Oil Palm Industries and Its Environmental Influence in Akpo, South-Eastern Nigeria

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***Abstract*: Palm oil is the most important product and one of the key economies of the agricultural sector in the developing countries. However, the growing of oil palm plantation and its subsequent activities of palm oil processing is threatening environmental quality. This study analyses the palm oil industries and its influence on the environment of Akpo town with a view to ensure environmental sustainability. This was achieved by conducting analysis of soil samples within the oil industrial sites to determine the level of Palm Oil Mill Effluents (POME) contamination on the environment, assessing the respondents' environmental perceptions and socio economic impacts of this oil industry. Laboratory analysis was used to determination of the physicochemical composition of Mg, pH, COD, BOD, P, Ca, organic carbon and nitrogen. The results showed that the concentration of Mg in POME contaminated soil is significantly higher compared to the non-POME contaminated soil ($p<0.05$). Similarly, the organic carbon content of POME contaminated soil has a higher concentration compared to that of non-POME contaminated soil ($p<0.05$). On the other hand, analyzed parameters (K, pH, COD, BOD, P, Ca and T.N) do not differ significantly between POME contaminated and non-POME contaminated soil. Comparing the POME contaminated soil with acceptable soil standard for agriculture showed that content were significantly higher ($p<0.05$) compared to the acceptable standard. From the questionnaire and field observation conducted, it was further observed that oil palm development has degenerated to loss of farm land, increased food insecurity, human right violation and sudden rise in price of land.**

Keywords: **Environmental degradation, Palm Oil Mill Effluent, Environmental quality, Contaminated Soil, Environmental Sustainability.**

I. INTRODUCTION

Palm oil is the most important product and one of the key economies of the agricultural sector in the developing countries. However, the growing of oil palm plantation and its subsequent activities of palm oil processing is threatening environmental quality. On the aspect of environmental concern, it has been witnessed on several occasions that Palm Oil processing gives rise to waste-water, known as Oil Mill Effluent (POME) that produced huge amount of methane gas from its anaerobic process and has 21 times Global Warming Potential (GWP) compared to the other gasses.

In the study area, the waste-water is often discarded in disposal ponds. This will result in the leaching of contaminants that pollute the groundwater and soil, and in the release of methane gas into the atmosphere. However, some POME are non-toxic waste, as no chemical is added during the oil extraction process, but it is believed it will pose some environmental issues if discharged directly to the environment due to its high chemical oxygen demand (COD) and biochemical oxygen demand (BOD) concentration. It will affect the future development of palm oil industry as this issue is concerned about the trade-off between economic development and environmental protection, in which, at the end will reflect the social development of local communities. There is the need to carry out soil analysis of soil sample from within the oil industrial sites to detect, identify and quantify the level of contaminants and environmental impacts; understanding the respondent's, environmental perceptions, socio-economic impacts and general knowledge of the study area will be captured through survey design. The researcher result will be very useful for the determination of environmental impacts of Palm Oil Mill Effluents (POME), the socio economic impacts of the economic activities of this oil industry; moreover, the environmental sustainability of oil palm oil industry will be investigated, with view of coming up with better policies and initiatives towards having a friendly, preservative and sustainable environmental management.

Palm oil is produced from the fruit pulp of the oil palm tree (*Elaeis guineensis*). This tree is native to the area of West Africa near the Gulf of Guinea, which is where its scientific name comes from. It is the most important product and one of the key economies of the agricultural sector thus contributing to enhance the livelihood of the people in developing countries [1], [2]. According to Thompson Ayodele and Matthew O. Eshalomi 2010, there is a consensus that the oil palm (*Elaeis Guineensis*) is a native to West Africa where many researchers cited Nigeria among the most probable place where the fruit was first domesticated before the 14th century, where the oil palm was quoted to be over century old, precisely introduced as an ornamental in 1871.

Palm tree is found predominantly in southern Nigeria especially in the wet rain forests and savannah, the region oil palm (*Elaeis Guineensis*) is locally called Nkwu (Igbo), Ope (Yoruba) and Ekpe (Igala) only but to mention few tribes in Nigeria. Oil palm is a monocotyledonous tree crop which belongs to the family palmea and subfamily cocoideane. NIFOR, 2009 as cited in ref. [3]. While reference [4] in their recent work observed that palm oil processing provides

employment and income for a proportion of rural population with poor access to resources in Ghana.

Palm trees can grow up to 30 meters tall and produce fruits which are grouped in big, compact and spherical bunch that can contain up to 2,000 fruits each. These tropical fruits are about the size of a large olive, rich in oil (45-65%), and are naturally reddish in colour. The fruit has a single seed or kernel, which is used to produce different oil, called palm kernel oil, which has a completely different structure from palm oil (fruit palm oil), [5]. Palm oil is extracted by heating and pressing the pulp of the fruit. The refining process is applied to purify the crude palm oil, providing highly versatile oil, with important functional properties. Subsequently, palm oil can be separated into different fractions, liquid (oil) and solid (fats), which can then be processed and mixed according to specific purposes in order to provide exclusive taste and texture in food products. It constitutes an essential ingredient of typical Nigerian diets and meals and now serves as a commercial product as well [6].

Malaysia is believed to be the largest producer and exporter of palm oil in the world [7]. It is the most productive vegetable oil in the world, with Malaysia, Indonesia, Thailand, Colombia, and Nigeria contributing more than 90% of global production (World Bank 2010). It is generally believed that the oil palm is indigenous from West Africa and Nigeria in particular [8], and in the 1960s Nigeria was the world leading producer and exporter of palm oil [9]. In the 1970s, decline in productivity of palm oil was observed in Nigeria and inability to develop plantations to sizeable level and poor quality of oil produce. Despite this decline in Nigeria, the country still occupies the 5th position in global production while the Asian economies have made significant progress in palm oil development and expansion [10].

According to the Global Palm Oil Conference in 2013, Nigeria palm oil production was growing at the rate of 2.2% but recent work by [11]. noted that Nigeria is still the fifth largest producer of oil palm in the world with domestic production of 930 thousand metric tonnes accounting for about 1.5% of global output. This study was carried out with a stance to investigate the effects of palm oil mill effluent (POME) on the quality of soil particularly during oil palm production and its environmental influence in Akpo, South-Eastern Nigeria between June 2018 and August 2019. The thematic choice of testing only soil samples were because the streams and water bodies are further away from all the oil mills industry sampled.

II. STATEMENT OF THE PROBLEM

Studies on oil palm production and its environmental implications is yet to be uncovered and the degradation of the environmental compartments and its associated consequences on human well-being goes unnoticed in Akpo, Aguata Local Government Area (LGA) of Anambra State. The examination of the environmental implications of oil palm production in Akpo, will no doubt be a reference point of accessing the environmental sustainability in production of palm oil within the region. There are six oil palm mill and other small scale mills for domestic use. The main ones include Divine Favour oil palm mill in Ogbo village, Umueze oil palm mill owned by Mba family, Gbajaa oil mill in Agbelu, Ezema oil mill in Amaife and Udodiugwu oil mill at Udo village. The first three mills mentioned are functioning properly, and this research will utilized them as case studies. The mills currently boast of producing over 50 gallons of oil per month irrespective of the season of the year, thus leading to continuous contamination of the environment with its waste both liquid and solid.

This research is therefore conducted to ascertain the environmental implications of oil palm activities and assessment of the impacts of oil palm production on the people whose welfare and livelihoods depend largely on the farming activities they carry out in the area with the view to ensure environmental sustainability. The significance concentrates on providing information to enhance waste management and environmental concern in palm oil mill industries, which will provide a platform for scientists wishing to undertake further research on the impacts of oil palm production and its application on the environment and health of the local communities in Nigeria at large. Scholars in environmental sciences will find this study resourceful and also community and society where palm oil mills are located, as the study seeks to create environmental awareness on the health implication of poor wastes management. The study will be useful to government agencies, environmental planners and scholars in environmental health, in that they will find this study resourceful to tackle the problem of environmental pollution due to the activities in palm oil mill industries.

III. CONCEPTUAL FRAMEWORK

This Paper is based on the concept of sustainable development. [12], described sustainable development as meeting the resources and services needs for current and future generations without compromising the health of the ecosystems that provide them and more specifically as a condition of balance, residence and interconnection that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity. Wastes from oil palm processing industry are a major factor of environmental pollution; thus require sets of goals for it evaluation and charting of roadmap for the sustainability and management of the menace.

According to De Montfort University Leicester [13], sustainable waste management can be defined as using material resources efficiently to cut down on the amount of waste produced, and where waste is generated, dealing with it in a way that actively contributes to the economic, social and environmental goals of sustainable development. Similarly they claimed that managing wastes is not only how we dispose garbage in landfill, or how much we recycle or what we recycle, but it is also how we do not create wastes to start with.

IV. LITERATURE REVIEW

Effluent water is defined as water discharged from industry, which contains soluble materials that are injurious to the environment such soluble materials may be gases such as CH, S0, and NH, halogens or soluble liquids or solids which contain ions that of either organic or inorganic origin and with their concentration above the threshold value. Since these compounds are harmful to the environment, it becomes necessary that effluents water should be treated or purified before discharged into the environment

The palm oil solid waste generated in Malaysia has continued to grow with the increase in demand for the palm oil as well as the increase in plantations developed for palm oil cultivation. Reference [14], showed that palm oil processing mill for crude palm oil (CPO) production generated large amounts of solid waste and waste water which has high environmental impacts. In 2015, the solid waste generated was about 80 million tons [15]. The palm oil solid waste generation can be analyzed from the plantation to the processing plant. In the analysis of the solid waste generation from palm oil industry considering the upstream and downstream sectors, [16], showed that about 77.8% of the solid waste comes from the upstream sector while 22.8% comes from the downstream.

Reference [17], carried out experimental study of palm oil effluent and oil palm frond waste mixture as an alternative biomass fuel were the laboratory analysis shows that the sludge from POME is a source of pollutant and harmful waste to the environment if discharged untreated, while Oil palm frond (OPF) is usually left on the ground for natural decomposition but however its mixture could be a promising source of alternative energy. The work of reference [18] used laboratory analysis to assess the experimental impacts of oil palm processing, the result reveal that POME impacts on the soil properties, the combustion of solid wastes emit suspended solid which often exceed the permissible limits, while ref.[19] examine the sustainable oil waste management in engineering development were the work noted that with right technology most waste generated during production like agricultural wastes and biomass from wastewater can be a potential fuel substitute. In a similar research conducted by [20] using laboratory investigation observed that POME is acidic in nature and thus must be properly dispose in any particular environment, agreeing with a similar work led by [21]. Using field observation to study air quality impacts of smallholder oil palm processing, [22], observed that the air quality parameters such as NO_2, NH_3, and CSO_2 during boiling were found to exceed the threshold limits. Reference [23] revealed that there are great variations in pH, Turbidity, temperature, alkalinity, TDS, TSS, TS, metals and nutrients that are poor planned and hence it is important for sustainable project initiators to understand the environment and social effects of the industry before any design [24].

However, ref. [25], reported the indiscriminate disposals of the wastes during palm processing and their environmental implication. Following this deleterious effect associated to palm oil processing; the Global increase in oil palm expansion is a cause for concern in environmental management. In view of this increase, some countries such as Malaysia, Indonesia, Thailand, Colombia, Asia, are making progress in transforming the waste to resources in order to reduce environmental harm [23]. It follows that all-encompassing solid wastes derived from palm oil mill effluent, have a utility function with zero wastage, thus a progress towards sustainable development [26], however, the sludge generated is considered biomass wastes that can be fully utilized as a renewable energy sources, [17]. The solid wastes are generated from the threshing, pressing and kernel cracking zone of processing activities including EFB, PPF, PKS and chaff ref. ([27]; [28],[29], [30], [22]).

Reference [18] discovered that only small fractions of the solid wastes are utilized as boilers fuel by the oil palm industry, while the rest are discharged into the environment with little or no treatment. Still, ref. [23] take the position that it is prudent for sustainable oil palm projects to provide opportunities for plantation and mills owners and workers to acquire, and share knowledge on the effects of their activities on the society and environment. As a result, [31] using standard microbiological techniques, replicate readings were subjected to analysis of variance and presented as means (± standard deviation) at 0.05 level of significance, thus concluded that this is environmentally significant and indicative of gross contamination of palm oil mill effluent which could in turn stimulate a wide variety of environmental issues.

According to ref. [32] the greatest constraints to level of adoption of oil palm production technologies were high cost of the technologies and lack of finance. Nevertheless, other paramount challenge faced by the oil palm industry is to maintain a balance between environmental security and socio economic stability. In the process of extraction of palm oil from oil palm fruit, biomass materials such as empty fruit bunch (EFB), palm oil mill effluents (POME) and palm pressed fibre (PPF) are generated as waste products [33]. Palm oil mill extracts 20% of oil from the fresh fruit bunch and produces 23% empty bunch, 15% fibre, and 12% nut. Oil losses occur in various by-products, including the fibre, which remains after the mesocarp oil is extracted by a screw press [34]. These practices create environmental pollution problems as incineration and boiler emit gases with particulates such as tar and soot droplets of 20-100 microns and a dust load of about 3000 to 4000 mg/nm and indiscriminate dumping of EFB and PPF causes additional methane emission into the atmosphere, [35]. Reference [36] work moreover confirmed that this indiscriminate disposal of POME tampers environmental quality, for example, disposal of POME into water bodies decreases the oxygen levels and destroy the aquatic chemistry. It has high amount of moisture content, with pH of 8.4 and enriched with organic matter.

V. MATERIALS AND METHOD

The study area is Akpo, located within latitudes 05^0 57′ 14.37″N, to 06^0 00′ 28.85″N and longitudes 07^0 05′ 43.23″E, to 07^0 07′ 46.12″E (5.954415N,7.095343E and 6.008014N,7.129479E) in Aguata Local Government Area, Anambra State Nigeria (Fig. 1), The Town is made up of six villages; Agbelu, Uhuala, Ogbo, Umueze, Amaife and Udo. It is bounded at the north by Nkpologwu and Aguluezechukwu, east by Ogboji, west by Amesi and south by Achina towns. The study area has a rugged relief as it lies partly on the Awka-Orlu upland and the flood plain of Mamu River, which is an area of moderate relief [37].

Geologically, the study area is overlaid by Agulu-Nanka formation, made up of highly sediments of friable sandstones, shales and limestone. They are mainly of cretaceous periods. The sandstones which mainly dominated the area, is susceptible to erosion, which is typified by the nearby and infamous Agulu-Nanka gully sites [38]. The area has much of surface drainage systems through which the excess water is removed from the land. The components of the drainage system form the tributaries of Mamu and Anambra rivers which empty into the River Niger [38]. The climate according to Koppen's climatic classification, is tropical Wet and Dry climate (Aw). The rainfall is controlled by the position of Inter-Tropical Divergence, which is experienced for 8 months of the year from April to November with July and September as the months of highest rainfall of about 350mm ([39], [40]). The vegetation lies within the humid tropical rainforest region of Nigeria.

The population of Akpo was 21,440 in 2006 [41] which has been projected to 31,288 in 2018 based on the approved 3.2% annual population growth rate by the National Population Commission. The main occupation of Akpo people is farming and trading. Some of them have "mbubo" (home garden) and *"ubi*"(out-station garden) and "*ikpa*" where they usually cultivate their farm product like cassava, maize, yam, melon, rafia and oil palm in commercial quantities. Akpo people are hospitable and enjoy good cultural heritage.

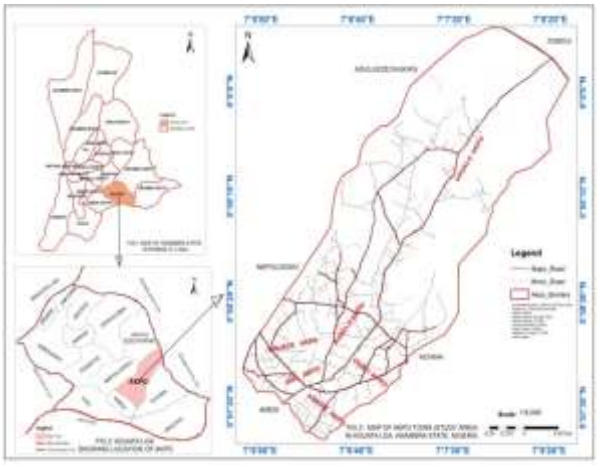

Fig. 1: The locational Map of the study area

VI. SOURCES OF DATA

This study assessed palm oil businesses and its influence on the environment of Akpo town. The research adopted the combination of experimental research (laboratory) and survey design (questionnaire and interview), employed field survey and while remote sensing/GIS methods were used for mapping the study area.

The survey design involved questionnaire distribution, observation, interviews and photography. Purposive and simple random sampling techniques were respectively used to select six palm oil mills in the study area. Triplicate palm oil mill effluents (POME) contaminated soil samples and non-POME contaminated samples were randomly collected using a Dutch soil auger along a transect 20m interval at upper and lower end of the POME site, while handheld GPS was used to collect the coordinates of the sampling points as shown in table 1. Where, the Central School Akpo field was taken as the 'control' sample location.

Table 1: The coordinates of the sampling points

		GPS COORDINATES		
S/N	**Descriptions**	**Latitude (N)**	**Longitude (E)**	**Remarks**
1	Amaife Oil Palm Industry	05° 57' 32.6"	07° 06' 13.1"	Nil
2	Umueze Oil Palm Industry	05° 57' 59.0"	07° 05' 46.1"	Soil Sample
3	Ogbo Oil Palm Industry	05° 57' 50.6"	07° 06' 47.7"	Soil Sample
4	Udo Oil Palm Industry	05° 57' 31.4"	07° 06' 06.5"	Nil
5	Ogbo Oil Palm Industry	05° 58' 05.4"	07° 06' 35.9"	Nil
6	Agbelu Oil Palm Industry	05° 58' 00.6"	07° 06' 26.3"	Soil Sample
7	Central School Akpo	05°57' 40.53"	07° 6' 24.05"	Control Sample

VII. DATA ANALYSIS

Soil samples within the oil production sites were tested to determine the physicochemical composition of Mg, pH, COD, BOD, P, Ca, organic carbon and nitrogen. The data generated was analysed using T-test at ($p<0.05$), to compare the mean of physicochemical in (POME) contaminated and non-POME contaminated soil samples. Fig. 2 is a map showing part of Akpo town indicating the location where the soil sample were collected, including a control sample point father way from existing oil mills. One sample T-test is used to compare analysed data with a standard, thus the POME contaminated site is compared with the acceptable standard for agricultural soil. On the other hand, the results of the analysis from the questionnaire were interpreted and presented using chi-square X^2 of homogeneity in the variation of oil palm waste management practices and uses. Additionally, likert of five point scales were used to analyse the respondents' environmental perceptions and socio economic impacts of this oil industry.

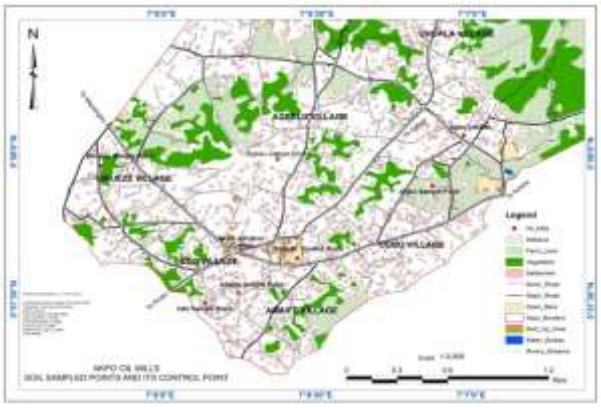

Fig. 2: Map showing part of Akpo town and the location of the soil sampled points

VIII. RESULT PRESENTATION AND DISCUSSION

The soil samples taken from the mill industries where sent to the soil laboratory for analysis. Table 2 is the result of the three samples gotten from the three mill case studies coded as SSA-SSC and one sample from a control site (SSD). However, the result of the study according to the table 3 reveals that the soil contaminated with POME has a higher concentration of pollution element of magnesium (Mg) and other more dominant pollution element are Potassium, Calcium, BOD and COD.

Table 2: Results of Soil Sample from Mill Industry

Parameters	SSA	SSB	SSC	SSD (Control)
Magnesium ppm	19.605	19.506	19.649	16.650
Potassium ppm	103.07	43.09	38.912	26.734
pH	6.39	6.37	6.64	6.54
COD	216.0	200.4	209.3	200.0
BOD	60.0	60.0	70.0	67.2
Phosphorous	60.06	6.40	6.39	5.24
Calcium	4.98	8.0	4.18	3.80
Organic Carbon	3.57	3.37	3.50	1.24
Total Nitrogen	0.11	0.13	0.15	0.10
Note: All units used are in mg/kg				

Source: Spring Board Laboratory, Awka (2020).

Table 3: Comparing physicochemical composition of POME and non-POME contaminated soil

Parameter	POME contaminated soil	Non-POME contaminated soil	Significance
Mg	19.586±0.378	16.150±0.378	**P<0.05**
K	61.691±26.756	26.735±26.756	p>0.05
pH	5.467±1.344	6.535±1.344	P>0.05
COD	208.567±5.833	200.00±5.833	P>0.05
BOD	63.333±4.303	67.150±4.303	P>0.05
P	24.283±23.094	5.240±23.094	P>0.05
Ca	5.720±1.502	3.750±1.502	P>0.05
Organic carbon	3.480±0.076	1.245±0.076	**P<0.001**
Total nitrogen	0.130±0.015	0.100±0.015	P>0.05

Similarly the soil contaminated with POME has a higher concentration of organic carbon compared to non-POME contaminated soil ($p<0.001$). The other parameters (potassium, pH, COD, BOD, phosphorus, calcium and total nitrogen) for POME contaminated soil do not differ with those of non-POME contaminated soil ($p>0.05$). Higher concentration of Mg in POME contaminated soil when compared to non-POME contaminated soil (control soil) could be attributed to decease in soil nutrients, again the higher organic carbon content lead to contamination of the soil. The comparison with the original land in the research area was very important because there is a natural chance that the land condition does not meet the standards for agriculture. Knowing fully well that POME contaminated soil could be associated to high carbon content of POME. Findings of this study are similar to the study ref. [30] that showed the POME contained soil contains higher organic carbon (%) as compared to control soil. The presence of high concentration of organic carbon and Mg content for POME in contaminated soil has implications for uses in agriculture.

Furthermore, comparative analysis of POME contaminated soil with soil standard acceptable for agriculture reveals that the concentration of magnesium, COD, BOD and calcium for POME contaminated soil do not fall within the acceptable standard for agricultural soil. However, other parameters of POME contaminated soil (potassium, pH, phosphorus, organic carbon and total nitrogen), are within acceptable standard for agriculture. This finding is supported by the analyses conducted [30] in Calabar and Uyo were it was observed that Palm oil mill effluent polluted soil samples collected from Calabar showed significantly higher ($p>0.05$) COD, BOD, TSS, organic carbon, nitrogen, available phosphorus, calcium, magnesium, and oil and grease content compared to that of Uyo. However, this is environmentally significant and indicative of gross contamination which could in turn stimulate a wide variety of environmental issues.

The Socio-Economic Impacts of POME waste as opined by the residents according to the analysis, have a mean score of >3.0, obviously showing that most response are on the side of strongly agree such as 'loss of land as a safety net' (63%), increased food insecurity (58%), etc (Fig.3).

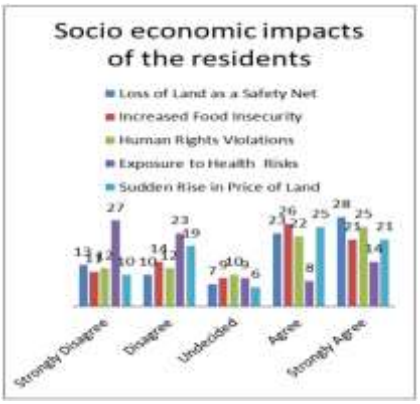

Fig. 3: Profile of the Socio-Economic Impact of POME waste on the Residents

However, the respondents are strongly of the opinion that oil palm frond and empty bunches respectively, have no negative impact on the environment, while POME and palm pressed fibre have detrimental effects on the soil (Table 4).

Table 4: Perceptions on the Environmental Effects of Palm Oil Waste (from most threatening to least)

Waste	Frequency	Percentage (%)
Oil Palm Frond	15	15.8
Empty Fruit Bunch	18	18.9
Palm Oil Mill Effluent	30	31.6
Palm Kernel Shell	7	7.4
Palm Pressed Fibre	25	26.3
Total	95	100

From the study on palm oil industries and its environmental implications it was observed that the local people in the oil palm industry could be taught ways through intervention programmes to enhance the utilization of oil palm waste, especially POME which seems to be more complex to manage. The disposed of oil palm waste in its untreated form continuously cause the loss of much valuable oil. So, to minimize pollution and to avoid this, the recovery oil from the solid wastes is the best method in the palm oil mill. Effluents water should be treated or purified before discharged into the environment. Environmental consciousness to be instilled so as to avoid indiscriminate disposal of POME and Land ownership for oil palm plantation should not threaten food security and the right of indigenous people.

IX. CONCLUSION

From this study, it is evident that POME when present in the environment significantly alters the physicochemical properties of soil and this is an indicative of gross contamination which could in turn stimulate a wide variety of environmental issues, due to the high concentration of biological oxygen demand (BOD), metals, and nutrients in palm oil mill effluents.

The result from questionnaire analysis indicated that Akpo community has degenerated to loss of land as a safety net, increased food insecurity and human rights violation etc. The residents highly perceived that oil palm frond and empty bunches respectively have negative impact on the environment, while POME and palm pressed fibre have detrimental effects on the soil.

For the remediation of the aforementioned consequences, this study has revealed the availability of different physicochemical parameters in this POME polluted soil sites, thus proposing the need for further research on the applicability of these isolates for biodegradation and bioremediation of palm oil mill effluents in contaminated sites. It is therefore a matter of urgency for the various stakeholders to find a lasting solution to the problem caused by palm oil mill effluents (POME).

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