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BIOTECHNOLOGY AND ENVIRONMENTAL SUSTAINABILITY

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Abstract Objectives: The human population of Nigeria is about 140 million and to achieve millennium development goals, requires improved biotechnology and a sustainable environment, among other factors. Pollution as a result of oil exploration, industrial, agricultural activities and poor waste management system have been identified as major threats to our environment. Phyto and bacteria bioremediation, are recommended methods of handling land polluted with oil. Genetic engineering of gene from gelly fish which shows florescence and the vector from the bacteria pseudomonas putida was able to produce a transgenic biosensor, an instrument of bioremediation, in the detection of land mines in the environment. Dianococaus radioduras an extrimophile is the most effective and efficient radiation repair bacteria, has been very useful in bioremediation. Intense reforestation will help to check global warming, flooding and desert encroachment. Microbial type culture shall upgrade biotechnology in Nigeria. Vertiver a plant with vertical root system above 2m in the soil provides good anchorage for erosion control. The challenges facing full scale success of Biotechnology in Nigeria includes lack of enabling laws and research facilities, Poor awareness and education. The socio economic gains in sustainable biotechnology includes: Growth in the Country‟s Gross Domestic Product (GDP); food security is enhanced; decline in poverty; tourist attraction and good health of the people.

Keywords: bioremediation; genetic engineering; transgenic; global warming; pseudomonas putida; Vertiver; biosensor.

Introduction The environment serves as a control to most of the characteristics displayed by plant, animal and other forms of micro organisms. There is a network of activities existing between biotic, (living components) and abiotic, (non-living component). Living things have various ranges of temperature to be at their pick or sterile or even go to extinction. For man to survive in the environment, the basic necessities of life such as, food, shelter and clothing are required. The

environment is rich with abundant resources ranging from the food we eat, mineral resources and variety of plants, animals and bacteria of different species. Human activities such as agricultural, industrial, constructional, exploration and recreational have in various ways had adverse effects on the environment. There is therefore the need to sustain the environment. Biotechnology offers some of the solutions to these environmental problems.

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To sustain the environment according to Clive James 2006, „we need to responsible and effective managers of resources that allows one generation to pass on to the next generation a legacy that is as good or better than the one inherited from the previous generation‟. Scientist have discovered that plants, animals and other micro organisms have physical or genetic characteristics that can be of good help in solving most environmental problems. Deforestation, oil and mineral exploitation and exploration, poor management of waste (biodegradable and non biodegradable), industrial activities and environmental disturbances such as conflicts and wars have tremendous effects on the environment and the lives of man and other living things. Phyto and bacterial bioremediation has been very useful in remedying oil polluted land and water, especially through genetic engineering. Totipotency of plants has allowed for rapid multiplications of different plants species and with desirable characteristics through genetic engineering, this property is useful in food security. Bacteria live everywhere and can colonise almost everything. They can be pathogenic (disease causing), food spoiling or totally harmless. Some bacteria like the extrimophile can survive extreme environmental condition like high temperature, high salt concentration or high pressure. Gene from these bacteria can be isolated and introduced into the gene of another plant, animal or bacteria to produce transgenic hybrid which could be plants, animals or bacteria. Example, the gene from gelly fish (which shows fluorescence) was isolated and combined with the gene and vector from the bacteria, pseudomonas putida, through genetic engineering to produce a

biosensor plant, capable of dictating land mines by glowing light, when the root of the plant make contact with trinitrotoleun (TNT), a constituent of land mines. Thiobacilus ferrooxidant, a bacteria, is capable of concentrating copper ore in the mining industry when combine with a gene from an extrimophile. Arabidopsis is a plant with a gene tolerant to extreme salt concentration. The gene can be isolated and combined with gene of plant with desirable interest to survive extreme salt concentrated area. This is a form of bioremediation. Nigeria is made up of three distinct climatic distributions; tropical forest zone in the south, Savannah in the Middle Belt, Desert in the North. This distribution influences the type of activities in the various zones. The North is characterised with environmental problem of desertification while the south is gully erosion and gas flaring. Some microorganisms have gene for enzymes capable of degrading petroleum. Deforestation has been trace to be one of the major causes of global warming, and sea level rise. Bacteria pesticides and viral pesticides are being developed which will help in reducing the use of the chemical pesticides. Several companies in USA like the Monsanto, Mycogen, Ecogen, Zoecon company etc. are actively involved in development of biological pesticides. Trials in these companies are going on to use genetically engineered live soil bacteria for coating seeds before planting. The company Ecogen Inc. was involved in developing biological pesticides against the two major crop pest budworm and ball worm by transferring a gene from Bacillus thuringiensis [Bt] into either a naturally occurring soil bacterium or into a strain

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of pseudomonas. The objective of this paper is to evaluate Nigerian Environmental problems, analyse the extent of Biotechnology regarding Millennium Development Goals

[MDGs] and proffer solution that will accelerate our growth and improve the level of performance, using Biotechnology.

2.0 WHAT IS BIOTECHNOLOGY Biotechnology is a term covering a broad range of scientific activities used in many sectors, such as food, health and agriculture. It evolves the use of living organism or part of living organism to provide new methods of production and the making of new products, including the genetic modification of food. Biotechnology is the practice of using plants, animals and micro organism to improve on our living standards, in which case our environment is friendlier, our health is improved, our resources are maximise and the cost is effective. 2.1THE ROLE OF BIOTECHNOLOGY IN ENVIRONMENTAL SUSTAINABILITY Biotechnology contributes significantly towards environmental stability and sustainability. The environment is constantly under threat of being polluted, depleted or destroyed. Biotechnology not only adapt environment to plant and animal but adapts plants and animals to the environment through gene manipulation and selection. The use of genetically modified crops has proven to be of much benefit to man and environment; the following are some of the roles of biotechnology in contributing to the stability of the environment: 1. Production of alternative fuel that is friendly to the environment, in which case bio fuels today have come to replace fossil fuels.

2. Solutions to the use of pesticides and herbicides. The use of pesticides and herbicides to

prevent plants from being infected with diseases has resulted to the destruction of the supposed protected plant. Some transgenic bacteria are known to contain gene that are resistant to these pesticide and herbicides, these genes can be isolated and alongside with the promoter and transferred to the plant/crop of interest. This helps the plant to be resistant to herbicides and pesticides because of the presence of these gene resistant to the pesticides and herbicides. The bacteria bacillus thuringensis has gene resistant to budworm.

3. Recycling of biodegradable waste. Biodegradable waste under anaerobic condition can be recycled to produce biogas, electricity and organic fertilizer. The advantages of these organic fertilizers includes:  Harmless to the environment  Replenishes the soil nutrient  Cost effective  Promote microbial activities in the soil etc.

4. Solution to desertification. Application of biotechnology have been able to convert areas with poor fertility soil to areas capable of growing plants, this is done through planting of genetic modified crops resistant to drought with irrigation. These

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plants due to gene manipulation are able to withstand high temperature and low water range. If the gene from an extremophile engineered with jatropha, the transgenic plant shall be more tolerant in the desert.

5. Solution to saline soil. This is a very serious problem in our environment and has contributed to very poor plant growth and extinction of most plants species. Biotechnology has really helped in solving this problem for example agriculture in most part of the country failed as a result of salt concentration. Irrigation water most often carries along with them salt. Today up to 6500 km2 hectare of farm land are lost per day as a result of salt build up. Salt build up affects plants in two ways.

i. stop the roots from taking up water

ii. cause enzyme block, alters the protein fold, thus affecting photosynthesis

Few plants can thrive in salty soil. Certainly not the major food crops, so finding a gene tolerance to salt becomes a challenge. Arabidopsis is a plant that is known to posses the gene that is tolerance to salt. Eduardo Blumwald in 1990 isolates the gene which occurs as protein in the plant Arabidopsis; this gene has the capability of sucking the salt from the soil and storing it in the cell vacuole in the leaves of the plant, a pretty good way to tolerate salt. But when the salt is in excess it becomes a problem. Using genetic engineering blumwald was able

added a vector and a very active promoter, beside the gene that allows the salt to be stored in the vacuole, the expression of this gene will be enhanced. He made this transgenic plant using this vector for high expression of the character. 6. Oil polluted soil can be remedied using phytoremediation or bacteria bioremediation at insitu. This accounts for the importance of type culture where bacteria or microorganism with desirable characteristic traits are preserved and used when and where the need arises.

7. Solution to global warming. Global warming has been traced to depletion of ozone layer as a result of the presence of green house gases such as carbon dioxide, sulphur dioxide, chlorofloro carbon etc. Plants are known to be major suppliers of oxygen and major consumers of carbon dioxide, this is one way in which carbon dioxide concentration can be reduced in the environment in which case there is little depletion of ozone layer. When the ozone layer is depleted, it results to the melting of the polar ice, this account for global warming and sea level rise.

8 Solution to land mines: Land mines are a sad legacy, dangerous and difficult to detect. Land mines contain TNT (trinitrotoluene), the united nation estimate about 100,000,000 land mines unexploded around the world. Neal Stewart 1990, in the University of Tennessee, use plant as a Sensor to land mines, when he isolated fluorescent gene

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from gelly fish, engineered with vector from the bacteria pseudomonas putida, that vector activate the gene of gelly fish and sensitive to the gene of the bacteria pseudomonas putida, when in contact with TNT, to produce Biosensor plant that emit light when in contact with TNT. This is an example of bioremediation. 8. Mining Activities: Mining activities involves lots of risk and effort. Mining for cupper for example, requires lots of physical and chemical processes to separate the ores. The bacteria thiobacillus ferrooxidants uses cupper sulphite for production of energy, and in the process deposit cupper as its bye product. This reaction slows down with time, due to intense heat produce, so gene from this bacteria are isolated engineered with gene from extrimophile bacteria to produce a transgenic bacteria capable of withstanding heat, thus the cupper is extracted (extrimophile bacteria are capable of withstanding extreme situations). This is example of bacteria bio remediation.

9. Water treatment: Biotechnology is also useful in water treatment. For example water contaminated with ammonia can be treated with the bacteria candida brocadia ammonioxidant, which help in converting the ammonia compound to gas directly.

2.2 IMPORTANCE OF BIOTECHNOLOGY There is no gain saying that Biotechnology is very important in government effort towards eradicating

poverty, job creation and providing food security. The role of Biotechnology in Environment, Agriculture, Medicine, and Food industry through genetic engineering in which transgenic plants and organism, are created through gene manipulation have been able to help man. Biotechnology has proven to be of very good solution to our environmental in the following ways:  Production of Bio fuel. Jatropha Curcas and other plants have proven to be useful in bio-fuel production.  Erosion control. Vetiver (Vetiveria zizanioides) is useful in Erosion control, because of its root penetration (about 2.4m depth) and ability to form clumps. It has also the ability to undergo self propagation  Production of Transgenic plants and bacteria that can be use in Bioremediation, example oil polluted lands.  Proffer solutions on the best ways of managing our waste.  Production of plants and animals with useful characteristics, such as beans with shorter cooking time and high protein content, vegetable rich in vitamin A, oil palm with high quality and nutritive value ,Cow with high milk production etc  Solution to global warming and flooding.  A technology that guarantee food security

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 Environmental beauty is not left out, as Green vegetation, and flower helps in beatifying our environment.  A technology that is transferable and adaptable.

2.3 Socio Economic gains of sustainable environment.

 Growth in the country‟s GDP  Food security is enhances growth  Decline in poverty  Good health of the people  Tourist attraction  Increase in local and foreign investors. 3.0 Environmental Challenges in Nigeria

3.1 Air Pollution Air pollution in Nigeria exist in different ways, pollution from the petroleum industry which is either during exploration, exploitation and transportation of oil tankers are of higher magnitude of pollution. Gas flaring in Nigeria is still existing, though there have been little effort to check this through the liquidified Natural Gas [LNG]. Pollution as a result of use automobile and generators too has much air pollution effects. 3.2 Water Pollution Oil spills deep sea horizon problems and engineering failures and misfit has contributed a lot to water pollution. Surface and subsurface hydrology is chemically altered possess serious health hazards. The use of pit-toilet has contaminated borehole water and water in aquifers. The presence of coaliform bacteria such as Salmonellae, Cryptosporidiosis and Hepatitis [1, 2 3]

in some bore hole water indicate a hydraulic communication with faeces. 3.3 Land Pollution Oil spill on land several other forms of waste on land has destroyed the biologically rich potential of land making the land unfit for planting. 3.4 Global Warming The average day temperature has increased tremendously. Ozone depletion gases such as CO2, CO and SO2 have increase drastically in our environment. The effects of global warming are melting of the polar ice, heat burn in man, high rate of transpiration in plant etc. 3.5 Flooding Sea level rise globally has been on the increase, this account for the regional and local flooding episodes. The reason is attributed to melting of the polar ice which is related to global warming. In Nigeria, South and Southeast part of the country has witness various degrees of flooding, destroying lives and properties. 3.6 Erosion Erosional effects in Nigeria especially gully erosion in the South and South eastern part of the country. In the north within erosion is predominant. The high water current with the undulating topography, generate high water current. The absence of drainage channels to control the flow of fluid and soil structure has contributed to high impact of erosion in this area. Human activities such as road construction, deforestation etc. must be mentioned as some of the primary cause of gully erosion. 3.7 Biodegradable and Non Biodegradable Waste Management Biodegradable waste is waste that can be degraded biologically, that is, can be broken down with the help of fungi, bacteria or enzyme. Non-biodegradable waste cannot be degraded with the help

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of fungi bacteria or enzyme. The problem of non-biodegradable is very serious in Nigeria as there is no defined plant to recycle polyethane bags plastics, used tyres etc. 3.8 Desertification Desertification in Northern Nigeria is of serious concern. This is due to low rainfall to support vegetation. 3.9 Failure of Engineering Structure Failure of engineering structures such as houses, bridges, dams etc is a serious environmental problem; most engineering structures have their foundation on refuse dumps, such foundations cannot be rigid and durable. Poor quality material has also been responsible for some failures. Biogenic organism such as soldier ants termites have contributed to most engineering failures. 4.0 Challenges of Biotechnology in Nigeria The challenges of biotechnology in Nigeria include: 1. Ignorance: Ignorant is a challenge, as most people are still misinterpreting the use of biotechnology products. Some are not even aware of the technology. 2. Enabling laws: the country needs enabling laws and policies to allow for full operation of biotechnology in the country. 3. Insufficient laboratories for Research purposes. 4. Training: Training of staff requires encouragement and incentives that will allow for transferred technology from even outside the country. This means more monies should be voted for the

Agencies to be better empowered. 5. Poor education

6. Lack or short of microbial tissue culture facilities. 5.0 PROJECTIONS AND WAY FORWARD 5.1 Projections

With the rapid growth in biotechnology and with the interest of Nigeria in the technology, millennium development goals such as food security, job availability, poverty, disease eradication and infrastructure distribution shall be a reality. 5.2 Way forward For millennium development goals to be achieved, the following are recommended:  Enabling laws to allow biotechnology to thrive  Enough budgetary provisions and proper implementation of the budgets  Microbial type culture should be well established in the country  Research and research facilities provided  Education should be encouraged at all levels.  Praying to God

6.0 Summary/Conclusion

Considering the enormous risks posed to the environment by human activities as discussed in this paper. Biotechnology could be referred to as a good technology which ensure the mitigation of the various effects and as well ensure sustainability of the environment. The

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various techniques that could possibly control and sustain our environment, as discussed in this paper, many have their roots in biotechnology. The rate at which the environment is degrading requires attention with very good remedial measures. Biotechnology offers some of the solutions to environmental problems, the sustainability of this measure becomes very paramount if we must continue to make the environment save for life. To accelerate economic growth and analyse the extent of biotechnology in Nigeria, a purpose for which this paper is written, the challenges of biotechnology in trying to sustain the environment from air pollution a consequence of gas flaring and pollution from cars and generators are of devastating consequences thus the need for bio fuel. Water and land pollution during oil transportation and exploration, exploitation, transportation and vandalization of pipes are all having negative consequences. The use of phytoremediation and bacteria bioremediation is of good help, global warming and desertification are currently being checked with the help of afforestation. Biodegradable and non biodegradable waste is also a trait to our environment. Good government policies and enough budgetary provision for biotechnology, including contributions from other sector of the economy shall help to check majority of the environmental problems. The awareness of biotechnology in Nigeria still requires greater efforts, lack of equipped laboratories are mitigating factors to having goods result in our environment.

References Ahn Y, Jung H, Tatavar R, Choi H, Yang J, Kim I S (2005): Monitoring of petroleum hydrocarbon degradative potential of indigenous microorganisms in ozonated soil. Biodegradation pp.16, 45-56 Atlas R.M (1981): Micobial degradation of petroleum hydrocarbons: an environmental perspective. Microbiological Reviews 45, 180-209 Benz M, Brune A, Schink B (1998): Anaerobic and aerobic oxidation of ferrous iron at neutral pH by chemoheterotrophic nitrate-reducing bacteria. Archives of Microbiology chap 169, pp.159-165 Boopathy R (2000): Factors limiting bioremediation technologies. Bioresource Technology chap 74, pp 63-67 Cantor C R (2000): Biotechnology in the 21st century. Trends in Biotechnology chap 18, pp 6-7 Chisti Y (2008): Biodiesel from microalgae beats bioethanol. Trends in Biotechnology chap 26, pp 126-131 Savada D (2010): Public lecture at Clare mont colleges Droste R L (1997): Theory and Practice of Water and Wastewater Treatment, John Wiley and sons Inc., New Jersey, pp 816 Global Socio-Economic and Environmental Impacts. International Services for the Acquisition of AgriBiotech Applications ISAAA Briefs 362006. 20 March 2007. Guenther, E (1990): The Essential Oils Vol.4 (New York: Van Nostrand and Company Inc. 178-181 (Australia: The Perfect Portion. 1997). Germplasm Resources Information Network, Chrysopogon Zizanioides. James, Clive (2006): Global Status of Commercialized Biotech/GM Crops

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International Services for the Acquisition of Agro-Biotech Applications. ISAAA Brief. pp.35 US Department of Agriculture National Agriculture Statistics Service, Agriculture Statistics Board.“Agriculture Chemical Usuage 2005 Field Crops Summary” May 2006. Veldkam P. J. F. (1999): A Revision of Chrysopogon Trin. Including Vetiveria Bory Poaceae in Thailand andMalaysia with notes on some species from Africa and Autralia, Austroballeya 5:522-523.