Abishek et al, 2014). The differences in weight of 3.7g (15%) and 3.9g (17%) between fresh weight and by products could be attributed to volatile substances. Direct transesterification was unsuitable for wet biomass as indicated by (Johnson et al 2009, Vijayaraghavan and Hemanathan, 2009). Hence it is ideal to dry algae before extraction. Direct extraction could be affected by the hydration level of the oil due to wetness, because the oil is hydrophilic.

**TABLE 2;** Table showing some properties of algal biodiesel, fossil diesel and ASTM biodiesel standard.

| Properties                                                | Algal biodiesel | Fossil diesel | ASTM biodiesel standard |
|-----------------------------------------------------------|-----------------|---------------|-------------------------|
| Density<br>Kgl <sup>-1</sup>                              | 0.884           | 0.838         | 0.84-0.90               |
| Viscosity<br>(mm <sup>2</sup> s <sup>-1</sup> cp at 40°C) | 4.4             | 1.9-4.1       | 3.5-5.0                 |
| PH                                                        | 7.2             | 7-9           | 7-9                     |

American Society for Testing Material (ASTM) (Jaaskelamen, 2009.01f) published new biodiesel blend specification as seen in table above (Table 2). To assess the potential of biodiesel, the properties of the diesel such as density, viscosity and Ph. were determined and comparison were made with the algal biodiesel, fossil diesel and ASTM biodiesel standard and it shows that the fuel properties of algal biodiesel is comparable to ASTM biodiesel

standard and fossil diesel, therefore algal biodiesel ( $0.884\text{Kg l}^{-1}$ ) is a potential diesel better than fossil diesel ( $0.838\text{Kg l}^{-1}$ ). The biodiesel was described to be environmentally friendly.

## **CONCLUSION AND RECOMMENDATION**

### **CONCLUSION**

It can be concluded that an algae as a third generation biofuel is a potential source of biodiesel and an economical choice for biodiesel production because of its availability and low cost and as a third generation fuel. Algal biodiesel is technically feasible because algae is easy to cultivate and harvest without much stress or space, high oil yields and reduced pressure on cultivable land. Algal biodiesel stability is relatively better than seed based biodiesel. (A.A.A. Kheira and N.M.M Atta 2008)

### **RECOMMENDATION**

This research therefore recommend a further research to be carried out on types of algae and quantity of biodiesel produced for possible use in large quantity by various machines to either supplement or replace the traditional fuel used in industries or homes for cooking due to the numerous advantage and importance of algae to the human environment. It was reported that high value strains oil rich algae in waste water can simultaneously remove more than 90% of nitrates and more than 50% of phosphorous from the waste water. Because waste water

treatment plants and their facilities have no cost effective means of removing large volume of nitrates or phosphorous from treated water (Bhattacharjee and Siemann, 2015). In addition to other advantages mentioned earlier, algae grows 20 to 30 times faster than food crops and contains up to 30 times more fuel than equivalent amount of other biofuel sources such as soya bean, canola, jatropha or even palm oil. Studies shows that they can also produce up to 60% of their biomass in the form of oil or carbohydrates. Algae can yield up to 94000 litres/ha/year of biofuel compared to corn which yield about 560 litres annually (Ullah and Anyawu, 2014) The utilisation of waste and ocean water is strongly advocated due to the continuing depletion of fresh water resources. Strains of algae can remove 90% of nickel and zinc from industrial waste water in relatively short period of time (Chong et al, 2000).

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