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EFFECT OF PALM OIL MILL EFFLUENT (POME) DUMPING ON SOIL PHYSICOCHEMICAL PARAMETERS AND SELECTED PLANT NUTRIENTS IN UTURU ABIA STATE NIGERIA

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Abstract

The effects of Palm Oil Mill Effluents (POME) dumping on soil physicochemical parameters and selected soil plant nutrients were studied. A total of eight (8) POME dumping sites were monitored in two seasons (wet: May – September and Dry: November – March) for four (4) years. Sample collection in each site was from discharge spot of effluents, 4 and 8 meters from discharge spot along route of effluent flow. Top soil samples (0-30cm depth), subsoil samples (31-60cm depth) and bottom soil samples (61-90cm depth) were collected from each sampling spot while control samples were obtained from spots within each sampling site uncontaminated with effluents. Significantly high values ($p<0.05$) were observed for POME soil samples temperatures, pH (acid) and percentage moisture relative to control soils. Similarly the test soil samples cation exchange capacities and exchangeable acidities were significantly higher ($p<0.05$) than that obtained from control soils. Although the POME dumpsite soil ammonium ion, nitrate and sulphate ions were significantly ($p<0.05$) lower than those from control soil samples, while aluminium, potassium, phosphate and sodium ions were higher ($p<0.05$) in POME dumpsite soils. Percentage nitrogen also increased ($p<0.05$) in the POME dumpsite soil relative to control soils. These findings attest to a possible use of POME as a biofertilizer if properly harnessed and managed.

Key words: Physicochemical, Biofertilizer, Effluents, Palm Oil.

Introduction

Palm oil is one of the two most important vegetable oils in the world's oil and fats market following soya beans – (Hartey, 1988). Oil palm (*Elasis guinensis*) is the most productive oil producing plant in the world with the production of about 10-35tonnes of fresh fruit bunch per hectare of land (Ma, *et al*; 1996). Crude palm oil contains fatty acid ester of glycerol commonly referred to as triacylglycerols which is one of the world's most important edible oil. The process of extracting the oil from the fruit involves boiling/steaming which sterilizes the fruit and softens the mesocarp. The separated and sterilized fruits thereafter undergo a process of digestion. The last stages are oil extraction, clarification and purification (Igwe and Onyegbado, 2007). Industrially water is removed by settling or centrifugation and finally by vacuum drying. The oil palm mills generate many by-products and wastes besides the liquid waste that have a significant impact on the environment if not properly dealt with. An important waste product of oil palm milling process is the Palm Oil Mill Effluent (POME). Effluent water is defined as water discharged from industry which contains soluble materials that are injurious to the environment (Wu *et al.*, 2009). Specifically palm oil mill effluent (POME) is the sum total of liquid waste which cannot be easily or immediately reprocessed for extraction of useful products and is run down the mill internal drain system to the so-called effluent (sludge) pit. Many researchers have shown that POME in both raw and treated forms contains very high level of nutrients such as N.P.K. and Mg (Lim, 1987, Dolmat *et al*., 1987). In Nigeria palm oil is processed industrially and locally and in most cases POME from these mills are, discharged directly untreated on nearby agricultural lands or into surface water bodies. Ideriah *et al* (2007) noted that POME discharged into river increased the level of heavy metals in such rivers and also altered their pH to acid (5.4 – 6.2). These they noted were harmful to aquatic lives and humans.

POME have also been noted to alter the soils water holding capacity, organic carbon and total nitrogen. This has been cited as a probable advantage of POIME over other effluents as it may be used to enhance soil fertility (Okwute and Isu, 2007). Other changes in soil compositions associated with POME have been cited by Woods (1977); Oriesogie and Aghimien (2002); Chinyere *et al*. (2015) etc. The high composition of carbohydrate, protein, nitrogenous compounds, lipid and mineral in POME (Hwang *et al*., 1978; Phang, 1990) with respect to its proximate composition have been carried out extensively (Habib *et al*., 1997). There has been trials of possible reuse of POME for other products (Wu *et al*., 2007, Suwandi, 1991; Masngut *et al*., 2007). Pasha (2007) formulated POME as food for animal and agricultural organisms. Similarly Igwe and Onyegbado (2007) summarized the various techniques applied to detoxify POME and Chinyere *et al*. (2013) altered the pH of POME.

Methodology

Sample collection: A total of eight (8) sampling sites were used for sample collection. In each site, three spots were chosen for the collection of samples thus:

Spot X: was the discharge point of effluents

Spot Y: Was a point four (4) meters away from spot X along the route of flow of discharged effluent.

Spot Z: Was a point eight (8) meters away from spot X along the route of flow of discharged effluents.

At each spot X, Y and Z three samples were collected and designated as X_1, X_2, X_3, Y_1, Y_2, Y_3 and Z_1, Z_2, Z_3.

Samples A ($X_1 + Y_1 + Z_1$) = Top soil samples from 0 to 30cm depth, B(X_2, + Y_2 + Z_2) = subsoil, samples from 31cm to 60cm depth and C ($X_3 + Y_3 + Z_3$) = bottom soil samples from 61cm to 90cm depth respectively. Control samples were collected from spots in each site not infiltrated by effluent and designated

D_1, D_2 and D_3 respectively. Samples collected were packed separately in marked cellophane bags tightly tied to avoid contamination and stored in refrigerators of temperature 4-6^oC. Samples were sieved (4mm) and sub-samples for the determination of physicochemical parameters were air-dried and sieved (2mm) before analysis. Analyses were done in two seasons thus: Wet season (May – September) and Dry season (November – March) respectively.

Sample Analysis:

Soil temperature was monitored *insitu* at the site of collection of samples using mercury-in-glass thermometer while soil pH was determined using pH meter as described by Bates (1954). Soil moisture was measured using method of APHA (1998). However, soil samples exchangeable acidity, cation exchange capacity. sulphate, phosphate, and nitrate were determined using the methods of Dewis and Freitas (1970). Soil sample ammonium ion was measured using the method of Vogel (1962) while sodium, potassium and aluminium ions in soil samples were determined using Atomic Absorption spectroscopy according to AOAC (2005). All statistical analyses were done using ANOVA and Duncan Multiple Range.

Results and Discussion:

In the POME dumpsites, the top soil samples had the highest temperatures followed by the subsoil ($P<0.05$) while the least temperature was that obtained for the bottom soil samples. However, the bottom soil samples showed no changes in temperature ($p>0.05$) (Fig. 1) compared with control soil samples.

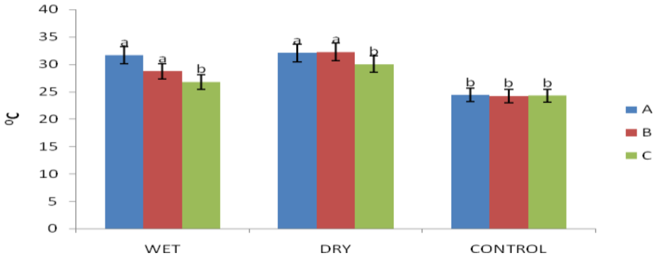

Fig. 1: Palm oil mill effluent (POME) infiltrated soil temperature (^oC) wet and dry season.
Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)

B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

Akubugwo *et al*. (2009) obtained a similar result for refined oil contaminated soils. This rise in temperature of POME contaminated soil is associated with microbial activities decaying this effluent. Soil temperature can strongly influence root growth and nutrient uptake by plants. This will subsequently hinder shoot development and mineral nutrient accumulation of plants (Hogue and Nelson, 1986, McMichael and Burk, 1998). Water viscosity influenced by temperature changes has been shown to affect metabolic activities in plant roots through changes in membrane lipids and enzymes associated with nutrient uptake ((Shufu *et al*., 2001).

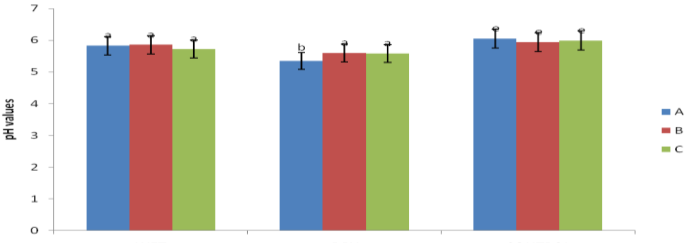

Fig. 2: Palm oil mill effluent (POME) infiltrated soil pH values. Wet and dry season.

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

The pH of the POME, dumpsite soil samples (fig2) were 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. There was no influence of the two seasons on this pH changes except for dry season top soils. Soil acidity radically affects nutrient availability to plants. At extremes of soil acidity or alkalinity, toxic levels of most elements in soil become present affecting seed germination and crop yield (Okwute and Isu, 2001a). The observed increased POME soil moisture content suggests that POME increase the water holding capacity of soils (fig 3).

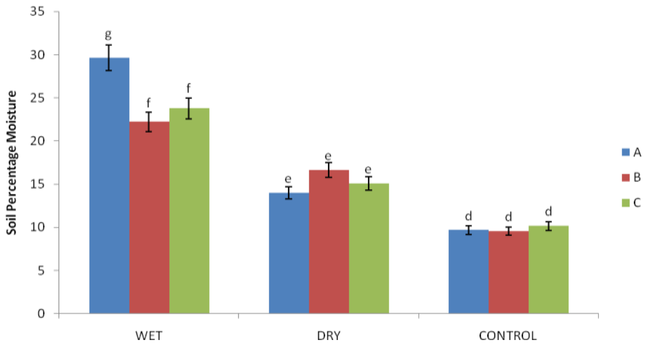

Fig. 3: Palm oil mill effluent (POME) infiltrated soil percentage moisture. Wet and dry season.

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different ($P>0.05$)

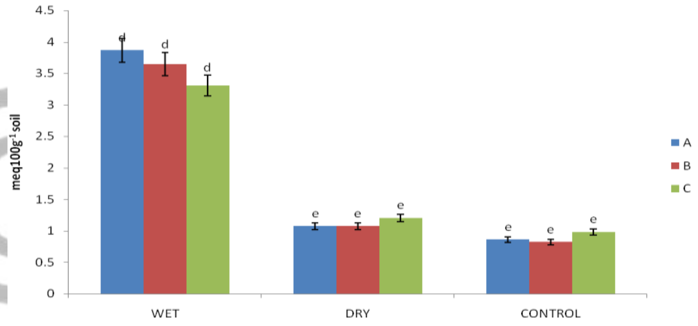

Fig. 4: Palm oil mill effluent (POME) infiltrated soil cation exchange capacity (meq100g^{-1} soil). Wet and dry season

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different ($P>0.05$)

Excess soil water reduces soil oxygen available to plants and microbes thus altering microbial activities. The cation exchange capacity along with exchangeable acidity of POME soils were significantly higher ($p>0.05$) than non-POME soils during the wet season in contrast to non-significant changes ($p>0.05$) obtained for the dry seasons. Increase in soil moisture contents during the wet season and complete ionization of cations is associated with the observed CEC and EA changes. Thus, the increased CEC and EA during the wet seasons are associated with decrease (acid) pH of the POME impacted soil samples. These are similar to results obtained by Oviesogie and Aghimien (2002) and Huan (1987). Both the top and sub-soil POME soil samples had significantly high ($p<0.05$) aluminium ion levels than the control soil samples. POME soil aluminium ion over non-POME samples correlated with the acid pH obtained for the POME infiltrated soil samples. Aluminium hydroxides like the minerals gibbsite are known to be very insoluble at neutral or alkaline pH. As the soil pH decreases however the excess of hydrogen ions can combine with the hydroxide ions yielding water and aluminium ion (Al^{3+}) in solution. This ionized aluminium becomes much more soluble as for other forms in soil (Brix, 2008). As the pH decreases below 5.5 the availability of aluminium and manganese increase and may reach a point of toxicity to the plant. Excess Al^{3+} in the soil solution has been noted to interfere with growth and function as well as restricting plant uptake of certain nutrients namely Ca^{2+} and Mg^{2+} (Brix, 2008). Acid soils also cause phosphate ions to form insoluble compounds with aluminum and iron leading to inhibition of root growth in plants (Rincoin and Gonzales, 1992). The roots have been observed to become stubby and lose much of their ability to take up nutrients and water (Ma *et al*., 2001). Aluminum ions also inhibit DNA replication, interfere with various plant enzymes, modify the structure of cell membranes and nitrate uptake by plants (Calba and Jaillard, 1997).

The POME soil phosphate ion was significantly high ($p<0.05$) in the wet than dry season and control (fig 5).

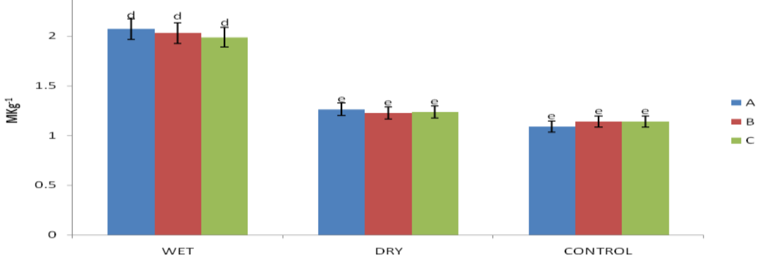

Fig. 5: Palm oil mill effluent (POME) infiltrated soil exchangeable acidity (MKg^{-1}). Wet and dry season

Results are mean of triplicate determinations ± standard deviation (SD)

A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

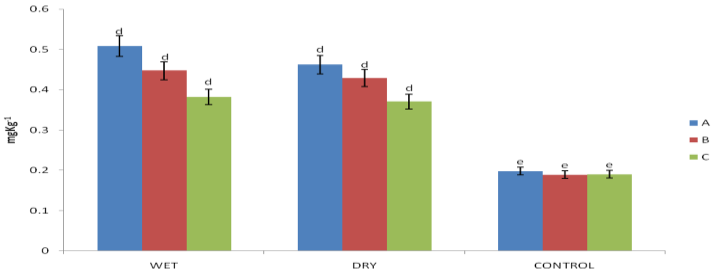

Fig. 6: Palm oil mill effluent (POME) infiltrated soil aluminum ion (mgKg^{-1}). Wet and dry season.

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

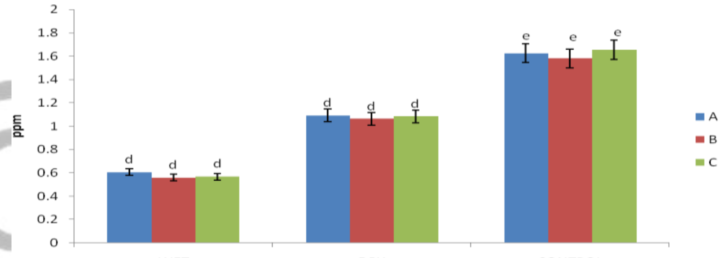

Fig. 7: Palm oil mill effluent (POME) infiltrated soil ammonium ion (ppm). Wet and dry season

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

The relationships observed in this and earlier studies (Chinyere *et al*., 2015) between soil moisture, organic carbon, phosphate and phosphatase activity are similar to those of Nelson and Sommers (1982). High soil moisture cause cations such as Fe^{2+} and Mn^{2+} to become more soluble and in turn combine with phosphate to form insoluble complexes thereby reducing plant and microorganism available phosphate in the soil solution. Depending on soil pH, this will lead to phosphate stress and stimulation of the phosphatases (Lijklema, 1977). Similar observations have been made by Ellery and Ellery, (1978). The percentage soil nitrogen level from three major soil types (Loamy, clayey and sandy) sampled indicated that the clayey soil retained most of its nitrogen in both seasons (Table 1).

TABLE 1: PERCENTAGE NITROGEN (%) FOR 3 SELECTED SITES (POME)

Sample	WET SEASON				DRY SEASON		
	1	2	3	← Site →	1	2	3
A_1 (0-30cm) Deep	0.88 ± 0.02^{a}	0.97 ± 0.05^{a}	0.81 ± 0.00^{a}		0.67 ± 0.05^{a}	0.84 ± 0.01^{a}	0.60 ± 0.01^{a}
A_3 (61-90cm) Deep	0.31 ± 0.00^{b}	0.45 ± 0.01^{b}	0.30 ± 0.04^{b}		0.22 ± 0.06^{b}	0.25 ± 0.00^{b}	0.19 ± 0.03^{b}
C_1 (0-30cm) Deep	0.73 ± 0.01^{a}	0.85 ± 0.00^{a}	0.52 ± 0.01^{a}		0.51 ± 0.03^{a}	0.66 ± 0.05^{a}	0.44 ± 0.01^{a}
C_3 (61-90cm) Deep	0.19 ± 0.06^{c}	0.32 ± 0.05^{b}	0.20 ± 0.00^{b}		0.18 ± 0.04^{b}	0.30 ± 0.01^{b}	0.13 ± 0.01^{c}
D_1 (0-30cm) Deep	0.29 ± 0.00^{bc}	0.31 ± 0.01^{bc}	0.29 ± 0.01^{bc}		0.26 ± 0.01^{b}	0.29 ± 0.00^{b}	0.10 ± 0.00^{c}
D_3 (61-90cm) Deep	0.10 ± 0.01^{c}	0.16 ± 0.00^{c}	0.12 ± 0.01^{c}		0.9 ± 0.00^{d}	0.12 ± 0.03^{c}	0.06 ± 0.00^{d}

Soil Texture of Site: Site 1 = Loamy Figures are mean of triplicate determination ±
Site 2 = Clayey Standard deviation
Site 3 = Sandy UND = Undetected
?? = Query result
D_1D_2 = Control
A_1 = Discharge point of effluent
C1 = 8 meters from A1 along effluent flow route
D = Control

Samples with same letters are not significantly different (p>0.05) for each season compared with control.

This was significantly high ($p<0.05$) in the wet than dry season – but both higher than in control soil samples. Organic nitrogen is usually bound to clay and humus particles known as soil colloids forming stable complexes (Sadej and Przekwas, 2008). This observation credits the higher levels of soil nitrogen obtained from clayey soils in this study. The POME soil ammonium ion was lower in both season compared with control soil samples. Depth and distance of sample collection from discharge point of POME had no effect on this observation. Okwute and Isu (2007b) reported the absence of ammonium oxidizers in POME treated soils and enumerated decreased aeration, increased moisture and organic matter content associated with POME soil as apparent inhibitory factors. The POME soil samples had higher soil nitrate levels ($p<0.05$) than control (fig. 8).

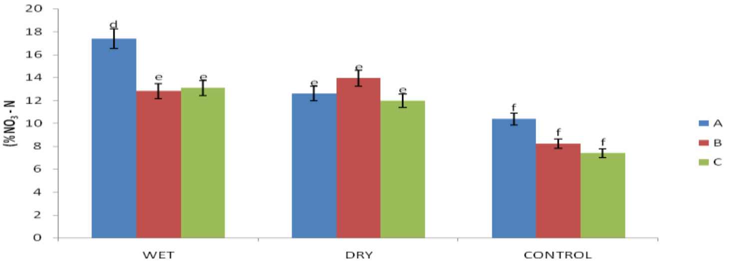

Fig. 8: Palm oil mill effluent (POME) infiltrated soil nitrate ion (% NO_3 - N). Wet and dry season

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different ($P>0.05$)

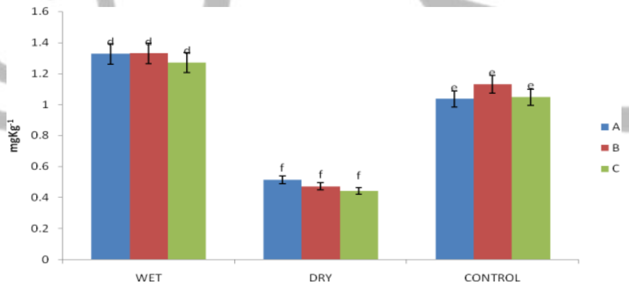

Fig. 9: Palm oil mill effluent (POME) infiltrated soil sodium ion ($mgKg^{-1}$). Wet and dry season.

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different ($P>0.05$)

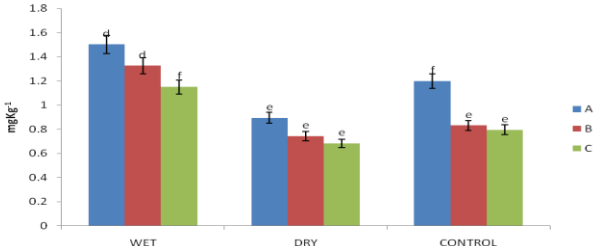

Fig. 10: Palm oil mill effluent (POME) infiltrated soil potassium ion (mg/Kg^{-1}). Wet and dry season.

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

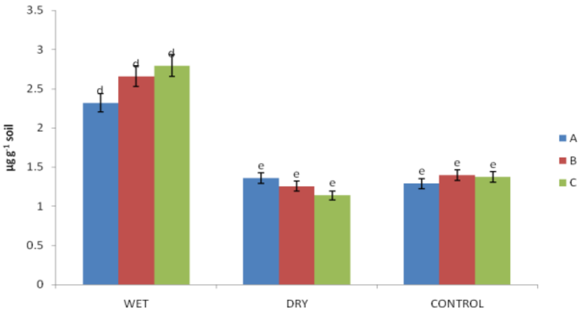

Fig. 11: Palm oil mill effluent (POME) infiltrated soil phosphate ion (µg g^{-1} soil). Wet and dry season

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

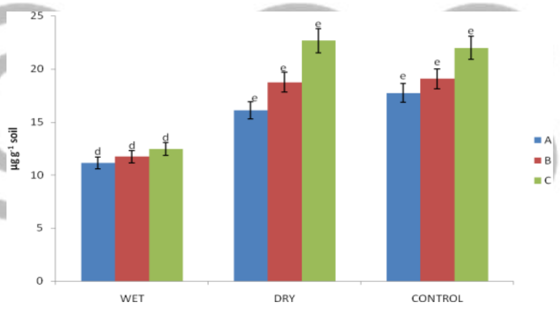

Fig. 12: Palm oil mill effluent (POME) infiltrated soil sulphate ion (µgKg^{-1}). Wet and dry season

Results are mean of triplicate determinations ± standard deviation (SD)
A = Top soil samples (0 - 30cm depth)
B = Subsoil samples (30 – 60cm depth)
C = Bottom soil samples (60 – 90cm depth)
Bars bearing the same letters are not significantly different (P>0.05)

This is associated with biodegradation of POME proteins in the soil. The POME soil nitrate levels decreased with depth and distance of sample collection from discharge point. However sodium ion in the POME dumpsite 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 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 than dry season and the control. Soil potassium ion levels increased with distance of sample collection from discharge point. The reason for this cannot be explained presently. This study obtained low ($p<0.05$) POME soil sulphate ion in the wet than dry season. This is believed to be due to increased metabolic usage by microbes and needs further investigation.

In conclusion, this research work tried to establish the various factors contributing to pollution problems posed by POME-dumping. Changes in soil temperature, pH, moisture, cation exchange, capacities and exchangeable acidities were observed. Similarly depletion of some of important plants nutrients in dumpsite soil samples was noted. The observed high soil aluminium and sodium ions; low nitrate, ammonium and sulphate ions were also major contributors. Efforts should therefore be made towards pre-treatment of POME before dumping as an ameliorating step.

References

Akubugwo, I. E; Ofoegbu, C. J. and Ukwuoma, C. U. (2007). Physicochemical studies on Uburu salt lake, Ebonyi State Nigeria. *Pakistan Journal of Biological Sciences (7)*: 3170 – 3174.

AOAC (2005). Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists, Washington DC. 116 – 187.

APHA (1998). Standard methods for the examination of water and waste water 18th edn. Washington (American Public Health Association). 89 – 141.

Bates, R. G. (1954). Electrometric pH determinations. John Willey and Sons Inc; New York.

Batistic L; Sarkar, J.M and Mayaudon J. (1980). Extraction, purification and properties of soil hydrolases. *Soil Biology. Biochemistry.* 12:59-63.

Brix, H. (2008). Soil acidity. *Protocol In Soil Acidity*, 3:1-4.

Calba H. and Jailard B. (1997). Effect of aluminum on ion uptake and H^+ release by maize. *New Phytology*. 137:607-616.

Chineyere, G. C., Akubugwo, E.I. and Ugbogu, E.A. (2015). Effects of altering palm oil and cassava mill effluents pH before dumping on dumpsite soils physicochemical parameter and selected enzyme activities. *Journal of Biodiversity and Environmental Science* 3(4).

Chinyere, G. C., Akubugwo, E.I. and Osuocha, K.U. (2013) Seasonal impact of palm oil mill effluents (POME) on dumpsites physicochemical parameters and selected enzyme activities in Isuikwuato Area, Abia State, Nigeria. *International Journal of Biochemistry Research* 3(4) 70-79.

Dewis, J.; and Fretias, F. (1970). Physical and Chemical methods of soil and water analysis. *Soil Bulletin 10*. FAD ROME. Pp 1 – 275.

Dolmat, M.T., Lim K.H., Zin Z.Z., Halium H (1987). Recent studies on the effects of Land Application of palm oil mill Effluent on oil palm and the environment. Proceedings of 1987 International OP/P.O Conference on Agriculture , Kwala Lumpur Malaysia. Pp. 596-604.

Doner, H.E and Lynn, W.C. (1989). Carbonate, Halide, Sulphate and Sulfide

Ellery, K. and Ellery W. (1997). Plants of the Okavango: A field Guide. Durban, R.S.A. Tsaro.

Akubugwo,E.I., Ogbuji,G.C., Chinyere G. C. and Ugbogu, A.E. (2009). Physicochemical properties and enzyme activity studies in a refined oil contaminated soil in Isuikwuato, Abia State, Nigeria. *Biochemistri* 21(2) 79-84.

Hartley C.W.S. (1988). The products of the oil palm and their extraction. *Oil Palm 3rd ed. Long Scientific and Technical with John Wiley and Sons. Inc*. New York: pp 721-724.

Hogue, E.J. and Neilson, G.H. (1986) Effect of root temperature and varying cation ratios on growth and leaf cation concentration of apple seedlings grown in nutrient solution. *Canadian Journal of Plant Science*. 66:637-645.

Huan, K.L; (1987). Trials on long-term effects of Application of POME on soil properties, oil palm nutrition and yields. In proceedings of the international, Palm Oil Conferences (eds) Dr. B. Hi Abdul Hallim, Hassan, Chew; Pol, Soon; B.J. Wood, E. Pushparajah (eds) 2:575-598.

Hwang Tik; Ong S.M; Seow C. C, and Tan H.K, (1978). Chemical composition of *palm oil mill effluents*. Planter5.4:749-56.

Ideriah, T.J.K; Adiukwu P.U., Stanley H.O., and Briggs A.O. (2007). Impact of Palm Oil Mill effluent on water quality of Receiving Olaya Lake in Niger Delta, Nigeria. *Research Journal of applied Sciences* 2(7); 842-845.

Igwe J.C. and Onyegbado C.C. (2007). A review of palm oil mill effluent (POME) water treatment. *Global Journal of environmental Research*. 1 (2): 54-62.

Jouhet,J., Marechal,E., Bligny,R., Joyard,J. and Block, M.A (2003). Transient increase of phosphatidylcholine in plant cells in response to phosphate deprivation. *Federation of European Biochemical Society* (FEBS) *Letters*; 544:63-68.

Lijklema, L; (1977) The role of iron in the exchange of phosphate between water and sediments. In: Interactions between sediments and water. (Ed. H.L. Golterman). The Hague: Dr. W. Junk, 313-319.

Lim, K.H. (1987). Trial on long-term effect of application of POME on soil properties, oil palm nutrition and yields. In: *Proceeding of the International Oil Palm Conference,* Kualar Lumpur, Malaysia. 2:575-595.

Ma A. N; Tajima Y., Asahi M., and Hannif J. (1996). A novel treatment process for palm oil Mill Effluent. *Palm oil Research Institute of Malaysia* (PORIM) Technology. 19:1-8.

Ma, Jian Feng; Fyan, Peter R; and Delhaize, Emmanuel (2001). Aluminum tolerance in plants and the complexing role of organic acids. *Trends in Plant Science,* 6 (6): 273-298.

Masngut N; Takrift M.S; Mohammad A.U; Kalil M; and Kadhum A.A. H.(2007).Performance of Oscillatory flow reactor and stirred tank oil mill effluent. *Journal of Teknology*. 47(9); 45-54.

McMichael, B.L. and Burke, J. J(1998). Soil temperature and root growth *Horticulture Science* 33:97-951

Nelson, D.W; and Sommers L.E; (1982). Total carbon, organic carbon and organic matter. In: Methods of soil analysis. Part 2, Chemical and microbiological properties. A.L Page, R.H Miller & D.R Keeney (eds). Madison, Wisconsin: *American Society of Agronomy,* 539-577.

Okwute, L. O; and Isu, N. R. (2007b). Impact analysis of Palm Oil Mill Effluent on the aerobic bacterial density and ammonium oxidizers in a dump site in Anyigba, Kogi State. *African Journal of Biotechnology 6*(2): 116 – 119.

Okwute, L. O; and Isu, N. R; (2007a). The Environmental impact assessment of palm oil mill effluent (POME) on some physico-chemical parameters and total aerobic bioload of soil at a dump site in Anyigba, Kogi, state Nigeria. *African Journal of Agricultural Research 2(12)*: 658 – 662.

Oviasogie P.O. and Aghimien A.E. (2002). Macro nutrient status and speciation of Cu, Fe, Zn and Pb in soil containing palm oil mill effluent, *Global Journal of Pure and Applied Science* 9 (1): 71-80.

Pasha T.N; (2007). Boosting animal feed. *Global oil and fats Business magazine*. 4: 43- 44.

Phang. S. M; (1990). Algal production from agro industrial and agricultural waste in Malaysia. *Ambiosis*. 19 : 415-8.

Rincom M. and Gonzales R.A (1992). Aluminum Partitioning in intact roots of aluminum tolerant aluminum sensitive wheat cultivars. *Plant Physiology*, 99:1021-1028.

Sadej, W. and Przekwas, K.(2008). Fluctuations of nitrogen levels in soil profile under conditions of a long-term fertilization experiment. *Plant Soil and Environment.* 5 (5): 197-203.

Shufu, Dong; Carolyn, F. Scagel; Lailiang, Cheng; Leslie, H. Fuchigami and Paul T. Rygiewicz (2001). Soil temperature and plant growth state influence nitrogen uptake and amino acid concentration of apple during early spring growth. *Tree Physiology*, 21:51-57.

Suwandi M.s.(1991). POME: From waste to antibiotic and bioinsecticide; Jurutera kim Malaysia. 1: 79 -99.

Vogel, A. I; (1962). A textbook of quantitative inorganic analysis including: Elementary instrumental analysis 3rd edn. Longmans, Green and Company Limited. Pp 210 – 250.

Wood, B.J. (1977). A review of current methods for dealing with palm oil mill effluent. *Planter* 53:477-495.

WU T.A; Mohammad A.W; Jahim J.M, and Annuar N. (2009). A holistic approach to managing Palm Oil Mill Effluent (POME): Biotechnological advances in the sustainable reuse of POME. *Biotechnology Advances* 27:40-52.

Wu T.Y; Mohammad A.W; Md Jahim J; Anuar N. (2007). Palm oil mill effluent (pome) treatment and bioresources recovery using ultrafiltration membrane; effect of pressure on membrane fouling. *Biochemical engineering*, 35:309-17.