International Review of Social Sciences and Humanities
Vol. 13, No. 2-Vol. 14, No. 1 (2017), pp. 14-23
www.irssh.com
ISSN 2248-9010 (Online), ISSN 2250-0715 (Print)

The Influence of Palm Oil Effluent on the Physical, Chemical and Soil Micro Organism Diversity in Akwa Ibom State, Nigeria

Joy Eko Atu
(Corresponding Author)
Department of Geography and Environmental Science
University of Calabar, Calabar.
Nigeria, PMB 1115 (Zip code +234)
E-mail: joye.atu@gmail.com

Linus Beba Obong
Department of Geography and Environmental Science
University of Calabar, Calabar
Nigeria, PMB 1115 (Zip code +234)
E-mail: linusarticles@yahoo.com

Ikono Ephraim
Department of Geography and Environmental Science
University of Calabar, Calabar
Nigeria, PMB 1115 (Zip code +234)
E-mail: ephraimikono@yahoo.com

(Received: 17-4-17/ Accepted: 28-7-17)

Abstract

The challenge of environmental management is multifaceted with multiple effects on the physical, chemical and biological aspects of the environment. The paper assessed the effects of palm oil effluent discharge on the physical, chemical and biological diversity of soils in Akwa Ibom State, Nigeria. Data for the study were obtained directly from the field via enumeration, measurement and laboratory analysis. Soil samples and related data were collected using soil auger and sterile containers; ruler, measurement tape, and geographical positioning system (GPS). The soil samples were obtained from three sample sites: 1. Point of Discharge, (POD) to a radius of 100metres round the POD. 2. From Point of Discharge (FPD) 1 taken at 100 to 200 metres distance from POD and 3 from Point of Discharge taken at 200-300 metres from POD. A total of five samples were collected at each sample site at a depth of 0-15cm (surface soil), making a total of 15 samples were collected put on the receptor bags, sealed, labeled and taken to the Soil Science Laboratory, University of Calabar, Calabar, for physical, chemical and biological analysis. The samples were collected during dry season (November, 2016) which is the peak of the processing season. Results indicated that the pH of the air-dried soils ranged from 4.7 to 4.8 and a generally low albeit impact of Al^{3+} in the soil solution could be significant in terms of influencing the biochemical behaviour; sand, silt and clay fractions varied amongst the sampled sites; Heterotrophic bacteria and fungi were fairly high especially in POD sampled sites; and a total of eleven bacterial and eight fungal species were identified. Proper effluent treatment prior to disposal to forestall long term aggregated impacts on recipient soils was recommended.

Keywords: Palm Oil Effluent, Physical, Soil Microorganism, Diversity, Akwa Ibom State.

1. Introduction

There has been a renewed concern in scientific literature over the past decade that agriculture, though fundamental to man's sustenance is also the primary cause of the World's contemporary environmental issues. According to (Hansen, Alroe & Kristensen, 2001) agriculture is responsible for environmental degradation. Soil degradation caused by excessive use of agrochemicals and unsustainable farming practices is a threat to the earth's natural resources in all parts of the world but especially in developing countries such as Nigeria. The use of agrochemical: (fertilizers and synthetic pesticides) have increased the production capacity of farmers on the one hand and also increased the levels of soil degradation on the other. Soil degradation challenges such as loss of fertility of soils, soil erosion and nitrate leaching are common problems associated with agricultural practices in Nigeria.

Agro-processing also contributes to pollution as noted by (Patricia, Dusen, Lundy and Gliessman, 1991). Agro-processing industries contribute high levels of Biological Oxygen Demand (BOD) into water-bodies and soils which adversely affects species life and diversity of the recipient of the effluent discharge. Therefore, oil palm system: cultivation, processing, consumption and waste disposal also raises soil degradation issues like other human activities. For instance, the extraction process, generate 50 per cent of Palm Oil Effluent (POE) (Okwute and Isu, 2007). Okwute & Isu (2007) estimated that every ton production of palm oil consumes 5 to 7.5 tons of water translating to POE. Generally, Palm oil effluent contain materials which at concentrations above threshold values are injurious to the recipient environment at least in the short term and may prove to have long term damages if sustainable measures of discharge are not adopted in the long term.

Processing of oil palm is carried out by small and medium scale farm households in Akwa Ibom State, especially in the study area (Etim Ekpo Local Government Area, Akwa Ibom State, Nigeria). Palm fruit *Elaeis guinensis* is the most important crop for the farming and even the non-farming households and almost every household has its own milling station. Therefore, though the scale of individual milling and effluent discharge may be small, collectively, it is a massive production system, hence, effluent discharged untreated on the nearby soils may have massive effect on the chemical and biological components of the soils. This is because the processing procedure involves, quartering the palm bunches (cut into four), leaving it overnight on the soil for easy manual separation of the fruit from the spikelet. The fruits are boiled on hot flames using fuel wood for energy for one hour or two hours depending on the flame of the fire and the species of the oil palm fruit and fuel wood. Thereafter, the parboiled fruits are poured into a digesting machine alongside water to be digested (mixed well), pressing it on the machine to extract oil and the effluent.

This effluent is then discharged with no treatment into the surrounding environment(soil). The soil is one of the most dynamic sites for microbiological interactions in nature and is the region in which several biological and biochemical reactions take place with consequent production of organic matter for diverse plant growth. It is in view of this fact that (Wu, Mohammed, Jahim and Anuar, 2009) stressed the need for treating waste water emanating from palm processes before introducing to the environment. This paper therefore assessed the influence of palm oil effluent discharge on the physical, chemical and biological diversity of soils in Akwa Ibom State, Nigeria.

Palm oil effluent is derived from the extraction, washing and cleaning process of the palm fruit (*Elaeis guinensis*). The effluents from the processing process contain cellulose fat, oil and grease (Agamuthu, 1995) which when discharged into aquatic ecosystem have been known to cause considerable damage to aquatic species (Dans and Reilly, 1980). This is because palm oil effluent contains high biochemical oxygen demand (BOD) 25,000 mg L-1, chemical oxygen demand (COD) 53,6350mg L-1, oil and grease 8,370 mg L-1, total solid 43, 635 mg L-1 and suspended solids 19, 020 mg L-1 (Ma, 1995, 2000). Palm oil effluents thus constitute a variety of waste. The multiple influences of palm oil on: socio-economic, health and environment has been variously recognized by scholars. It is based on this fact that several studies have been carried out on the socioeconomic and environmental impacts of oil palm in the past five decades. Some of these studies include: (Okwute and Isu, 2007; Oswald and Sama, 2002; Laurence, Koh and Butler, 2010; Koh and Wilcove, 2008; IPOC and WWF, 2004; Isinguzo, 1999; Fitzherbert, Struebig, Mu, Danielsen, Bruhl, Donald and Phalan, 2008; Ebong, 1999; FAO 2002; Ahmad, Ismali and Bhatia 2003; Butler 2011; Chandrasekharan, Sundram and Basiron 2000). Incidentally, all these studies did not look at the influence of palm oil effluent on soil fungal and bacterial diversity, hence, the necessity of this study.

From the foregoing, the study investigates the consequences of disposing waste emanating from Palm Oil processing on the biological diversity of soils in AkwaIbom State, Nigeria. Specifically, the study objectives were:

i. To examine the physical and chemical properties of palm oil effluent affected soils in Akwa Ibom State, Nigeria.
ii. To identify the fungal and bacterial diversity of palm oil effluent affected soils in Akwa Ibom State, Nigeria.

2. Material and Method

Study Area: Etim Ekpo Local Government Area is located 50km from Uyo the capital city of Akwa Ibom State. It is situated within 4^0 51-5^0 03’ North of equator and longitude 7^0 44’ East of the Greenwich meridian. Etim Ekpo Local Government Area is bounded in the North by Abak Local Government Area, South by Azunimi in Abia State, East by Ukanafun Local Government Area, West by Ika Local Government Area and Essien Udim Local Government Area. It comprises of seventy four villages and five clans: Utu, Uruk, Ikono, Obong and Ututanang clan. It occupies 183.3 square kilometers with Utu Etim Ekpo town as it’s headquarter (Essien, 2010).

Data Source: The data for this research paper were obtained directly from the field by the researchers via enumeration, measurement and laboratory analysis. Relevant literature was reviewed to validate the findings from the field.

Sampling: A purposive sampling section along Ikot Udobong, Akwa Ibom State, Nigeria was chosen for the study because these areas receive direct and regular discharge of Palm Oil Effluent (POE) from the mill stations in Ikot Udobong village (Usung akai) in Etim Ekpo Local Government Area of Akwa Ibom State. The soil auger was used in collecting samples which were stored in sterile containers for analysis. Other instrument include; ruler, measurement tape, and geographical positioning system (GPS).

The soil samples were obtained from three sample sites: (1) Point of Discharge, (POD) to a radius of 100 metres round the POD. (2) From Point of Discharge (FPD) 1 taken at 100 to 200 metres distance from POD and (3) From Point of Discharge 2 taken at 200-300 metres from POD. A total of five samples were collected at each sample site at a depth of 0-15cm (surface soil). Therefore, a total of 15 samples were collected put on the receptor bags, sealed, labeled and taken to the Soil Science Laboratory, University of Calabar, Calabar, for physical, chemical and biological analysis. The samples were collected during dry season (November,

2016) which is the peak of the processing season. Results are presented as mean of each sampled site.

Analysis of Soil Samples: Soil samples were collected from predetermined sample sites, air dried for 7 days, sieved with a 2mm sieve mesh and used to test for particle size distribution using Bouyoueos (1951) hydrometer method parameters; Soil pH was determined in 1:1 (soil: water) ratio using the pH meter (Jackson, 1958a), Organic carbon was determined using the Walkley and Black wet oxidation method (Walkley and Black, 1974), Total nitrogen was determined using the modified Kjeldahl digestion method (Jackson, 1958b), Available phosphorus was determined using the Bray No. 1-P method (Bray and Kurtz, 1945), The exchangeable cations were leached with a IN NH40AC extraction method (Peech, 1945), K and Na (Meq/100) were determined via flame photometer, Ca and Mg were determined by the EDTA titration method, Exchangeable acidity was determined by the IN KCL extraction method, Effective cation exchange capacity (ECEC) was by the addition of exchangeable bases to the exchangeable acidity and Percentage base saturation was determine by the use of the formula:

$$\frac{\text{Total exchangeable}}{\text{Effective cation exchange capacity}} \quad X \quad \frac{100}{1}$$

Heavy Metal: Buck Scientific 2000A and Barnhisel & Bertsch, 1982 methodology was adopted to determine the heavy metal content of the soil.

Soil Sample Enumeration of Total Heterotrophic Bacteria (THB) and Fungi (THF): One gram (1.0 g) each of soil samples from the sampled sites (POD FPD 1 and FPD 2) were suspended in 10 milliliters (ml) of sterile distilled water. One milliliter (10ml) of the soil suspension was diluted serially (using physiological saline) in ten-fold to the ranges 10^{-1}-10^{7}. One-milliliter aliquots of dilutions 10^{2}-10^{6} were each seeded onto triplicate plates of nutrient agar using surface spreading technique. Agar plates for enumeration of total heterotrophic bacteria were supplemented with 50µg/ml of Nystatine (to inhibit fungal growth) incubated at 30^{0}C for 48 hours. Viable number of colonies per plate was multiplied by the reciprocal of the dilution factor and recorded as colony forming units per gram (cfu/g) of soil (American Public Health Association, 1998).

For total heterotrophic fungi, 1ml 10^{-3} dilutions were plated in triplicate on potato dextrose agar (PDA) using surface spreading techniques. The medium was supplemented with 100 mg of streptomycin and 15 mg of penicillin to inhibit bacterial growth. Culture plates were incubated at 28^{0}C for 72 hours. Colonies were enumerated as colony forming units (cfu) per gram of soil sample (cfu/g).

Enumeration of Hydrocarbon Utilizing Bacteria (HUB) and Fungi (HUF) from Soil: One milliliter of 10^{2}-10^{4} dilutions each was inoculated onto mineral salt medium agar of Zajicsuplisson (Mobil, 1986). Medium for hydrocarbon utilizing bacteria (HUB) was supplemented with 50µg/ml Nystatine (to inhibit fungal growth). Cultures for hydrocarbon utilizing fungi were supplemented with 100mg of streptomycin and 15 mg of penicillin per plate (to inhibit bacteria growth). The only source of carbon was provided after inoculation via the vapour phase transfer using sterile filter paper saturated with about 5.0 ml crude oil and placed on plate cover which was inverted to cover the culture plates. Plates were then incubated for 7 days at 28 - 30^{0}C. Colonies of hydrocarbon utilizing bacteria and fungi were enumerated as colony forming units per gram of soil sample (cfu/g).

Statistical Analysis: Descriptive statistics such as ranges, means, tables and percentages were used for computing, organizing and presentation of data.

3. Results and Discussion

Chemical Properties: The pH of the air-dried soils ranged from 4.7 to 4.8 Table 1. This depicts strong alkalinity to near neutrality. The Electrical Conductivity (EC) values varied from 0.089 to 0.774dSm^{-1} were recorded for the soils samples in all the sample sites Table 1.The organic carbon in soils of the prescribed area varied from 1.8 percent to 2.6 percent as indicated in Table 1. Total nitrogen varied from 0.12 to 0.20 percent Table 1. Available phosphorous varied from 31.62 to 32.25mgkg$^{-.}$

The exchangeable cations for the surface soil samples were as follows: Ca (4.0–5.0 cmolkg^{-1}); Mg (2.6 – 3.2 cmolkg^{-1}); K (0.12 – 0.19 cmolkg^{-1}) and Na (0.07 – 0.08cmolkg^{-1}). Effective cation exchange capacity (ECEC) was very moderate in both surface and subsurface soils with range values of 8.31 to 8.92 cmolkg^{-1} Percent base saturation ranged from 85 to 88 percent. Exchange acidity value for surface soils (0.24 to 0.72 cmolkg^{-1}). This was generally low albeit impact of Al^{3+} in the soil solution could be significant in terms of influencing the biochemical behaviour. The result of the analysis of heavy metals content of soils of the area show that all the heavy metal content is within the pollution permissible limits as demonstrated on Table 1. This result implies that POE has not changed the chemical content of the soils in Akwa Ibom State at present.

Table 1: Mean Values of Chemical Properties of POME soils (POD), Moderate effluent affected soils FD 1 and None Effluent affected soils FD 2 with international pollution permission limits (PPL) for agro-processing industries

CP	Unit	POD	FPD 1	FPD 2	PPL
pH	-	4.7	4.7	4.8	5.1-6.5
Org C	%	2.2	1.8	2.6	2.0
T.N	%	0.12	0.12	0.14	0.20
AVP	Mg	31.65	32.25	32.2	20
Ca	Cmo/kg^{-1}	4.2	4.0	5.0	10-20
Mg	CMo/kg^{-1}	3.2	3.1	2.6	3-8
K	Cmo/kg^{-1}	0.14	0.12	0.19	0.6-12
Na	Cmo/kg^{-1}	0.08	0.07	0.07	0.7-12
AL	Cmo/kg^{-1}	0.24	0.6	0.72	4.1
H	Cmo/kg^{-1}	0.78	0.42	0.34	
ECEC	Cmo/kg^{-1}	8.64	8.31	8.92	10
BS	%	88	87.7	85	60-80
EC	dSm^{-1}	0.089	0.67	0.77	-
Heavy Metals	Mg/kg^{-1}	1326	1999	1326	10,000-100,000
Fe	Mg/kg^{-1}	7.0	10.35	8.01	2-100**
Cu	Mg/kg^{-1}	10.62	8.06	8.00	5-100**
Cr	-	8.74	6.37	6.00	-
Cd	Mg/kg^{-1}	0.74	7.15	7.12	10-100
Ni	-	2.92	3.84	3.45	-
Pb	Mg/kg^{-1}	0.03	0.05	0.04	20-500**

* = after Brady & Weil, 1996 ** = after Bohn et al 1985 CP = chemical property

Physical Properties: The physical properties of the soils sampled from the prescribed location are presented on Table 2. The sand, silt and clay fractions varied amongst the sampled sites. But, overall, the soils are classified in this study as more sandy in texture on all sampled site because the soils were characteristically coarse-textured with a high content of sand exceeding 70 percent.

Table 2: Physical parameters (PP) of soils on sampled sites

PP	**Unit**	**POD**	**FPD 1**	**FPD 2**
Sand	%	78.0	77.0	78.0
Silt	%	11.7	10.7	12.7
Clay	%	10.3	12.3	9.3
Bulk density	Mgm^{-3}	1.1	1.0	1.2
Pore space	%	60	62	64

Pp = Physical Parameters

Biological Diversity: The total heterotrophic bacterial counts range from 35 X 10^6 to 70 X 10^6cfu/g and the total heterotrophic fungi count also ranged from 11 X 10^3 to 27 X 10^3cfu/g Table 3. The heterotrophic bacteria and fungi were fairly high especially in POD sampled sites. This could be related to the high level of POE in the area that serves as attraction to degrading microorganisms.

Table 3: Total heterotrophic bacterial and Fungal Counts across the sample sites

Sampled sites	**Unit**	**Total bacterial count**	**Total fungal count**
POD	CFu/g	70×10^6	27×10^3
FPD 1	CFu/g	60×10^6	25×10^3
FPD2	CFu/g	35×10^6	11×10^3

Legend: CFU/g = colony forming unit per gram of soil; $10^{6\,=}$ dilution factor & 10^3 dilution factor

A total of eleven bacterial and eight fungal species were identified. Bacteria and Funga species identified on all the sample sites were classed as abundant species, bacteria and funga occurring on only two of the sampled sites are classed as common while species that occur only on one sample site was considered a rare species. Furthermore, any of the species (bacteria, funga) that occur only on one sampled site and has less than 10 per cent occurrence is considered very rare. Based on this classification, Leugothricspp (bacteria) is a rare species identified only on FPD 2 with a percentage occurrence of only 2 as seen in Table 4.

Table 4: Percentage occurrence of identified fungal and bacterial isolates from sampled soils

Identified bacterial and fungal species in soil samples	Sampled Sites		
	% POD	% FPD 1	% FPD 2
Identified Bacteria			
Azotobacter (Gram-ve rod)**	30	30	0
Nitrobacter (Gram –ve rod)**	20	20	0
Rhizobium spp(Gram variable)**	25	10	0
Streptomyces spp (Gram variable)*	10	25	35
Acinetobacterspp (Gram-ve rod)***	13	0	0
Bacillus sp (Gram -ve rod)*	30	25	25
Pseudomonas spp (Gram-ve rod)**	55	12	0
Microscocusspp (Gram +vecoccus)*	40	30	15
Arthrobacterspp (Gram variable)*	20	7	5
Nitrospiraspp (Gram)***	12	0	0
Nocardiaspp (Gram Variable)***	20	0	0
Leugothricspp (gram +vecoccus)***+	0	0	2
Identified fungi			
Rhizopun**	0	25	1
Aspergillum*	25	20	4
Cladosporium**+	2	2	0
Actinomyces**	0	30	25
Mucor**	2	0	10
Penicillium*	19	11	1
Plecospora***+	0	0	5

* = Abundant species ** = Common species *** = Rare species ***+ = very rare & critical species

Discussion

Chemical Analysis: The pH of a soil is a fundamental indicator of the reactions taking place in soils, therefore, an analysis of soil pH is a relevant starting point in every soil analysis. The result of the study showed the soil pH to be in the range of 4.7- 4.8 values across the sample sites, indicating that Palm oil effluent discharge has not affected the soil pH in Akwa Ibom State**.** EC: This range of values is in tandem with the values of (Miller and Donahue, 1995) of non-saline soils for sensitive crop species (FAO, 1974). The result implies the soils do not have salinity problems and can be utilized for farming.

Organic Carbon: The level of organic carbon content in the soils is not detrimental nor pollusive, thus, the soils can support cropping systems in the current state. The range of values of nitrogen in the soils was rated low when compared with the medium range of 0.10 to 0.45 percent prescribed by (Holland *et al.*, 1989) for soils of the area. These ranges are however inconsistent with the work of Ukaegbu and Akamigbo (2005) who reported average total percentage of 0.08 in soils of the Cross River Coastal plain sands.

Phosphorus makes an important part of nucleoprotein in the cells nuclei, which control the splitting of cell and growth of deoxyribonucleic acid (DNA) molecules. Available P contents were high across all sampled sites as values were above 15mgkg^{-1} (FPDD, 1990), although, this level of Phosphorous is an asset to farmers in this environment as fertilizer application is not required for crop growth.

The abundance of bacterial and fungal numbers on POD is normal since there is a higher content of organic matter on the POD soils than FPD 1 and FPD 2 soils, thus organic degrading bacteria and fungi were more on the POD than the other soils samples. POE was therefore responsible for the higher occurrence of bacteria and fungi on POD soils. This finding corresponded with the assertion of (Alexander, 1977) "that human activities are responsible for rapid increase in biological activities in soils". However, very rare species (Plecospora spp-fungi & Leugothric spp-bacteria) were found only on the FPD 2 (none effluent affected soils). This is a cause for concern in the long term as the finding may imply the eroding of bacteria and fungi species that are very beneficial to the optimal working of the soil ecosystem. The abundance of Bacillus species in all the samples and 55 percent occurrence of pseudomonas spp in POD is an evidence that pseudomonas spp has a vital role to play in the breaking down and leaning processes. Nitrobacterspp (nitrifying bacteria involved in nitrogen and production of bio-fertilizer) was also identified on POD soils.

4. Conclusion

Palm oil Effluent discharge has no influence on the physical and chemical parameters of the soils in Akwa Ibom State as indicated by results of the findings. The soil is therefore, not contaminated at present. However, the biological diversity of the soils has been influenced by POE. Therefore, there is a need for proper effluent treatment prior to disposal to forestall long term aggregated impacts on recipient soils.

This is because the identified bacteria diversity of POE affected soils was restricted to mostly abundant and common species, whereas, soils that were not affected by POE discharge had very rare species. Hence, appropriate measures such as: discharge on only designated and controlled areas and use of centralized effluent water processing plant should be adopted and adapted to threat the effluent prior to reuse and discharge on the soils. This is to forestall any long term effects of aggregated POME on beneficial soil bacteria and fungi.

References

[1] A. Ahmad, Ismali and S. Bhatia, Water recycling from oil mill effluent (Pome) using membrane technology, *Desalination*, 157(2003), 87-95.

[2] M. Alexander, Microecology, In: *Introduction to Soil Microbiology (2nd ed)*, (1977), 1-72, Wiley and Sons, New York.

[3] Anonymous, The truth about palm oil available in official site of America palm oil available in official site of America palm oil council site of America palm oil council, (2007), http://www.americanpalmoil.com/palmtruth.html, (2003-2004), Retrieved March 28 (2007).

[4] C.H. Boyoucos, A recalculation of the hydrometer method of making mechanical analysis of soils, *Agron. J.*, 43(1951), 434-438.

[5] R.A. Bray and L.T. Klutz, Determination of total organic and available forms of phosphorus in soils, *Soil Science*, 19(1945), 39-45.

[6] R. Butler, In Brazil, palm oil plantations could help preserve Amazon, (2011), http://e360yale.edu/content/feature.msp?id-2415, Accessed on 7 November (2011).

[7] N. Chandrasekharan, K. Sundram and Y. Basiron, Changing nutritional and health perspectives on palm oil, *Brunci International Medical Journal*, 2(2000), 417-427.

[8] F. Danielsen, H. Benkema, P.F. Burgess, C.A. Brunl, F. Donald, D. Murdiyarso, B. Phalan, I. Rejinders, M. Struebig and M. Fitzherbert, Biofuel plantation on forested lands: Double jeopardy for biodiversity and climate, *Conservation Biology*, 23(2009), 348-358.

[9] S.K.A. Danso, *Biological Nitrogen Fixation in Tropical Agro Systems: Twenty Years of Biological Nitrogen Fixation Research in Africa*, (1992), A Wiley Sayce Co-Publication.

[10] S.K.A. Danso and G.D. Bowen, Biological nitrogen fixations in trees in agro ecosystem, *Plant Soil*, 141(1989), 117-119.

[11] P.E. Ebong, Influence of palm oil (Elaesis) guineensis on health, *Plant Foods for Human Nutrition (Formerly Qualitasplantaru)*, 53(3) (1999), 209-222.

[12] Empire Marketing Board, *The World Trade of Palm Oil*, (1932), 117-23.

[13] U.I. Essien, *Brief History of Etim Ekpo*, (2010), An Online Publication, http://www.etimekpo4goodluckandgodswill2011.org/brief-history.html.

[14] S.S. Esu, Ethno-archaeological study of aspects of traditional crafts and industries of aspects in AkwaIbom State, *Unpublished B.A. Project*, (1992), Department of Archaeology and Tourism, University of Nigeria, Nsukka.

[15] FAO, Small-scale palm oil processing in Africa, *FAO Agricultural Services Bulletin*, (2002), 148 ISSN 1010-1365, Italy.

[16] FAO, FAOSTAT online statistical service, Food and agriculture organization of the United Nations, Rome, Italy, (2009), Available via URL http://faostat.fao.org/, Accessed on August (2011).

[17] FAO, Global forest resources assessment 2010, food and agriculture organization of the United Nations, (2010), Rome: Italy.

[18] E.B. Fitzherbert, M.U. Struebig, A. Morel, F. Danielsen, C.A. Bruhl, P.F. Donald and B. Phalan, How will oil palm expansion affect biodiversity? *Trend in Ecology and Evolution*, 23(10) (2008), 539-545.

[19] FPP, World bank lifts suspension on financing palm oil, Forest peoples programme, *England 1/ASA 2002 International Institute for Applied Systems Analysis*, (2011).

[20] B. Hanson, H.F. Alroe and E.S. Kristensen, Approaches to assess the environmental impact of organic farming with particular regard to Denmark, *Agriculture, Ecosystems and Environment*, 83(1-2) (2001), 11-26.

[21] IPOC/WWF, Indonesia, impact assessment on oil palm development by Dr. Asril Darussamin, IPOC/ Mr. Fitriam Ardiansyah, wwf Indonesia, (2004).

[22] N.S. Isinguzo, Towards a healthier Nigerian environment SPDC experience, *Technical Paper at the Nigerian Environmental Society New World Environment Day Celebration 1999*, (1999), At Presidential Hotel Rivers State, Nigeria.

[23] M.L. Jackson, *Soil Chemical Analysis*, (1958a), 13, Prentice Hall, Engle Wood Cliff, New Jersey, USA.

[24] M.L. Jackson, *Soil Chemical Analysis*, (1958b), 50, Prentice Hall, Englewood Cliff, New Jersey, USA.

[25] L.P. Koh and J. Ghazou, Biofuels, biodiversity and people: Understanding the conflict and finding opportunities, *Biology Conservation*, 141(2008), 2450-2460.

[26] L.P. Koh and D.S. Wilcove, Is oil palm agriculture really destroying tropical biodiversity? *Conservation Letters*, 1(2008), 60-64.

[27] W. Laurence, L.P. Koh and R. Butler, Improving the performance of the roundtable on sustainable palm oil for nature conservation, *Conservation Biology*, 24(2) (2010), 377-381.

[29] E. Menichetti and M. Otto, Energy balance and greenhouse gas emission of biofuels from a life cycle perspective, In: R.H. Howarth and S. Bringezu (eds.), *Proceedings of the Scientific Committee on Problems of the Environment (Scope) International Biofuels Prospect Rapid Assessment*, 22-25 September (2008), Gummersbach, Germany.

[30] D. Mitchell, *Biofuel in Africa: Opportunities, Prospects and Challenges*, (2011), The World Bank, Washington DC.

[31] National Population Commission, National population census for NPC, Abuja, (2006), www.ncp.gov.ng.

[32] O.L. Okwute and N.R. Isu, Impact analysis of palm oil mill effluent on the aerobic bacterial density and ammonium oxidizers in a dumpsite in Anyigba, Kogi State, *African Journal of Biotechnology*, 6(2) (2007), 116-119.

[33] N. Oswal and O. Sarma, Palm oil mill effluent treatment by a tropical marine yeast, *Bioresearchers Technology*, 85(1) (October) (2002), 35-37.

[34] A. Patricia, D. Dusen, J. Lundy and S. Gliessman, Integrating social, environmental and economic issues in sustainable agriculture, *American Journal of Alternative Agriculture*, 6(1991), 34-39.

[35] M. Peech, Determination of exchangeable cations and exchange capacity of soil: Rapid micro-methods utilizing centrifuge and spectro-photometer, *Soil Science*, 56(1945), 25-38.

[36] M.B. Peoples and D.F. Herridge, Nitrogen fixation by legumes in tropical and sub-tropical agriculture, *Adu. Agron*, 44(1990), 155-223.

[37] RSPO, RSPO certification systems, (2007), Roundtable on Sustainable Palm Oil, Zurich.

[38] RSPO, Promoting the growth and use of sustainable palm oil, (2011), Roundtable on Sustainable Palm Oil, Zurich.

[39] W.H.F. Talbot, *The Pencil of Nature*, (1969), New York: Da Capo Press Publication.

[40] R.K. Udo, *Geographical Region of Nigeria*, (1970), London: Mavison and Gribb Ltd.

[41] UNEP and UNESCO, The last stand of the orangutan, (2007), State of Emergency: Illegal Logging Fire and Palm Oil in Indonesia, National Parks.

[42] S.S. Urguiaga, Contribution of nitrogen fixation to sugar cane: Nitrogen 15 and nitrogen balance estimates, *Soil Science Proc*, 56(1992), 105.

[43] A. Walkley, An examination of degtjareff method for the determination of soil organic matter and a proposed modification of the chronic acid titration method, *Soil Science*, 1(1934), 37-38.

[44] T.Y. Wu, A.W. Mohammed, J. Jahim and N. Anuar, A holistic approach to managing palm oil mill effluent (pome), *Biotechnological advances* 27(1) (2009), 40-52.