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A Review of Nipa Palm as a Renewable Energy Source in Nigeria

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Abstract: The aim of this study is to evaluate the renewable energy potential of Nipa Palm, a bio-energy crop widely available yet underutilized in Nigeria. The combustion of fossil fuels such as coal, oil, and natural gas has increased the concentration of carbon dioxide in the earth's atmosphere. The carbon dioxide and other so-called greenhouse gases allow solar energy to enter the Earth's atmosphere, but reduce the amount of energy that can re-radiate back into space, trapping energy and causing global warming. Nipa Palm which has been regarded as an environmental menace is now regarded as one of the candidates for renewable energy to fulfill the requirement of clean carbon emission. Abundant quantity of Nipa Palm provides an impetus for the sustainable generation of bio-ethanol. This sugar based bio-ethanol source development in Nigeria provides not only profitable use to a problem plant but also provides an opportunity and incentive to generate some Carbon Emission Reduction (CERs) credits.

Keywords: Bio-ethanol, bio-fuel, global warming, Nipa Palm, *nypa fruticans*, weed

INTRODUCTION

Rapid rate of emissions of greenhouse gases such as carbon dioxide, methane, nitrous oxide, ozone and chlorofluorocarbons from anthropogenic sources such as burning of fossil fuels, tropical deforestation, and other human activities has resulted in increase in global temperature, otherwise known as global warming. Increased amounts of solar energy have been trapped by these gases raising the earth's surface temperature (NRDC, 2006). A strong strategy against climate change requires a strong reduction of the greenhouse gas emissions. Fuels from biomass do not add significantly to the greenhouse gases as the biomass is formed by carbohydrates, the carbon taken from the air by photosynthesis and given back to the air within the natural carbon cycle. Whereas by using fossil fuels carbon is transported from the earth crust to the atmosphere, thus increasing the CO_2 content. Carbon dioxide is recognized as the most important (at least in quantity) of the atmospheric pollutants that contribute to the "greenhouse effect", a term coined by the French mathematician Fourier in the mid-1800s to describe the trapping of heat in the Earth's atmosphere by gases capable of absorbing radiation. By the end of the last century, scientists were already speculating on the potential impacts of anthropogenic carbon dioxide (Sarmiento, 1993). Bio-fuels are gaining increased public and scientific attention, driven by factors such as oil price hikes, the need for increased energy security, and concern over green house gas emissions from fossil fuels. The current use of food crops such as sorghum and cassava (NNPC, 2007), for the production of bio-fuel in Nigeria will lead eventually to a food-fuel crisis. Hence the present Nigerian bio-fuel development policy should give serious consideration to food price impact as higher food prices will profoundly affect food security. This kind of processes, however, has created a direct competition between food and energy sector for the utilization of such feedstock. Since the price of the feedstock contributes more than 55% to the production cost, inexpensive materials such as nipa should be considered to make bio-ethanol competitive in the open market .The higher food prices resulting from the expanding use of food staples such as cassava in bio-fuel production would consequently reduce food consumption in developing countries such as Nigeria, which in turn would result in undernourishment. Nigeria being among the world's largest producer of Nipa Palm has the potential of producing bio-ethanol in large amounts from it. The Nipa Palm (*Nypa fructicans*, Wurmb.) is the only palm that can be found in most tropical mangrove systems (Hutton, 1996) and in the Niger Delta it has become an

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invasive species which is colonizing vast parts of this large mangrove system, rapidly. It propagates aggressively and replaces native species. Several eradication efforts have been implemented, but they have largely been unsuccessful. There is need to look at turning this weed into profit, by utilizing its ethanol potential. The objective of this study is to review Nipa Palm which hitherto regarded as an environmental menace is now regarded as one of the candidates for renewable energy to fulfill the requirement of clean carbon emission.

DESCRIPTION OF THE PLANT-NIPA PALM (*NYPA FRUTICAN*)

The Nipa Palm grows in soft mud and slow moving tidal and river waters that bring in nutrients. It has a horizontal trunk that grows beneath the ground and only the leaves and flower stalk grow upwards above the surface. Thus, it is an unusual tree, and the leaves can extend up to 9 m (30 ft) in height. It differs from most palms in the lack of an upright stem, but instead, has thick, prostrate, rhizomatous stems that branch dichotomously underground. A new plant grows out vegetative from each branch, often creating extensive pure stands that are closely packed. The terminal shoot supports a cluster of erect, pinnate leaves, of which the alternating leaflets are lanceolate and numerous (30-40 per leaf). The flowers are a globular inflorescence of female flowers at the tip with catkin like red or yellow male flowers on the lower branches. It is monoecious and the flowers are dimorphic (Toe *et al*., 2010). Pollination appears to by a variety of insects and wind (Hoppe, 2005), with drosophila flies and bees probably playing a more dominant role (Tomlinson, 1986). The flower yields a woody nut, these arranged in a cluster compressed into a ball up to 25 cm (10 in) across on a single stalk. The ripe nuts separate from the ball and are floated away on the tide, occasionally germinating while still water-borne (Toe *et al*., 2010).

Origin of Nipa Palm in Nigeria: Nipa Palm (Nypa *fruticans*), known as the attap palm (Singapore), Nipa Palm (Philippines), and mangrove palm is the only palm considered a mangrove. This specie, the only one in the genus *Nypa*, grows in southern Asia, northern Australia as well as the Niger delta region of Nigeria. It was, introduced into the Niger Delta at the beginning of the 20th century, i.e., in or about the year 1906, and it was brought by foreigners from Europe, who planted the Nipa Palm in Old Calabar from where a subsequent plantation was initiated in Oron in 1912 (Holland, 1922). In 1946, a further 6000+ seeds originating from Malaysia were planted throughout the brackish swamps of the Niger Delta (Zeven, 1971). It is from these two single points of entry that the species today have colonized large areas of the coastline throughout West Africa. The seeds were planted to check erosion of beach tidal waves of the

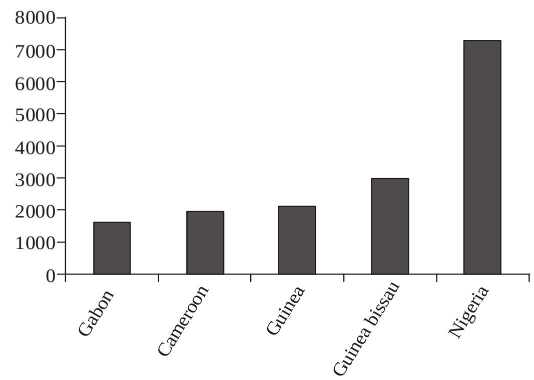

Fig. 1: Total mangrove area of the five countries in West Africa containing the largest coverage of mangroves, km^2 (UNEP-WCMC, 2006)

Atlantic Ocean through the Cross River estuary (NCF, 2000a). Nipa's colonizing ability has however rather than helped has reduced the firmness of the soils by its prostrate underground stem (NCF, 2000b).

In Nigeria, various parts of the Nipa Palm are used for several purposes (Udofia and Udo, 2005). Despite these uses, it is regarded as a nuisance in Nigeria because of its adverse ecological impacts on waterways and marine lives (Etukudo, 2001). The same plant is regarded as an endangered species in Singapore (Hutton, 1996) where technologies for the utilization for bio-ethanol production has being greatly explored. Lack of scientific technology on the utilization of any species generally results in under utilization and inadequate management.

Despite the invasion of the Mangrove habitat by Nipa Palm, it has enormous economic value to the people. Eradicating it completely is not a viable solution as presently pursued by the Nigerian government. One economic viable option of controlling its invasion is in its utilization as a renewable energy source in bio-ethanol production.

DISTRIBUTION OF MANGROVES

Mangroves occur in 19 West African countries from Mauritania in the north with the southernmost stands in Angola. Nigeria contains the most extensive mangrove ecosystems, which comprise nearly 35% of the total cover for the region (UNEP-WCMC, 2006). Figure 1 shows that Nigeria has the highest coverage area of mangrove in West Africa and Nipa is a mangrove that dominates this mangrove while Gabon has the least coverage in West Africa. Thus Nigeria should take advantage of its mangrove to establish a bio-ethanol raw material source. Eight true mangrove species are found in West Africa (Tomlinson, 1986), of which Nipa Palm is among these species. Mangrove swamps in Nigeria stretch along the entire coast and are found in nine of the 36 states. The largest extent of mangroves is found in the Niger Delta between the region of the Benin River in the west and the Calabar Rio del Rey estuary in the east.

The Nigerian mangrove system is the largest in Africa and the third largest in the world after India and Indonesia (Macintosh and Ashton, 2003), covering an area of over 7,000 km^2 of which over 504,000 ha found in the Niger delta region. *Nypa fruticans* has become the third most dominant species, and now expands up to 45 km from the sea shore to the hinterland.

A maximum width of 30 to 40 km of mangroves is found on the flanks of the Niger Delta, which is a highly dynamic system. Throughout the creeks in the eastern parts of the Niger Delta, the nipa is fast gaining grounds, especially along the coasts of Lagos, Rivers and Akwa Ibom states. In Port Harcourt, nipa vegetation is common sight along the creeks that lace the city (Umana, 2000). There is need to device means of maximizing the utilization of this weed or problem plant species in Nigeria.

Mangrove and risk reduction of climate change: Mangrove provides economic and environmental benefits Mangroves can fix greater amounts of CO_2 per unit area than in tropical ocean, where fixed by phytoplankton. Mangroves are also able to accumulate and store carbon in the soil in huge amounts. A 20 year old mangrove stores 11.6 kg/m^2 of carbon with C burial rate of 580 g/m^2/year and hence, plantation of mangroves provides great benefits to control global climate change by stabilizing atmospheric carbon (Fugimoto, 2000).

The dominant plant in the mangrove forest in Nigeria is the Nipa Palm. A hectare of regenerated mangrove forest could annually sequester 13 tons of carbon and produce 11 tons of fuel alcohol, which could prevent 7 tons of new fossil fuel emissions. This would be a very cost-effective way to produce bio-fuels and sequester huge amounts of carbon. The carbon dioxide (CO_2) reduction using biomass as energy source depends on: the energy crop cultivated, the conversion technology chosen and the current energy source replaced. Fossil fuels are the main sources of CO_2 emissions.

Situation of bio-ethanol production in Nigeria: The global bio-ethanol supply is produced mainly from sugar and starch raw materials. Sugarcane in the form of molasses and starchy materials in corn and cassava contain high levels of fructose, glucose and sucrose are the easiest to convert to ethanol but they compete with food supply. Cassava is already used for ethanol production in Nigeria in small processing units with capacities varying from 50 to 2000 L a day (NNPC, 2007). Nigeria aims to produce cassava ethanol worth over USD150 million every year, once it establishes a suitable infrastructure. This includes construction of 15 ethanol plants with assistance from Brazil (Chege, 2007). In various countries worldwide, researchers are currently trying to improve cassava starch technology. However, nipa (*Nypa fruticans*) is a non-threatened and underutilized sugar yielding palm which produces rich sugar sap from its inflorescence continuously for up to 50 years.

Prospect of Nipa Palm for bio-ethanol production: Bio-fuel produced and used within the same country are a way to reduce dependence on foreign sources of oil and other fuels, providing energy security and an economic boost for agriculture and industry. Energy from biomass can be generated from organic matter of vegetable or animal origin. The big advantage that biomass offers over other renewable energy sources such as wind and solar is that it can be easily stored and used when needed. It can provide a constant, non-fluctuating supply of energy. Bio-fuels are also a type of renewable energy resource, unlike fossil fuels, which cannot be grown or created. Nipa Palms have several qualities that make them potentially sustainable for bio-fuel production:

- **Easily available:** The biomass is easily available, and has a year round supply. They are perennials that can be tapped all year round. Tapping potential produces less waste than fruit production, such as with oil palms or baggase disposal problem as in sugarcane.
- **Low costs:** The raw material is available at low costs to making the ethanol cost effective and does not compete with food crops for agricultural land. The sugar factory itself is greatly simplified as there is no expensive crushing mill to maintain.
- Large stands appear in the wild, meaning that is possible to utilize wild growth rather than develop commercial plantations. The impact of large scale tapping may also serve as human control of this invasive species.
- **High sugar yield:** The sugar content of the sap is high. The sugar yields cited compare very favorably with values for the sugarcane industry.
- Nipa Palm trees are not a food source and its sap can be drained every day without the need to harvest the plants. The plant will live for 50 years; all that is needed is to just collect the sap.
- Nipa alcohol may be blended with petrol up to a 1:4 ratio without the need to redesign or adapt the carburetors of gasoline engines.

From Table 1, it can be shown that Nipa Palm has the highest yield of ethanol compared with the other ethanol raw materials listed in the table. Nipa Palm is now receiving steady interest as a potential bio-fuel feedstock because trials show it yields unparalleled amounts of sugar. Theoretical ethanol yields based on actual juice

Table 1: Raw materials for bio-ethanol production and their yield

Crop	Yield (ton/ha)	Ethanol (L/ton)	Ethanol (L/ha)
Sugarcane	50-90	70-90	5,000-8,000
Wheat	1.5-2.1	340	510-714
Barley	1.2-2.5	250	300-625
Rice	2.5-5.0	430	1,075-2,150
Maize	1.7-5.4	360	600-1,944
Sorghum	1.0-3.7	350	350-1,295
Irish potatoes	10-25	110	1,110-2,750
Cassava	10-65	170	1,700-11,050
Sweet potatoes	8-50	167	1,336-8,350
Grapes	10-25	130	1,300-3,250
Nipa Palm			15,000-20,000

Biopact Bioenergy News (2007)

harvests in Malaysia and Papua New Guinea are estimated to reach up to 15,000 to 20,000 L per ha (by comparison: sugarcane yields around 5000-8000 L; corn, 2000 L). Prompted by these results, the world's first initiative to actually produce ethanol on a large scale from wild stands of the plant was launched in Malaysia 4 years ago (Biopact Bioenergy News, 2007).

Rural areas in Nigeria are also endowed with forest produce, cassava, sugar cane, rice, maize, animal waste, crop residue, jatropha seeds among others. According to Ololade (2007), the country is poised for the production of bio-fuel given its cassava, sugar cane, rice, maize and sorghum output.

Government efforts so far in bio-fuel development: Effort by government of Nigeria to develop bio-fuel industry started with the establishment of a Renewable Energy Division (RED) by Nigeria National Petroleum Commission (NNPC) in August, 2005 (NNPC, 2007). The framework of the Commission include: the coordination of the country's vision for efficient production of bio-fuel; the integration of petroleum sector with agriculture; and the creation of rural wealth and employment through bio-fuel industry.

Between 2005 when RED was established and 2008, very little has been achieved. A summary of these achievements include:

- Public awareness campaign especially in the cultivation of crops use for the production of bio-fuel. Farmers were encouraged to cultivate cassava, sugar cane, maize etc.
- Quality assurance framework was set up by Standard Organization of Nigeria (SON) for the importation and production of bio-fuel.
- Retail outlets were selected for effective distribution of the products.
- NNPC staff was trained on bio-fuel handling techniques, especially in quality assurance.
- Facilities in the downstream sector of the petroleum industry especially in Atlas Cove and Mosimi were modified to handle bio-fuel products imported into the country (NNPC, 2007).

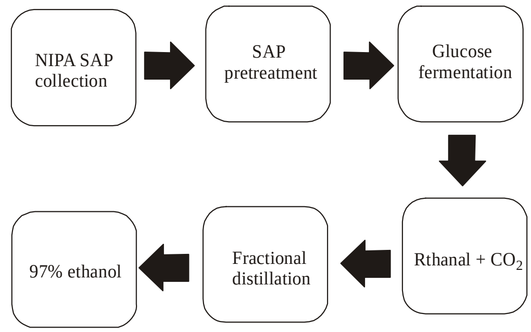

Fig. 2: Flow chart of Bio-ethanol production from Nipa Palm

Tapping NIPA for SAP: The Nipa Palm can be tapped as early as five years old and will continue to produce sap for another fifty years. The flowering stalk is cut and inserted into a pot or plastic bag, and the end sliced everyday to stimulate new flow and prevent bacterial growth. The base of the stalk is pounded with a mallet to keep the flow going. About half to one litre of sap can be collected per day. A flower stalk can be tapped in this way for 3 months. Nipa has a very high sugar-rich sap yield. Fermented into ethanol the palm's large amount of sap may allow for the production of 6,480-15,600 L of ethanol per hectare. Sugarcane yields 5,000-8,000 L per ha and an equivalent area planted in corn would produce just 2000 L per ha.

Figure 2 shows the flow of bio-ethanol production from Nipa sap collected going through glucose fermentation with the given off of carbon IV oxide (CO_2) and then fractional distillation.

The sap of Nipa Palm is highly rich in sugar (Sucrose) and may allow for the production of 6,480-15,600 L of ethanol per ha. Yeast is added to the solution, which is then heated. The yeast contains an enzyme called invertase, which acts as a catalyst and helps to convert the sucrose sugars into glucose and fructose (both $C_6H_{12}O_6$). The fructose and glucose sugars then react with another enzyme called zymase, which is also contained in the yeast to produce ethanol and carbon dioxide. The fermentation process takes about three days to complete and is carried out at a temperature of between 25ºC and 30ºC. The ethanol, which is produced from the fermentation process, still contains a significant quantity of water, which must be removed. This is achieved by using the fractional distillation process.

CONCLUSION

If the use of the Nipa Palm for ethanol production is adopted by Nigeria then it will bring many needed jobs to the Niger Delta area. Although the Niger Delta is the home to the Nigerian oil industry, it is considered the poorest part of the country. For the people of the area, growing the tree will be a very painless process, as it does not require special care. Harvesting the sap is easy to learn and when perfected, can procure even more sap. The growth of this industry will bring many jobs to the area. These jobs are estimated to pay well above the local minimum wage. The benefits do not end there; there is more than enough sugar to meet the ethanol needs. FAO projects in Cambodia have shown that palm sap can be used as animal feed. In a country like Nigeria, where increasing livestock populations are depleting and degrading the available grazing land into desert, this can be quite a revolutionary find.

Bio-fuels offer a big potential for a strategy against climate change. Nipa ethanol is a better renewable energy alternative to ethanol produced from palm trees, sugarcane, corn, cassava and other plants because ethanol from these sources eat into food production and raises their prices .When ethanol fuel is produced from energy crops such as Nipa Palm its use as a transportation fuel reduces dependence on imported petroleum, contributes no net carbon dioxide to the atmosphere and provides new markets for depressed farm economies. Instead of the complete eradication of the weed as presently unsuccessfully pursued by the Nigerian government a much viable option such as its use in bio-ethanol production should be capitalized on.

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