



IMPACT OF PALM OIL MILL EFFLUENT ON THE SOIL IN UPKOM- BENDE FOREST RESERVE, ABIA STATE, NIGERIA

*Chikwendu, M. U and Ogbonna, A. N.

Department of Forestry and Environmental Management Michael Okpara University of Agriculture Umudike, P.M.B 7267, Umuahia, Abia State, Nigeria

*Corresponding author: nwogwugwu.michael@gmail.com; austinogb@yahoo.com; +2348065254590

ABSTRACTS

The palm oil industries in southeastern Nigeria is a major agro-enterprise. This study examined the impact of the palm oil mill effluent on the soil in Ukpom Bende Forest Reserve Abia State, Nigeria with the objective of assessing the impact of palm oil mill effluent (POME) on soil physicochemical properties in Ukpom Forest Reserve. A Randomized Complete Block Design (RCBD) was employed. Three topsoil samples were collected at a downslope distance of 10m, 20m, and 30m respectively with 3 replicates each and control (Non-polluted site) of 100m away from study site. Total of 9 samples and control were collected and taken to soil laboratory in National Root Crop Research Institute Umudike, Abia State to analyzed the soil particle matter size, Organic carbon, Organic matter, Total nitrogen, Available phosphorous, Exchange cations (Na, K, Ca, Mg), Electrical conductivity and EA that affect the percentage (%) of sand and silt of the soil. Result revealed pH, Ca^{2+} , Mg^{2+} and % silt significantly increases ($p<0.05$) along the slope 10-30m, while % BS, EC, P, K, Na, EA, ECEC, % OC, % OM, and % sand significantly decreases along the slope 10-30m, and the % clay is seen constant along the slope of 10-30m. However, EC, P, % OC, % OM, % N, % silt, % clay, K^+ and EA increases significantly ($p<0.05$) compared to control site, while pH, Ca, Mg, % BS, ECEC, Na and %sand decreases significantly($p<0.05$) compared to the control sites. Result revealed that POME causes deterioration of soil physicochemical properties and increase soil acidity. Therefore, we recommend that adequate treatment and proper disposal of POME should be promoted and awareness carried to the rural oil palm processors.

Keywords: Effluents, palm processing, soil quality and soil concentration

INTRODUCTION

Palm tree (*Elaeis guineensis*) is one of the most important economic crops in the tropics. It is the highest yielding and most important source of vegetable oil of all oil-bearing plants (Odior, 2007). This important economic tree is generally agreed to have originated from the tropical rainforest region of West Africa. The main belt runs through the southern latitudes of Cameroon down to Nigeria and through Togo. Palm tree is indigenous to the Nigerian coastal plain, having moved inland as a staple crop. In Nigeria, oil palm cultivation is part of the way of life of most people living in the southern part of the country. It is like their culture (FAO, 2002). Additionally, every part of the oil palm can be put to advantageous use, such as palm ribs and fronds for roofing and thatching, brooms, baskets, wickerwork, and mats while its residue can

be used for fire lighting and as energy source, and is particularly suitable for low-cost and low-technology activities. Due to all these uses, it offers an almost unlimited scope for employment and thus a source of livelihood and income for many (Oladipo, 2008). According to Ayodele (2010), palm oil production provides jobs for at least 1.8 million Nigerians.

Palm oil is the main edible vegetable oil produced and consumed in Nigeria where the oil palm tree features regularly in the natural vegetation of the lowland humid to sub-humid areas in a belt that covers almost 24 million 44 hectares (ha) (Opeke, 2003). Dispersed smallholders harvest fruits from the wild/semi-wild palms and process them to produce 80% of the palm oil output and through which Nigeria accounted for 43% of global palm oil production up till the mid-1960s. The

performance has declined such that the annual output at 850,000 metric tons (MT) leaves an overall supply gap of 0.5 million MT currently met through imports (Omoti, 2001). Palm oil accounts for 34 percent of the world's annual vegetable oil and 63 percent of the global exports (REF). Nigeria is currently the third largest producer of palm oil in the world after Indonesia and Malaysia; however, it remains a net importer.

Palm oil is a very productive crop which offers a high yield at a lower cost of production than other vegetable oils. Global production and demand for palm oil are increasing rapidly and such expansion comes at the expense of tropical forests destruction which forms critical habitats for many endangered species, and a lifeline for some human communities (WWF, 2017).

Palm oil processing is carried out using large quantities of water in mills where oil is extracted from the palm fruits. During the extraction of crude palm oil from the fresh fruits, about 50% of the water results in palm oil mill effluent (Ahmad *et al.*, 2003).

Careless disposal of waste, especially palm oil effluent (POME) poses threat to the micro-organisms and the soil. A traditional method used in the mill for separating the broken palm kernel from the shell (chaff) involves pouring both mixture of the kernel and its shell in a pit of clay water so that all the nuts float in the clay water while the shell settles at the bottom (Oke, 2002). The global production of palm oil is growing at a very high rate and the pollution caused by waste materials from palm mills has become a serious problem (Orji *et al.*, 2006). In Nigeria, the business of palm oil extraction is dominated by the peasant farmers who use mainly the semi-mechanized methods of extraction and the palm oil mill effluent generated is poured away into available piece of land near the mill, this practices usually leaves the soil with increase PH which dissolves in the water and contaminates the water bodies (Orji *et al.*, 2006). The aim of this work was to assess the effects of oil processing mill on the surrounding soil in Ukpom-Bende Forest Reserve in Abia State.

MATERIALS AND METHODS

This work was carried out in Ukpom-Bende Forest Reserve in Abia State. Ukpom-Bende Forest Reserve has an area of 14.750km². The area is located within latitude 5°35'N-5.567°N and longitude 7° 38'E-7.633°E, temperature range-of

21°C and 27°C with average annual rainfall range of between 1900 mm and 2200 mm, with a relative humidity of 65-85% (ADP, 2010). The soil is loamy clay and is derived from the crystalline acid rocks of undifferentiated basement complex (Ogbonnaya, 2002)

Methodology

Soil sample was randomly selected and collected using disinfected trowel at distance between 10m, 20m and 30m from point sources of palm oil processing sites and passed through sieved (2mm) to remove debris, stones in the soil polluted with POME in three different processing site and were thoroughly mixed on the spot in order to obtain composite sample (5kg) and adjacent agricultural land for control sample (100 m) away from processing sites, percentage soil particles was determined by hydrometer method of Day (1965)

The collected topsoil sample from the point source was kept in a black polythene bag and correctly labeled. The collected soil samples were air-dried for seven (7) days and soil samples were taken to the National Root Crop Research Institute (NRCRI) Umudike, soil laboratory unit used to analyze for various parameters. Another method adopted in this study was observation, inventory survey, and consultation of textbooks, magazines, journal and internet services.

Laboratory test procedures to determine the physicochemical properties.

Determination of pH by the glass electronic pH meter 1:2, 5-soil: H₂O ratio

The pH meter was put on acid calibrated with buffer solutions of pH 4:0 and pH7-0 and pH 9:2. The electrode was inserted into the soil suspension and the pH value was observed and recorded.

Determination of Organic Carbon

With the use of a 10 ML bulb pipette, about 10 mL of potassium dichromate was added to a 0.5g measurement of air-dried soil in a 500 mL conical flask, 20 mL of concentrated Tetraoxosulphate (VI) acid was added to the preparation in order to supply heat to the solution. It was then left for 30mins before diluting with about 200 mL of distilled water. 10 mL of (H₃PO₄) acid and 0.2g of Sodium fluoride were also sequentially added to the preparation. Using a diphenylamine indicator, the preparation was back-titrated with concentrated ammonium ferrous sulphate to a greenish endpoint.

Determination of soil pH

Soil pH was determined in water 1:2 soils: water ratio using pH meter with a glass electrode. 20 g of air-dried soil was weighed into a 50 ml beaker, and 20 ml of sterile saline water was added and allowed it to stand for 30 minutes. The electrode of the pH meter was inserted into the 1:2 soil /water partly settled suspension and measured the pH. The result was recorded as soil pH measure in water

Determination of organic matter

Organic matter was determined by the dichromate wet-oxidation method

Determination of Exchangeable Acidity

About 50mL of KCL added and shook for 2hours, this was filtered into a conical flask and titrated with 0.02N NaOH using phenolphthaleine indication.

Kjeldahl Method Determination

The Kjeldahl method permits the available nitrogen to be precisely determined in the plant and in the soil. The method of determination involves three successive phases which are:

- i. Digestion of the organic material to convert nitrogen into HNO_3 .
- ii. Distillation of the released Ammonia into an absorbing surface or medium.
- iii. Volumetric analysis of the Ammonia formed during the digestion process.

Digestion of the organic material is carried out by digesting the sample with Con. H_2SO_4 in the presence of $\text{CuSO}_4 \cdot \text{H}_2\text{O}$ as a catalyst and K_2SO_4 which raise the digestion temperature. The organic material decomposes into several components i.e. $\text{C} \rightarrow \text{CO}_2$, $\text{O} \rightarrow \text{H}_2\text{O}$ and $\text{N} \rightarrow \text{NH}_3$

During the distillation step, the ammonium ions (NH_4^+) are depending on the amount of ammonium ions present, concentrations in the range of 0.01N to 0.5N are used.

Determination of Total Exchangeable Bases by the NH_4AOC Extraction Method

The effect of time of shaking on the amounts of exchangeable Mg, Ca, Na and K Extracted from the soils. The sample mixture was filtered with a No.42 what man filter paper into a 50mL volumetric flask, the extraction was used for the determination of calcium and magnesium (Ca^{2+} and Mg^{2+}) by the versants EDTA Potassium and

sodium (K^+ and Na^+) by the flame photometric method (Nelson and Sommer, 1982)

Determination of particle size distribution

Analysis by the Buoyous Hydrometer

Particles of sand size (0.05-2.00 mm) are usually determined by sieving. The sieve defines a particle diameter as the length of the side of a square hole through which the particle can just pass. Smaller particles are usually determined by classic sedimentation methods as hydrometer or pipette. Sieving combined with Hydrometer Method (SHM) has been adopted as an international. Dissolve 40 g of SHMP in 1 L of deionized water. Use an ultrasonic bath to ensure complete dissolution. Lower the hydrometer into a 1 L cylinder filled with 125 mL of SHMP solution and 875 mL of deionized water. Weigh 40.0 ± 0.05 g of air-dried soil pulverized to pass 10 mesh sieves ($<2.0\text{mm}$) into the 200 mL container. Determine oven dry soil moisture on the second sample of soil. Add 100 mL of HMP solution, cap and place on a reciprocating horizontal shaker for sixteen (16) hours. Quantitatively transfer the suspension to the sedimentation cylinder and add deionized water to bring to 1.0 L final volume. Allow the suspension to equilibrate to room temperature for two (2) hours.

Determination of available phosphorus by the Bray 2 methods

Phosphorus is extracted from the soil using Bray 2 solution as the extractant. The extracted phosphorus is measured colourimetrically, based on the reaction with ammonium molybdate and development of the 'Molybdenum Blue' colour. The absorbance of the compound is measured at 882 nm in a spectrophotometer and is directly proportional to the amount of phosphorus extracted from the soil. Dissolve 2.22 g ammonium fluoride A.R. (NH_4F) in deionised water and transfer to a 2 L volumetric flask. Add 17 mL concentrated hydrochloric acid and bulk to volume with deionised water (Bray, 1945)

Electrical conductivity (EC)

In the same soil solution (1:2 soil /water solution) for pH determination, electrical conductivity electrode was inserted into the partly settled suspension and the EC was measured.



Figure 1: Non-polluted farmland



Figure 2: POME discharge on the forest land

Data Analysis

All statistical analysis of data from various treatments was carried out using analysis of variance (ANOVA) test ($p < 0.05$) using factorial experiment. Means were separated using least significance difference (LSD).

RESULTS

Table 1 shows the different visual characteristics of the soil samples from the experimental sites. The POME site was observed to be bare without

vegetation while the non- POME site was grown with weeds and high vegetation. Due to the oil-palm effluent discharge noticeable in site, observation reveals that the colour of the soil was dark brown, damp and odiferous while that of the non – POME site was observed to be brown, dry and free from odour due to the environment are not disturbed. The POME sites was also observed to covered with debris from the processing mill while that of the non-POME site was filled with debris from leaves as it is from unpolluted environments.

Table1: Visual Characteristics of Ukomp Bende Forest Reserve POME

Characteristics	Site (POME-Effluent Discharge Site)	Site (Non-POME-Control Site)
Vegetation	Bare without vegetation	Grown with weeds
Colour	Dark brown	Brown
Moisture	Damp	Dry
Odour	Odiferous	Free of odour
Constitution	Debris processing mill	Debris from leaves

Effect of palm oil mill effluents on soil quality

The results in Table 2 below shows that the percentage (%) polluted soils parameters of sand significantly decreased from distance of 10m, 20m and 30m respectively and increases significantly as compared to the control site ($p < 0.05$), while the silt increases from the distance of 10m, 20m and 30 respectively and significantly decreases as compared to the control sites ($p < 0.05$)

Ca^{2+} , Mg^{2+} , ECEC, pH, and % BS decreases significantly lower compared to the control site ($p < 0.05$). The trend of the concentration showed a significant increase in pH, Ca^{2+} and Mg^{2+} , from

distance 10m, 20 m, and 30m respectively. The pH concentration increases from 3.9, 4.37 and 5.0 from distance of 10m, 20m and 30m respectively while trend concentration showed a significant decrease in with distance in ECEC and %BS from distance of 10m, 20m and 30m respectively. Na^+ at 30m (0.19) away was significantly lower compared to the control site (0.24). EC, P, % OC, % OM, K^+ and EA increases significantly higher compared to the control site ($p < 0.05$). The trend of the concentration showed that EC, P, % OC, % OM, K^+ and EA decreases with distance from 10m, 20m, and 30m respectively compared to the control site, while % N increased significantly at 10m (0.17)

way compare with control site(0.07) and decrease in trend on 20m and 30m respectively. K^+ and EC increased at 10 meters to 20 meters but decrease

from 20 meters to 30 meters but these changes were statistically insignificant.

Table 2: Effects of palm oil mill effluents on soil physicochemical parameters

Parameter	Control	10 meters	20 meters	30 meters
% Sand	95.3±3.22	74.97±4.93*	71.63±12.34*	69.63±4.73*
% Silt	1.7±0.06	18.7±2.65*	21.7±9.17*	23.57±3.59*
% Clay	3.00±0.1	6.67±2.08	6.67±3.21	6.67±1.53
pH	7.2±0.24	3.9±0.46* ^a	4.37±0.61*	5.00±0.75* ^b
EC	3.26±0.11	6.61±0.26* ^a	5.87±0.23* ^b	5.41±0.12* ^c
P	15.1±0.51	28.63±2.08*	26.57±4.68*	24.57±2.03*
%N	0.07±0.02	0.19±0.08*	0.16±0.03	0.14±0.06
%OC	0.06±0.02	3.66±0.13* ^a	3.13±0.45* ^b	2.03±0.27* ^c
%OM	1.14±0.04	6.04±0.34* ^a	5.05±0.63* ^b	4±0.14* ^c
Ca ²⁺	8±0.27	4.47±1.17*	4.53±0.46*	4.60±1.74*
Mg ²⁺	2±0.07	1.23±0.06*	1.33±0.23*	1.42±0*
K	0.21±0.01	0.68±0.21*	0.65±0.14*	0.59±0.23*
Na	0.24±0.01	0.23±0.05	0.22±0.02	0.19±0.02*
EA	0.16±0.01	0.46±0.1*	0.41±0.13* ^a	0.35±0.05* ^b
ECEC	10.62±0.36	7.96±0.76*	7.19±0.18*	6.47±1.5*
%BS	98.46±3.33	95.18±1.16	93.61±0.59*	92.54±0.39*

Results show mean ± standard deviation of three replicates; * indicates significant difference from control ($p < 0.05$); parameters in the row with different letters are significantly different for each parameter.

DISCUSSION

Soil is a potent system of the terrestrial ecosystem. The direct discharge of POME may have a profound influence on the physicochemical of the soil. The pollutant level of POME varies with the quality of the raw material and production process used to manufacture the palm oil. In assessing the impacts of POME on a different level of distances from 10m, 20m, and 30m, the result showed significant differences ($p \geq 0.5$). This is in line with a report by Iyakndue *et al.*, (2017) that stated pollution of soil with varying concentrations of POME, showed profound changes and affects physic-chemical properties of the soil. The pH of the POME, soil samples (Table 2) was observed to decrease significantly ($p < 0.05$) compared to control soil samples. The observed decrease in pH is associated with decaying of organic matter in POME which alters the soil pH. This is in line with the report of Okwute and Isu, (2007a) that Soil acidity radically affects the nutrient availability of plants which presently affects seed germination and crop yield.

The decrease silt content of soils around the oil processing mill is consistent with the report of Nnaji *et al.*, (2016) and this could be attributed it to

the increased deposition of solids from the effluent onto the soils. Increase in soil acidity with decreasing distance to the oil mill site is in accordance with the findings of Iwuagwu and Ugwuanyi (2014) and Nnaji *et al.*, (2016) who observed a decrease in soil pH of soils in palm oil processing site. Palm oil mill effluents when discharged is acidic but gradually becomes alkaline as biodegradation takes place (Hemming, 1997). The low pH may be due to the organic and free fatty acids arising from partial degradation of palm fruits before processing.

Oil mill effluents increased the soil electrical conductivity and the EC values decreased significantly with increasing distance from the mill. This is comparable to values obtained by Eze *et al.*, (2013) who found higher EC values in soil samples contaminated by palm oil effluent than in control samples. Electrical conductivity (EC) is a measure of the amount of salts in soil the and it may be inferred that the higher mean EC value in the soil means higher deposition of dissolved ions from the effluent.

Increase in the mean % organic carbon, % organic matter, and available phosphorus in the oil mill samples conforms to the findings of Rupani *et al.*, (2010), and Nnaji *et al.*, (2016) who observed a

significant increase in these parameters in soil amended with palm oil effluent. The organic matter of a soil is usually determined and reported as a measure of the organic carbon concentration in the soil as reported by Nelson and Sommers (1982). Organic matter content strongly affects soil fertility by increasing the availability of plant nutrient by improving soil structure and water holding capacity. It also acts as an accumulation phase for toxic, heavy metals in the soil environment (Deiana *et al.*, 1990)

The POME soil nitrate levels decreased with depth and distance of sample collection from the discharge point. However, sodium ion (Na^+) in the POME sample soils were higher ($p < 0.05$) than in non-POME contaminated soils. Sodium uptake by plants from soil is mostly that adsorbed onto exchange sites (exchangeable Na^+) while potassium (K^+) is not freely absorbed in free or exchange forms (Jouhet, *et al.*, 2003).

The POME soil samples were observed to contain significantly ($p < 0.05$) high potassium ion concentration in the wet soil than dry soil and less on the control site. Soil potassium ion levels decreased with a distance of sample collection from the discharge point.

Mean Ca^{2+} , K^+ and Na^+ were significantly higher in the oil mill samples compared to the control sample similar to the findings of Okwute and Isu (2007b). For this reason, the recycling of organic waste through their application to the soil can be an

important promising practice for agricultural activities.

Conclusion and Recommendation

This study has shown that waste products from palm oil mill effluent (POME) causes degradation of soil physicochemical properties and increase the soil acidity due to an increase in soil pH. Thus, while essential products like palm oil are obtained from oil palm milling, the adverse environmental impact of palm oil mill effluent discharge should be observed and giving proper attention. Organic matter deterioration of soil increases in soil acidity level which affects downstream biodiversity, crop yield output decreases, and human beings. Therefore, it was observed that POME also caused profound changes in the soil physicochemical properties of the polluted soils. The result revealed a significant difference in the soil pH, %Sand, Ca^{2+} , Mg^{2+} , Na^+ , ECEC and %BS between the non-polluted soils while no significant difference was observed in EA, P, EC, K, % N, % OM, % OC, %clay and % silt.

In conclusion, this study revealed that POME could be harmful to the soil if not properly manage. Therefore, the government should create awareness to those involved in small- and large-scale palm oil processing on the need for proper disposal of effluent because if not properly managed, it can negatively affect soil fertility by inhibiting microbial proliferation.

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