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PLANTS AND ENVIRONMENT FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

Plants are vital to the mother Earth; they purify the air, filter water, prevent erosion and act a buffer against climate change. They offer a home to plant and animal species and also provide natural resources such as medicine, food, timber and fuel. This paper discusses plants and environment for sustainable development with emphasis on the role of plants in carbon sequestration and types of carbon sink. The increasing effects of deforestation on flora and fauna, which include increased greenhouse gas emissions, acidic oceans, loss of biodiversity, flooding and erosion as well as decreased life quality are highlighted. These effects can be mitigated through education, protection of marginal lands, tree planting, sustainable agricultural practices, use of alternative energy sources, use of renewable wood resources, forest-derived products, reduced paper consumption and forest-friendly policies. Greener routes to sustainable environment could be achieved through afforestation, phytoremediation, nanotechnology and biofuel. A naturally motivated investigational practice for the biosynthesis of nanoparticles (NPs) is now established as an emerging area of nanoscience research and development for sustainable environment.

Keywords: Plants, environment, phytoremediation, deforestation, biofuel, nanotechnology

INTRODUCTION

Plants transform light into energy that other organisms use. These include food -for example, sea turtles and manatees eat sea grasses, and people and livestock eat plants - and the natural gas/oil/coal/firewood that we use to fuel fires and to generate electricity. Plants also sequester CO_2 - an important greenhouse gas - by using the carbon as an important material for growth. Plants provide a habitat for all sorts of creatures, including humans, other plants and microbes. Plants improve resilience and protect health: mangrove forests protect coastlines from erosion and storm surges, the roots of plants stabilise the ground and help retain water in the soil so that watersheds will be healthy and ensure the supply of groundwater and water to rivers and lakes. Medicines and supplements are obtained from plants; green spaces in urban areas provide cleaner air and cooler, more relaxing surroundings for stressed city people. Plants support the economic and political environments too - natural resources, of which plants are key, are the foundation of economic growth and drive political agenda. Plants play an important role in influencing the climate. The carbon is sequestered and CO_2 released when plants are burned as fossil fuel, influencing the micro-climate of a region, especially through evapotranspiration. Plants use carbon dioxide while photosynthesizing, removing it from the atmosphere.

The World Bank (2013) estimated that 20 per cent of increasing atmospheric carbon dioxide levels has resulted from deforestation. They estimated that as much as 50 per cent of global warming over the past 50 years is due to changing land-use patterns and deforestation in the modern age. A single tree is

estimated to absorb 1.33 tons of carbon dioxide per 100 years, an average of just over 26 pounds of carbon dioxide per year (World Bank, 2013). Global warming is an increase in the average temperature of the earth's surface over time. This rise results from the "greenhouse effect," in which gases such as carbon dioxide trap heat within the earth's atmosphere. The rising temperatures could cause catastrophic climate change.

CONCEPT OF CARBON SEQUESTRATION

Carbon sequestration means capturing carbon dioxide (CO_2) from the atmosphere or capturing anthropogenic (human) CO_2 from large-scale stationary sources like power plants before it is released to the atmosphere. Once captured, the CO_2 gas (or the carbon portion of the CO_2) is put into long-term storage. CO_2 sequestration has the potential to significantly reduce the level of carbon that occurs in the atmosphere as CO_2 and to reduce the release of CO_2 to the atmosphere from major stationary human sources, including power plants and refineries. There are two major types of CO_2 sequestration: terrestrial and geologic. Terrestrial (or biologic) sequestration means using plants to capture CO_2 from the atmosphere and then storing it as carbon in the stems and roots of the plants as well as in the soil. Geologic sequestration is the method of storage that is generally considered for carbon capture and storage (CCS) projects. Carbon Capture and Storage is the practice of capturing CO_2 at anthropogenic sources before it is released to the atmosphere and then transporting the CO_2 gas to a site where it can be put into long-term storage. A carbon sink is any natural reservoir that absorbs more carbon than it releases, thereby lowering the concentration of CO_2 from the atmosphere. Globally, the two most important carbon sinks are vegetation and the ocean. Public awareness of the significance of CO_2 sinks has grown since passage of the Kyoto Protocol, which promotes their use as a form of carbon offset. There are also different strategies used to enhance this process

DEFORESTATION AND ITS IMPACTS

Deforestation is directly linked to development and felling of trees is at times unavoidable. However, for a sustainable attitude towards nature and towards the environment, the impacts of such destructions must be remedied. Tree planting is the best way to remedy the impacts of development on our environment. There is, therefore, the need to replace a tree which has been felled by another tree. Deforestation is the permanent destruction of forests in order to utilise the land or trees. Typically, deforestation is the clearing of trees without the intention of establishing future growth. Harvesting, forest fires and insect infestations do not count as deforestation because the affected areas will eventually grow back. In some countries, such as Canada and America, all areas harvested must be reforested either by replanting or through natural regeneration.

The land is often converted into farms, plantation, roads, housing and other city uses. Deforestation is most severe in various countries such as the Amazon, Borneo, Congo Basin and the Russian Far East. Over half of the world's forests have been destroyed over 10,000 years, the majority in just the last 50 years. These immense changes include large-scale extinction events, desertification, climatic changes, topsoil loss, flooding, famine, disease outbreaks and more. Deforestation has even been caused by extensive war; throughout history, fire has often been used to deprive the enemy of necessary resources. If they are not reforested, they inevitably end up as wastelands directly from soil erosion and desertification. In Nigeria, in an attempt to fight insurgency, roadside trees are cut down in the belief that forest serves as a hideout for hoodlums. According to Olagunju (2015), drought and desertification can be remedied through integrated

approaches such as awareness programmes, protection of marginal lands, tree planting, sustainable agricultural practices and use of alternative energy sources.

The increase of mining on tropical forests is causing further damage due to the rising demand and high mineral prices. These projects are often accompanied by large infrastructure construction, such as roads, railways and power systems. Mining deforestation is putting additional pressure on our forests and freshwater ecosystems. Similarly, America, China, Japan and Canada make up more than of the world's paper production—400 million tons a year. Approximately 640 million trees represent the paper that is thrown away each year, according to the Environment Paper Network. Recycling could save 27.5 million tons of carbon dioxide from going into the atmosphere. By using recycled paper, the forests will remain as an ecosystem and wildlife habitat. Due to overpopulation, more land is needed to establish housing and settlements. Many more roads and highways are being built in order to accommodate the rising number of vehicular movement. With population increase comes the need for increased food production and raising of livestock—resulting in deforestation. Logging industries cut down trees for furniture, paper, building materials and many more products. These are a direct impact of growing human population, which is why it is important to purchase from sustainable companies which actively work against deforestation. In addition, wood-based industries such as paper, matchsticks and furniture need a substantial quantity of wood. Lumber and charcoal are common examples of trees being used as fuel. Cooking and heating the world over use these resources, and half of the illegal removal from forests is believed to be used as fuelwood.

Globally, charcoal industry is a multi-billion dollar industry. According to the Food and Agriculture Organization (FAO) of the United Nations (2007, 2010) over 40 million metric tonnes of charcoal are consumed globally and approximately 2.4 billion people rely on wood and charcoal for their daily fuel. Nigeria currently ranks second to Brazil in the production of charcoal. The western countries particularly prefer Nigeria's charcoal, as the country is rich in tropical hardwood, which burns slower and hotter. Nigeria presently exports 380, 000 metric tonnes of charcoal annually (Food and Agriculture Organization, 2017). It is a cheap source of fuel to purchase and use. It is also a source of generating income through exportation and local sales. The business involves the sourcing, storage, packaging (in about 5 kg bags) and transportation of the hardwood charcoal. Aderogba and Adeniyi (2019) highlighted the significance of charcoal production around the world, its roles in the economy of communities and major challenges.

Large areas are also cleared to construct roads in order for large trucks to have access to logging sites. Selective logging is where only the most valuable trees are felled; however, this does not help our problem as one large tree may bring down surrounding trees and thin the forest canopy. The forest canopy is extremely important to the ecosystem as it houses animals, protects plants and insect population and protects the forest floor. Similarly, it has been observed that agricultural expansion and livestock ranching are a major cause of deforestation in agricultural plantations. An increasing supply-demand for products such as palm oil and soybeans is driving producers to clear forests at an alarming rate. Farmers often clear the land for cattle by using slash-and-burn techniques (cutting down trees and burning them). Unfortunately, they will then use the property until the soil is completely degraded; this process is

repeated on a new patch of woodland. Although reforestation may take place, but it will take many years to return to its original condition.

Cattle ranching and deforestation are more pronounced in Latin America. Over the past 40 years, forest area has been reduced by almost an astounding 40 per cent. During the same period, pasture regions and cattle population have grown significantly and rapidly. It is based on global and local concerns that the Federal Government of Nigeria initiated Rural Grazing Area settlement (tagged ''RUGA'') in 2019, aimed at curbing open grazing of animals that continues to pose security threats to biodiversity, farmers and herders. The Benue State government and several notable Southern and Middle Belt socio-political groups have completely condemned the plan and called for its scrapping.

Forests are essentially the lungs of our planet. All plants take in carbon dioxide and release oxygen. Trees are able to convert more carbon dioxide than a regular plant, though. Forest loss is often caused by climate change. Tropical rainforests are extremely humid due to the water vapour released along the oxygen. But when a forest is cut down, the humidity levels decrease, causing the remaining plants to dry out. For example, drying-out of tropical rainforests increases fire damage. Fires, which can be both accidental and intentional, destroy forests quickly. Recently, nearly 40,000 fires gutted Brazil's Amazon rainforest, the latest outbreak in an overactive fire season that has charred 1,330 square miles (2,927 square km) of the rainforest in 2014. These Amazonian wildfires are a man-made disaster, set by loggers and cattle ranchers who use "slash-and-burn" method to clear land. Feeding off very dry conditions, some of those fires have spread out of control (The Conversation, 2017).

There are increasing impacts of deforestation on flora and fauna which include increased greenhouse gas emissions, acidic oceans, loss of biodiversity, flooding and erosion as well as decreased life quality. These effects can be mitigated through education, use of renewable wood resources , forest-derived products, reduced paper consumption, forest- friendly policies, etc. One of such initiatives is the Great Green Wall of the Sahara and the Sahel (French: *Grande Muraille Verte pour le Sahara et le Sahel*) which is Africa's flagship initiative to combat the effects of desertification. Led by the African Union, the initiative aims to transform the lives of millions of people by creating a mosaic of green and productive landscapes across North Africa. This intiative was conceived from the initial idea of a line of trees from east to west bordering the African desert. The vision of a Great Green Wall has evolved into that of a mosaic of interventions addressing the challenges facing the people in the Sahel and the Sahara. As a programming tool for rural development, the overall goal of this partnership is to strengthen regional resilience and natural systems with sound ecosystem management, protection of rural heritage and improved living conditions. The project is a response to the combined effects of degradation of natural resources and drought in rural areas. It is a partnership that supports communities working towards sustainable management and use of forest, rangelands and other natural resources. It seeks to help communities mitigate and adapt to climate change, resources and to improve food security.

PHYTOREMEDIATION

The contamination of the environment by heavy metals is one of the major threats to water and soil as well as human health. Phytoremediation has been used to remediate metal and hydrocarbon-contaminated sites (Ndimele *et al*., 2010). Environmental pollution has been known to cause severe illness and sudden death in humans, which is largely attributed to mining, automobile exhaust, agricultural and industrial activities.

Heavy metals have been classified among major causes of pollution (Adedokun *et al*., 1989; Galadima *et al*., 2011). Phytoremediation could be the cheapest and simplest options among the available soil clean-up strategies (Susarla *et al.*, 2002). The use of plants for contaminant-degradation or extraction of xenobiotic from water or soil substrate has been reported by a number of authors (Bouwman *et al*., 2005; Abdulkadir *et al.*, 2019).

Remediation without excavation of contaminated site, often referred to as botanical bioremediation (Chaney *et al.*, 1997), involves the use of green plants to decontaminate soils, water or air. It is an emerging technology that can be applied to both organic and inorganic pollutants present in the soil, water or air. However, the ability to accumulate heavy metals differs significantly amongst species and among cultivars within species due to different mechanisms of ion-uptake that are operative in each species, based on their genetics, morphological, physiological and anatomical characteristics.

Fig. 1 shows different categories of phytoremediation which include phytoextraction, phytofiltration, phytostabilisation, phytovolatisation and phytodegradation, depending on mechanism of the remediation which is based on the problem on ground (Garbisu and Alkorta, 2001). Lead has been listed as a potential carcinogen by the United States Environmental Protection Agency (2006). It causes many problems in both plants and animals. It accumulates in the body's organs such as brain, which may lead to poisoning (plumbism) or even death. The gastrointestinal tract, kidney and central nervous system are also affected by the presence of lead. Children exposed to lead are at the risk of impaired development, lower intelligence quantum, short attention span, hyperactivity and mental deterioration. According to Doctors Without Borders (2012), lead poisoning claimed the lives of over four hundred (400) children between 2010 and 2011 and left over 2, 000 others at risk in Zamfara State, Nigeria. This phenomenon indeed poses a clear danger to Nigerian children.

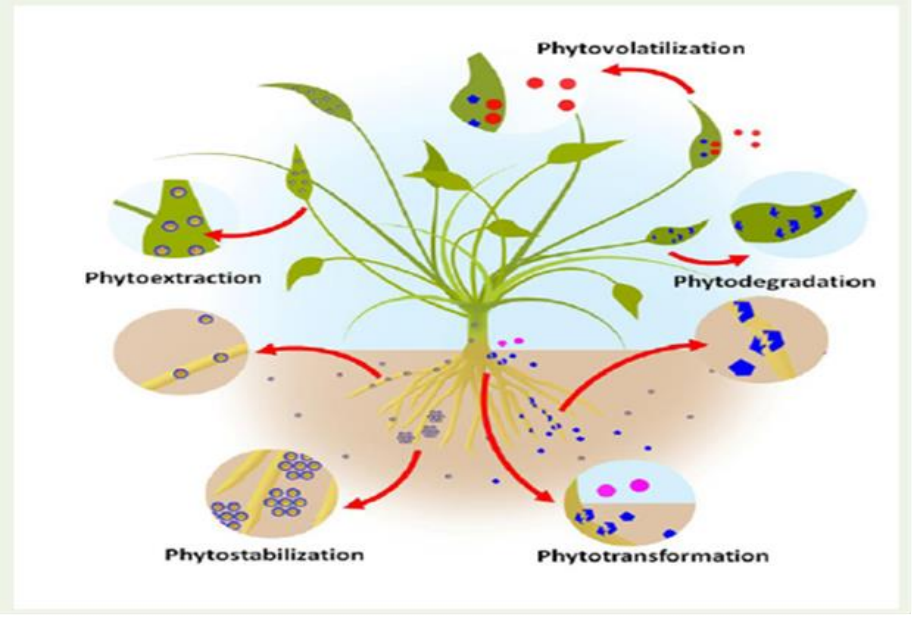

Fig.1: Categories of phytoremediation

Many metals are essential to plant growth but are toxic at higher concentrations thereby causing oxidative stress by formation of free radicals, which replace essential metals in the pigment or enzymes disrupting their function. Heavy metals render the land unsuitable for plant growth and destroy biodiversity. In recent times, hydrocarbon pollution in the Niger Delta region has become a serious environmental problem and many plants with potentials to tolerate petroleum pollution have been reported and could be useful in addressing the challenges (Frick *et al*., 1999).

ALLELOPATHY AND ENVIRONMENTAL MANAGEMENT

Weeding in crop production systems is accomplished mainly by the use of chemical herbicides. It is recognised that the overuse of chemical herbicides causes the pollution of ground water (Zhang *et al.,* 2017) and the herbicidal resistance among weeds (Heap, 2014). Recently, there has been focus on the utilisation of allelochemicals as sources of new herbicides and novel modes of action. Information on the allelopathic potential of Nigerian plants is scarse in spite of high floral diversity with over 15, 000 plant species in this country. The screening of invasive plant species in Nigeria could provide a unique opportunity to discover phytotoxic compounds with novel mode of action for developing a natural herbicide. Allelochemicals can be formulated to be competitive with chemical herbicides and the use of adjuvants and nanoformulations is an effective way to increase the efficacy of natural plant inhibitors.

Allelopathy is a phenomenon involving either direct or indirect and beneficial or adverse effects of a plant (including microorganisms) on another plant through the release of chemicals in the environment (Rice, 1984). For over 2,000 years, allelopathy has been reported in the literature with respect to plant interference. Generally, plants contain thousands of natural products, but not all are implicated as being allelopathic (Bell and Charlwood, 1980; Rice, 1984; Aliero and Afolayan, 2009). According to Rice (1984), phenolic compounds are among the most abundant groups of secondary metabolites in plants and bear hydroxlated aromatic rings including simple phenols, phenolic acids, phenylpropanoids, coumarins, quinones, flavonoids, tannins and other miscellaneous phenols. The structures of some allelochemicals are presented in Figure 2.

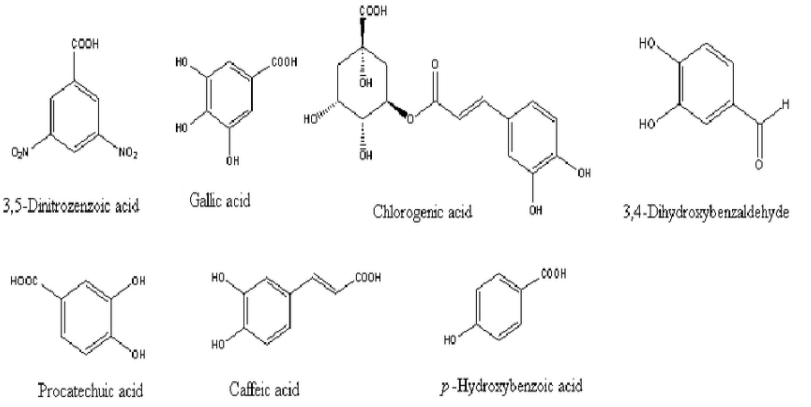

Fig. 2: Some allelochemicals isolated from *Delonix regia* (Chou and Leu, 1992)

Allelochemicals represent an excellent strategic source of natural chemicals that may be involved in developing natural herbicides (Qasem and Foy, 2001; Aliero and Afolayan, 2009; Aliero and Adamu, 2009). Allelochemicals have eco-friendly novel modes of action and are capable of replacing existing herbicides (Duke *et al*., 2000). There are different modes of action or little overlap between allelochemicals and synthetic herbicides, hence there is an imminent need to explore novel compounds with different mechanisms of action and new molecular target sites not previously exploited by existing herbicides (Dayan *et al*., 2012). In this regard, allelochemicals could be used as sources of new chemical structures for maximising the suppressive effects in future herbicides with specific target sites (Aslani *et al*., 2014, 2016; Ahmed *et al*., 2017).

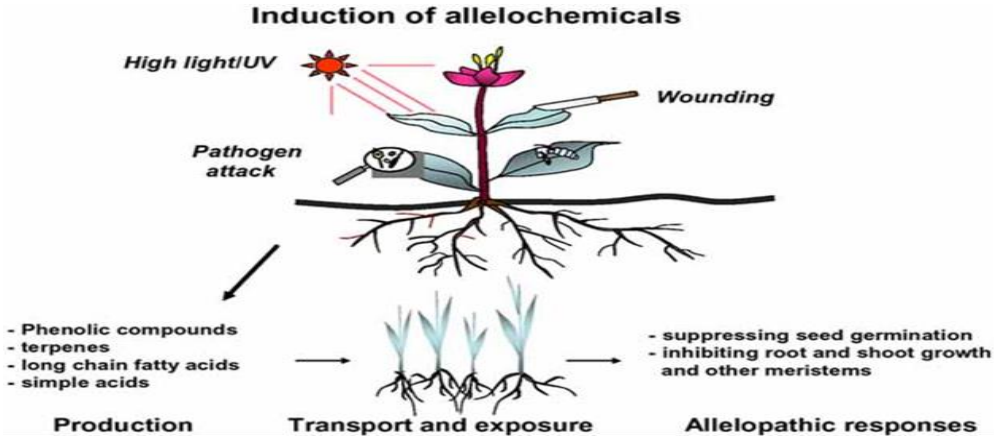

Fig. 3: Induction of allelochemicals by environmental Stresses.

Autotoxicity is ranked second after soil-borne diseases in importance in re-seeding plants. Studies suggest that it may be a primary factor that increases disease and other stresses on germination of seedlings and reduction in plant yield (Singh *et al*.., 2001). They recommended the use of resistant species and cultivars, plant nutrient situation and soil type. Plant residue should be removed after harvesting. The use of organic fertilizer, crop rotation and management of autotoxic force to different plants helps in reducing the effect of autotoxicity (Ill-Mu *et al*., 1998; Haq *et al*., 2010; Lim *et al.,* 2017). In recent years, nanotechnology has been explored due to its potential to revolutionise the agricultural industry (Kumar *et al*., 2017). The efficacy of pesticides with nano-scale crystals and nano- autotoxicity is ranked second after soil-borne diseases in importance in re-seeding plants. The efficacy of pesticides with nano-scale crystals and nano- encapsulation has been improved in recent times. Nano-emulsion system could be another alternative for effective delivery of pesticide and herbicide. In recent years, many types of nanoformulations have been developed to maximise efficiency of pesticide. But there is no report regarding application of nanoformulation in enhancing effectiveness of allelochemicals. In this relation, scientists have tried to reverse the trend of reliance on chemical weed managements through developing effective natural herbicides (Kato-Noguchi *et al.,* 2012). The procedure for production of silver nanoparticles is presented in Fig. 4.

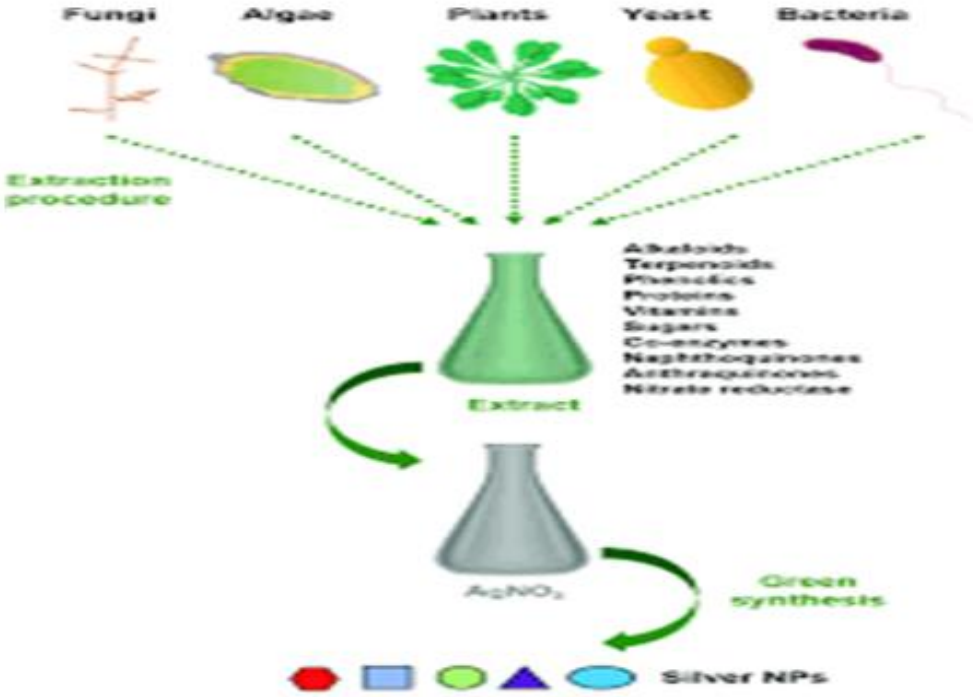

Fig. 4. Procedure for silver NPs production

Nanoformulation of plant natural herbicides has the potential to increase crop productivity, increase stability of the active agent, prolong effect on target, biodegradable with low environmental harm and favourable safety profile (Arokiyaraj *et al.*, 2014; Sandeep *et al.*, 2017), while resolving the drawbacks of conventional agrochemicals which have negative environmental impacts (Koul, 2019). Nanoemulsions are clear, thermodynamically stable mixtures of oil, water, surfactant and co-surfactant. These are the oil-in-water type of emulsions with the average droplet size ranging from 5 nm to 100 nm (Amin and Biswajit, 2019).

BIOFUELS FOR SUSTAINABLE DEVELOPMENT

The problem of climate change, rising crude oil prices, need for energy security and acknowledgement of the finite nature of fossil fuels have resulted in a shift in energy policies and choices among nations. Attention has and is being directed at renewable energy sources and currently biofuels have taken a centre stage in energy plans and policies of most countries. Biofuels are termed green fuels due to their low level emission of greenhouse gasesn (GHG), and are made from crops such as corn, soybeans, sweet sorghum, jatropha, oil palm, cassava and sugar cane. Biofuels are viewed by developing countries as a means of creating jobs, stimulating agriculture and rural economic development and a source of foreign exchange earnings and savings while the industrialised West view biofuels as a mitigant to GHG emissions and a source of energy security. Many countries in both developed and developing worlds have lunched biofuel programmes and have set biofuel production and utilisation targets.

Nigeria presently has a policy on biofuels entitled Nigerian Biofuel Policy and Incentives (2007). The Policy document was approved by the Federal Executive Council on June 20th, 2007 and gazetted as a National Biofuels Policy and Incentives (NBPI) at the same time. The Nigeria National Petroleum Corporation (NNPC) was given the mandate to create an environment for the take-off of a domestic ethanol fuel industry. The aim was to gradually reduce the nation's dependence on imported gasoline, reduce environmental pollution while at the same time creating a commercially viable industry that can precipitate sustainable domestic jobs. The framework of the policy and the incentives is meant to create an enabling environment that is expected to sensitise and catalyse the development of the country's biofuel industry (Dayo, 2008). The biofuel programme constitutes a major and unique attempt to integrate the agricultural sector of the economy with the downstream petroleum sector, while fostering the use of other renewable energy sources. To make the project a realisable objective, the Federal Government, through the Nigeria National Petroleum Corporation (NNPC), created the Renewable Energy Division (RED), to champion the implementation of the programme. The NNPC, by mandate of the former President, Olusegun Obasanjo, inaugurated the Renewable Energy Division in August, 2005, and charged it with the responsibility of developing the biofuel industry in Nigeria (http://www.tribune.com.ng/16092008/). This is aimed at linking the agricultural sector to the Gas and oil industry. RED shall provide a consistent, steady supply of alternative fuel to the utmost satisfaction of customers and continuously seek to improve the quality of its management systems. The policy document made clear definitions of concepts as they relate to the biofuel industry in Nigeria. It is imperative to look at these definitions:

1. Biofuels shall mean fuel ethanol and biodiesel and other fuels made from biomass and primarily used as automative, thermal and power generation, according to quality specifications stipulated by the Standards Organisation of Nigeria (SON), Department of Petroleum Resources (DPR) and any other competent government agancies.

2. Biomass shall mean agriculturally produced raw materials which are available on a renewable or recurring basis, including trees, plant fibre, cellulose-based materials, industrial wastes and the biodegradable component of municipal solid waste.

3. Fuel ethanol shall mean hydrous or anhydrous bio-ethanol suitably denatured for use as motor fuel, according to quality specifications stipulated by SON, DPR and any other competent government agencies.

4. Bio-diesel shall mean fatty acid methyl ester or mono-alkyl esters derived from vegetable or or animal fats for use in diesel engines, according to quality specifications stipulated by SON, DPR and any other competent government agencies.

5. Out-growers Scheme shall mean an arrangement between farmers in farming communities and Bio-fuel mill owners and/or companies for the purpose of feedstock production or cultivation.

6. ServCos shall mean Agricultural Service Companies independently managed and set up for the purposes of providing support to farmers through outgrowers schemes. ServCos may be companies set up by individuals or fully/partly owned subsidiaries of Biofuel plant operations.

7. Biofuel Feedstock: The following crops shall qualify as bio-fuel feedstock for production in the country: cassava, sugarcane, oil palm, jatropha, cellulose-based materials and any other crop as may be approved by the Bio-fuel Energy Commission (NBPI 2007, 4-5).

PLANTS IN EROSION CONTROL

Erosion is the gradual washing away or removal of the topmost surface of the earth's crust. This removal is caused by erosive agents particularly in the region where it occurs. According to Faniran and Areola (1976), erosion is the process of detachment and transportation of soil materials by the erosive agents of water, wind and ice. Plants provide protective cover on the land and prevent soil erosion and slow down water as it flows over the land. Plant roots hold the soil in position and prevent it from being blown or washed away.

Studies have shown that plant species such as *Ipomea asarifolia* cover improve the characteristics and fertility of soil (Anka and Aliero, 2002). The root system of *Ipomoea* conserves water and binds sand particles together to help build a more friable soil structure whereas its decayed roots add to the organic matter content of the soil (Aliero and Anka, 2001). The shoot system accumulates organic matter around the plant's vicinity, prevents soil erosion and retains nutrients (Abdullahi *et al.,* 2011). *Cynadon dactylon* controls erosion and helps in dune stabilisation (Glenn *et al.,* 2012). Its strong, stout rhizomes and stolons spread rapidly to provide quick soil cover, prevent weed invasion and resist drought (USDA, 2012). Generally, planting of trees reduces flooding, prevents erosion and serves as wind-breaks in an environment.

CONCLUSION

Intensive and continuous monoculture of the same plants on the same field for several years causes replanting injuries like outbreak of diseases and insect pests, exhaustion of soil fertility, development of chemical interference (allelopathy) leading to growth and yield reduction, generation failure and population deteriotion. Therefore, knowledge of autotoxicity among plants, autotoxic chemicals, phytotoxicity as well as control measures is useful for sustainable crop production. For a sustainable development, there is the need for advocacy and community awareness on the use of renewable wood resources, alternative sources of protein and less consumption of meat, forest-derived products, reduced paper consumption and other forest-friendly policies. Phytoremediation has shown great potentials in the clean-up and the maintenance of a sustainable environment. There is the need to reduce, re-use and recycle materials in order to sustain the environment. In recent times, a naturally motivated investigational practice for the biosynthesis of nanoparticles is now established as an emerging area of nanoscience research and development. Silver nanoparticles have received greater attention.

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