The potential of microalgae for biofuel production in Ghana

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Introduction

- Biofuel in the form of Shea butter oil has long been used in the Northern Region in Ghana, however, nationally the use of biofuel as a source of energy started recently after the oil shocks in 1970s and 1980s.
- As a result the Government of Ghana established the National Energy Commission to develop a strategy to mitigate the impacts of the escalating crude oil prices.
- One of the key recommendations of the committee was the need for Ghana to develop alternative fuels to petroleum products
- Recently the interest in biofuel production has been rekindled mainly from the plant Jatropha, oil palm, soyabean ect.
- Research has however, shown that microalgae has the highest biofuel potential than all these plants mentioned above and are environmentally safe

Why the need for alternative fuel (Biofuel)?

- To lower the dependence on imported petroleum in the economy
- Petroleum based fuel is very expensive and is not expected to get cheaper.
- Biofuel is biodegradable.
- Non toxic
- Less carbon dioxide, sulphates, nitrates and particulate matter emissions .
- The recognition that continuous use of petroleum sourced fuel is unsustainable due to depleting supply against increased demand.
- Global warming due to increased accumulation of atmospheric carbon dioxide and greenhouse gases (GHG).

What is Microalgae

- Microalgae are photosynthetic microorganisms that convert sunlight, water and carbon dioxide to biomass through the process of photosynthesis with the release of oxygen (Chisti, 2007).

- They are microscopic and therefore not seen with the naked eye except with the aid of a microscope.

- They are similar to higher plants, but lack many of the distinct organs found in higher plants such as leaves, stems and roots.

- They occur as unicellular, colonial and filamentous forms and can be found in all aquatic i.e. fresh, brackish, estuarine and marine and terrestrial environments.

- They are divided in five major groups namely green algae, blue-green algae, brown algae, red algae and diatoms.

Importance of Algae

- Algae produce about 70% of the world atmospheric oxygen through the process of photosynthesis.
- Algae are rich in several essential nutrients such as carbohydrates, proteins, enzymes and fibres and are excellent food sources.
- Algae also contains minerals and vitamins like vitamin A, B1, B2, B6, C, niacin, iodine, potassium, iron, magnesium and calcium.
- Algae are also used as fertilizer.
- Algae can be used in forensic medicine, pharmaceutical, cosmetics and textile industries .

Why algae as a source of biofuel ?

- Algae have emerged as one of the most important sources of biofuel capable of meeting global demand for transport fuels without adversely affecting supply of food and other crop products.
- Biofuels are renewable.
- Algae have the highest yielding feedstock for biofuel (Sharif Hossain and Salleh (2008).
- Algae can double their volume overnight.
- Algae can be harvested day after day.
- Up to 50% of an algae's body weight is comprised of oil as against 20% of that of palm oil.
- Algae can produce up to 250 times the amount of oil per acre produced by soybeans.
- It has been estimated that up to 15,000 gallons of oil per/acre/yr could be produced from microalgae, compared with only 18 gallons from corn and 48 gallons from soybeans. (Thomas F. Reising, USA).
- It is very simple to extract oil from algae.
- Algae grow well in brackish water which is unsuitable for other forms of agriculture and also in waster waters.
- Microalgae can provide several different types of renewable biofuels such as methane, ethanol, biodiesel and photobiologically produced biohydrogen (Sharif Hossain and Salleh (2008).

Types of algae used for biofuel production

- Over 300 species of algae mostly green algae and diatoms e.g.
- Green algae requires nitrogen to grow while the diatoms require silicon to grow.

Microalgae	Oil Content (% dry wt)
Chlorella sp. (Green algae)	28-32 %
Chlorella vulgaries (Green algae)	14-22 %
Dunaliella sp. (Green algae)	23 %
Euglena gracilis (Green algae)	14-20 %
Nitzschia sp. (Diatom)	45-47 %
Oedogonium sp. (Green algae)	27 %
Scenedesmus dimorphus (Green algae)	16-40 %
Spirogira sp. (Green algae)	33-64%

Source: Sharif Hossain and Salleh (2008).

Optimum Growth Conditions

Algae for biofuel production has been cultured in lakes, brackish and marine water, open outdoor ponds, closed ponds, green houses, photobioreactors, plastic tanks/tube, waste waters and desert land.

pH	7 to 9
Water Temperature	18 to 25 ^oC
Light intensity (lux)	2,500 to 5000
Nutrients	Nitrates, ammonia, phosphates and some trace metals
Salinity	12 to 40 g/l (depends on volume and density)
Aeration	Continuous/stirring with paddle wheel
Photoperiods (light and dark hours)	16:8
Carbon dioxide source	

How do we grow algae fast and cheap enough to make economic sense in Ghana

- Algae can be grown in Ghana either by using either **open ponds** or **closed structures called bioreactors**. However, in the short term open ponds will be advantageous because they require less technological development and lower cost.
- For long term potential bioreactors will be practical as open ponds can only be located in areas with abundant water leading to competition with other forms of farming.
- High productivity algal farms will also require carbon source for growth and this condition will favor bioreactors.
- Open ponds also have the problem with contamination by wild algae and evaporation of enormous amount of water into the atmosphere.
- Bioreactors also can allow more surface area for light absorption thereby increasing growth, but cost more than open ponds and require more maintenance and attention to keep them at the proper temperatures and light levels.

The Economics of Biofuel Production from Algae in Ghana

- In 2008, Ghana spent a total of **US$ 2.4 billion** on oil imports equivalent to **13.7 %** of GDP (ISSER, The State of the Ghanaian Economy, 2009).
- The price of a barrel of oil was **US$ 140/barrel.**
- This amount was used for the importation of **1.975 million tonnes** of crude oil and **1.037 million tonnes** of petroleum products (Energy Commission, Ghana).
- Total oil need nationally is estimated at **851 billion gallons/year.**
- It has been estimated that under optimal conditions algae can produce up to **15,000 gallons of oil per/acre/yr** (Thomas F. Reising, USA).

Based on these, if the country is to replace its current oil demand with algal fuel, then the following can be deduced:

a. Ghana needs about **23 million hectares** of land to grow algae for oil production to meet all national needs.
b. Total land available for agricultural purposes as at 1999 was **5.3 million hectares** (Earth Trends, 2003).
c. The total size of the country is estimated at **24 million hectares** (Quaye et al., 2010)
d. This implies that the entire land area of the country will have to be used to meet our national demand for oil production from algae.

Constraints

- It is an expensive venture (capital and operating cost)
- High technology and engineering (photobioreactors etc)
- Source of algae (Isolation or purchasing strains)
- The water temperature needs to be just right for algae to proliferate
- Ponds chocked with invasive weeds
- Atmospheric levels of carbondioxide is not always enough to support exponential growth
- Land – competition with food crops grown to feed mankind

Conclusions

- After a long study (18 yrs, 1978-1998) by the US Department of Energy (CNN report, April 2008), it was concluded that algal oil can never compete economically with fossil fuels but not unrealistic.
- The climatic conditions, the basic technology and capital for biofuel from algae in Ghana is available. However, there is not enough land available to embark on such massive land consuming venture to make meaningful contributions to the oil needs of Ghana.
- Other technologies (bioreactors) would be needed in place of open ponds for algal production to save land for other important needs (Agriculture, housing and industries)
- Significant research and development will be required to optimize yields in order to maintain sustainable land and water use