06.30.2024

JOURNAL OF

Health, Metabolism & Nutrition Studies (JHMNS) Vol. 4 No. 3

ASSESSMENT OF ENVIRONMENTAL IMPACT AND NUTRIENT CONTENT OF PALM OIL SLURRY IN LIVESTOCK NUTRITION IN NIGERIA

[1]ABIOLA-OLAGUNJU .O.; [2]JOHN-DEWOLE .O.O.; [3]MAKO A. A.; AND [3]AKINWANDE V. O.

[1]Department of Microbiology, Lead City University, Ibadan. Nigeria.
[2]Department of Chemical Sciences, Lead City University, Ibadan, Nigeria. [3]Department of Agricultural Sciences, Tai Solarin University of Education, Ijagun, Nigeria.

abiolaolagunjuoluwanike@gmail.com

ORCID 0009-0002-4088-4413

ORCID 0000-0003-4883-7750

Abstract

The aim of this study was to assess the nutrient content and environmental impact of palm oil slurry (POS) disposal on soil of some selected palm oil processing locations in South-western Nigeria. Soil samples were collected from three different dump sites (DS) and a non-dump site (NDS) in South-western Nigeria to determine the proximate, physico-chemical and microbiological

Introduction

Nigeria is the fifth largest producer of palm oil in the world with domestic production of 930,000 (nine hundred and thirty thousand) metric tons accounting for about 1.5 % of global output (Izah *et al.*, 2016). Oil palm industry has positive economic impacts, as it is a source of employments to millions of people in

E-ISSN 3026-8664 P-ISSN3027-2238

characteristics. The POS was fermented at 24 hourly intervals for 72 hours to determine its nutrient content. Results revealed significant variation for chemical composition of slurry in dry matter, crude protein and neutral detergent fibre, (15.31 - 40.12; 6.21 – 9.05 and 46.03 - 52.14 % for 0 – 72 hours fermentation respectively). Significant variations for pH, water holding capacity, organic carbon, total nitrogen and available phosphorus, ranged from 5.75 - 6.68; 23.01 - 36.18 %; 2.58 - 3.31 %; 13.03 - 14.50 % and 22.02 - 28.00 ppm in NDS and DS respectively. Same trend was observed for the microbial count (log_{10}cfu/g): Total heterotrophic bacteria count, hydrocarbon utilizing bacteria count, hydrocarbon utilizing fungi count ranging from 6.89 – 8.28; 2.53 - 6.02 and 2.73 – 3.15 respectively. However, significant differences also occurred between the various slurry DS and NDS for total heterotrophic fungi count and nitrifying bacteria ranging from 8.01 – 4.00 and 3.84 – 2.89 in NDS and DS respectively. The biological oxygen demand (BOD) of the POS increased persistently over a period of five years in the range of 255 – 5000 mg/liter. Similarly, the chemical oxygen demand (COD) took the range of 500 – 8000 mg/liter. Slurry DS were altered; however, proper use and safe disposal of POS on the soil could lead to improved soil fertility. Fermentation of POS increased protein content (maggot buildup) which could be beneficial to livestock, most especially fish farmers.

Keywords: dump site, microbial count, nutrient content, palm oil slurry, physico-chemical characteristics

Nigeria. However in Nigeria, there is paucity of information about the environmental impact and nutritional potential of the waste(s) from the industry. The palm oil processing emits three waste streams namely: gaseous (pollutant gases), liquid (palm effluent i.e. slurry) and solid (palm press, fibre chaff, palm kernel shell and empty fruit bunch) Hartley C.W.S. (1988). Only a small fraction of the solid wastes are utilized as boilers fuel by the palm oil industry, while the rest are discharged into the environment with little or no treatment (Izah *et al*., 2016).

In Nigeria's oil palm industry, most of the palm oil slurry produced by small scale traditional operators undergo little or no treatment and are usually discharged in the surrounding environment. This slurry could pollute streams, rivers and surrounding land.

The assessment of the possible ecological effects of slurry from palm oil industries on the environment through surveillance on the physico-chemical alterations caused by these discharged wastes are therefore of uttermost significance. Using three dump sites in southwest Nigeria: A; Mamu dump site in Ogun State, B; Ikoyi dump site in Osun State and C; Badeku Jako dump site in Oyo State as reference points.

From the foregoing, the study investigates the consequences of disposing wastes emanating from palm oil processing on the biological diversity of soils in southwest Nigeria. Specifically, the study objectives were:

i. To examine the physicochemical properties of palm oil effluents on soils' biodiversity.
ii. To determine the mean count of microorganisms isolated from different slurry dump sites and non-dump site.
iii. To determine the proximate composition (%) of palm oil slurry from the three different sites

Materials and Methods

Sample Collection

Soil samples were collected using the grab method. 20 soil samples were collected from each of the slurry dump sites and the control sample was collected about 10 yards away from the slurry site. The soil samples

E-ISSN 3026-8664 P-ISSN3027-2238

were put in a polythene bags and the raw effluent in a sealed container with labels, and taken to the laboratory less than 6 hours of collection, where it was air-dried and passed through a 2 mm sieve in order to separate the soil from the stones. Thereafter, the microbial and physicochemical properties were determined, within 24 hours of collection.

Fermentation of Slurry

Fresh slurry collected from each of the sites was subjected to fermentation. The slurry was left to stand for 0, 24, 48 and 72 hours to allow maggot built-up, after which it is taken to the laboratory for proximate analysis.

Determination of the Physicochemical Parameters

A number of physicochemical parameters of the contaminated soil samples were determined. The parameters included pH, water holding capacity (WHC), total nitrogen (TN), available phosphorus (AP) and total organic carbon (TOC). The pH was measured using Hach pH meter (Model EC1O). All analyses were in accordance with APHA, 2005.

Enumeration of Total Heterotrophic Bacteria and Fungi

Samples of the polluted soils were serially diluted in 10 folds. Total viable heterotrophic aerobic counts were determined by plating in duplicates using pour-plate technique. Then molten nutrient agar at 45 ^{o}C was poured into the Petri-dishes containing 1 mL of the appropriate dilution for the isolation of the total heterotrophic bacteria and fungi respectively. They were swirled to mix and colony counts were taken after incubating the plates at room temperatures for 48 hour.

Enumeration of Hydrocarbon-Utilizing Bacteria and Fungi

The hydrocarbon-utilizing bacteria and fungi were determined using the mineral salt agar of Mills *et al.*, (1978) as modified by Okpokwasili & Amanchukwu (1988).

Proximate analysis

Crude protein, ether extract and total ash of samples were analyzed in triplicates using standard procedure of A.O.A.C (2012). The crude protein was determined with the micro kjeldahl distillation apparatus, while the fibre fraction (NDF) was determined according to Van Soest *et al.,* 1994

Statistical analysis

The data generated were subjected to One Way Analysis of Variance procedure (ANOVA) of SAS (1999). Significant means were separated using the Duncan multiple range test of the same package.

Results and Discussion

Table 1: Proximate composition (%) of Palm oil Slurry from three different sites

	Fermentation Hours				
Slurry Sites	0	24	48	72	SEM
Site A					
Dry matter	41.69^{a}	40.61^{b}	40.33^{c}	40.12^{d}	0.10
Crude protein	8.15^{d}	8.26^{c}	8.66^{b}	9.05^{a}	0.01
Ether extract	31.00^{d}	31.05^{c}	31.11^{b}	31.21^{a}	0.01
Ash	3.25^{d}	3.31^{c}	3.40^{b}	3.52^{a}	0.001
Neutral detergent fibre	46.31^{a}	46.23^{b}	46.11^{c}	46.03^{d}	0.03

Vol. 4, No. 3
Journal of Health, Metabolism and Nutrition Studies

Site B					
Dry matter	40.36^{a}	40.31^{b}	40.25^{c}	40.00^{d}	0.10
Crude protein	7.21^{d}	7.33^{c}	7.47^{b}	7.64^{a}	0.01
Ether extract	33.10^{d}	33.15^{c}	33.18^{b}	33.21^{a}	0.04
Ash	4.11^{d}	4.22^{c}	4.30b	4.38^{a}	0.10
Neutral detergent fibre	49.41^{a}	49.30^{b}	49.25^{c}	49.02^{d}	0.12
Site C					
Dry matter	40.34^{a}	40.28^{b}	40.21^{c}	40.10^{d}	0.10
Crude protein	7.31^{d}	7.44^{c}	7.56^{b}	7.79^{a}	0.11
Ether extract	32.25^{d}	32.38^{c}	32.41^{b}	32.47^{a}	0.12
Ash	4.18^{d}	4.24^{c}	4.27^{b}	$4. 31^{a}$	0.01
Neutral detergent fibre	51.58^{a}	51.42^{b}	51.37^{c}	51.24^{d}	0.10

^{ab}= means on the same column with different superscript differed significantly ($p<0.05$)

Table 1 presents the proximate composition of slurry with maggots build at 24 hourly intervals, from 0 to 72 hours. Significant variation was observed in all parameters measured. Dry matter was inversely related to crude protein (Nur, 2012 and Nwoko *et al.*, 2010). The slurry with maggot build up at 72 hours had the highest crude protein content (7.64 to 9.05 %). This is an indication that the protein content of palm oil slurry will increase as days of discharge increases. This further indicates that palm oil slurry can be incorporated into farm animal feed in order to boost the protein content at low costs and healthy conditions. Since palm oil slurry has high microbial digestibility, incorporating it in animal feed is also expected to bring a high nutrient conversion in livestock.

In a study conducted by Inaoka *et al* (2017), it was reported that the broiler chicks fed with graded protein supplement of dried maggots showed greater weight gain than the control group which were fed with starter that is containing soybean as its protein source. This suggested that the maggot-containing feed had an enhanced nutrient composition when compared to the soybean starter feed, especially in essential amino acids. It also has greater protein and essential amino acid digestibility. Therefore, it is considered that maggots, which are the secondary products of biologically processed chicken droppings using houseflies, are an appropriate source of protein and energy to help broiler chicks grow and gain weight. Result from the isolation and identification of the organisms found in POS showed the bacterial presence of *Staphylococcus epidermis*. While *Hansenula spp., Debaryomyces spp*. and *Botrytis palmivora* were the fungus present in the POS. These microbes were actively involved in degrading and breaking down of the POS over a particular time frame.

Table 2: Physicochemical Characteristics of Slurry from DS and NDS

Sample Location	pH	WHC (%)	OC (%)	TN (Mg/ l)	AP (ppm)
Site A	6.68^a	36.18^a	3.31^a	14.50^a	28.00^a
Site B	6.65^a	35.94^a	3.24^a	14.48^a	27.91^a
Site C	6.51^a	35.82^a	3.20^a	14.43^a	27.98^a
Control Site	5.75^b	23.01^b	2.58^b	13.03^b	22.02^b
SEM	0.43	1.50	0.20	0.53	1.20

^{a,b}=means on the same column with different superscript differed significantly ($p<0.05$)

WHC= water holding capacity; OC= Organic carbon; TN=Total nitrogen; AP= Available phosphorus

Table 2 presents the physicochemical characteristics of the three oil-palm slurry dump sites A, B, C, and the (control) NDS. The data generated showed that the physicochemical characteristics of soils at dump sites were altered. This shows that the slurry is biodegradable and non-toxic as its disposal on the soils does not cause any noticeable damage, but significantly increased the soil nutrient levels needed for plant growth (Bek-Nielsen *et al*., 1999). It was also shown that the slurry raises the levels of organic carbon, water holding capacity, total nitrogen, available phosphorus and most especially the pH level of the soils to the range of maximum nutrient availability (Ahmad *et al.,*2003 and Batjes, 2005). This is in agreement with the earlier report which observed that, since no foreign chemicals were added during oil extraction process, palm oil slurry is considered non-toxic to the soil environment and biodiversity (Eze *et al*., 2013). The pH increased due to biodegradation of the slurry by the microorganisms in the dump-sites (Okwute and Isu, 2007). Soil acidity is one the principal factors affecting nutrient availability to plants. Therefore, to trap essential plant nutrients required for optimum crop yield, the soil pH needs to be tending towards alkaline (Chin *et al.,* 2013). The major nutrients (Nitrogen, Potassium and Phosphorus) cannot effectively promote high crop yields if the soil pH is too acidic. At pH values less than approximately 5.5, toxic levels of these elements may be present in the soil. Soils have a near-neutral pH (unless the soil is used for growing acid-loving crops). In fact, most crops grow at a pH between 6.5 and 7.5 (Hajek *et.al*, 1990).

The organic matter of a soil is usually determined and reported as a measure of the organic carbon (OC) concentration in the soil as reported by Nelson and Sommer (1982). Organic matter content of a soil, strongly affects its fertility by increasing the availability of plant nutrients, improving the soil structure and the water holding capacity (WHC) (Agi, 1980). Hence, there is always a positive correlation between OC and WHC of a particular soil sample. However, the organic carbon concentration can also act as an accumulation phase for toxic, heavy metals in the soil environment (Deiana *et al.*, 1990). For this reason, the recycling of organic wastes through their application to the soil can be an important promising practice for agricultural activities (Okwute and Isu, 2007).

Table 3: Mean Count of Microorganisms Isolated from different Slurry Dump Sites and a Non-dumpsite

Sample Location	THBC	THFC	HUBC	HUFC	NBC
	Log_{10}cfu/g/ Log_{10}cfu/mL				
Site A	8.28^{a}	4.18^{b}	6.02^{a}	3.15^{a}	2.93^{b}
Site B	8.00^{a}	4.00^{b}	5.98^{a}	3.00^{a}	2.89^{b}
Site C	8.20^{a}	4.16^{b}	6.01^{a}	3.15^{a}	2.92^{b}
Control Site	6.89^{b}	8.01^{a}	2.53^{b}	2.73^{b}	3.84^{a}
SEM	0.35	0.21	0.40	0.15	0.02

^{ab}= means on the same column with different superscript differed significantly ($p<0.05$)

THBC = Total heterotrophic bacteria count; THFC = Total heterotrophic fungi count; HUBC = Hydrocarbon utilizing bacteria count; HUFC = Hydrocarbon utilizing fungi count

NBC = Nitrifying bacteria count.

Table 3 shows the mean count of microorganisms isolated from the 3 slurry dump sites and a non-dump site. The mean counts of microorganism for palm-oil slurry dump sites were similar. Total heterotrophic bacterial count (THBC) ranged significantly ($p < 0.05$) from 6.89 - 8.28 log_{10}cfu/g in NDS and DS respectively. Similar trend was observed for hydrocarbon utilizing bacteria (HUBC) and fungi counts (HUFC), they ranged from 2.53 - 6.02 log_{10}cfu/g and 2.73 - 3.15 log_{10}cfu/g respectively. These values are in agreement with the report of Eno *et al*., (2017). The total heterotrophic fungi count and nitrifying bacteria count ranged from 4.00 to 8.01 log_{10}cfu/g and 2.93 - 3.84 log_{10}cfu/g respectively. It was observed that all the non-dump sites had higher fungal count compared to the dump sites; the implication of this is that, palm-oil slurry had a negative effect on the fungi growth (Eno *et al*., 2017). The high concentration of slurry at dump sites together with excess water could have suppressed the growth of microbes; meanwhile the slurry pH could also be implicated in this case (Nwago and Okolo, 2011). The microbial bio-load of the palm-oil slurry dumpsites was significantly higher than that of the non-dumpsite ($P < 0.05$) and may also be attributable to higher organic matter in the dumpsites A, B, C and a more favourable pH for them.

Table 4: Physicochemical Properties of Oil Palm Slurry Dumpsites over a period of 5 years

Parameters	Year 1	Year 2	Year 3	Year 4	Year 5
BOD	255	550	1200	2500	5000
COD	500	1500	4500	6000	8000

Total solids	500	1500	2000	3000	4000
Suspended solids	400	400	600	800	1000
Oil and grease	50	50	75	100	150
T °C	45	45	45	45	45

Table 4 shows the physicochemical properties of the slurry dumpsites over five years. It was observed that continuous dumping of POS has detrimental effect on soil nutrients as it increases its BOD and COD over the five-year period. Furthermore, Malaysia, being one of the highest producers of world palm oil and hence POS, has set BOD level of 100 g/L as being detrimental to the soil. This has also been reported by Ahmad *et al* (2003). The microbes boycott the aerobic metabolic routes to embrace the anaerobic pathway, thereby breaking down the complex triglycerides chain in POS in order to make oxygen available for the metabolic activities of the microorganisms, this was corroborated in the findings of Mohammadreza, *et al*., 2014 and Nwuche, C.O., Aoyagi, H., Ogbonna, J.C., (2014). Although, the progressively high COD values recorded in this work is an indication that intense microbial activities are reported and could have assisted the breakdown of the complex fibrous particles of the POS, thereby making the nutrients in it more available when fed to animals. Since COD is an important aspect to estimate the organic content of POS. Large quantities of water are used during the extraction of crude palm oil from the fresh fruit bunch, and about 50 % of the water results in POS production. The disposal of this very contaminating effluent is turning into a noteworthy environmental issue and global monitoring would be recommended.

Conclusion

The effect that palm oil slurry had on soil properties would rather help farmers, mostly in the rural areas to improve soil fertility in order to boost crop production. Additionally, increasing the farmers' understanding on the importance of palm oil slurry (POS) to soil's physicochemical properties and proper application of required quantities of the slurry to the soil will enhance their farming skills and productivity (Oswal, et al., 2002). It is also important to let farmers know that slurry should be properly treated before discharge into the environment to avoid impacting negatively on the environment due to its acidic content and a very high biochemical oxygen demand. The proximate result also indicated that the slurry can be left to stand for 2-3 days to enhance maggot built-up, which in turn, improve the crude protein content before incorporating into animal feed; as it technically and sufficiently boost the neutral detergent fibre content of the feed.

References

Agi F.I. (1980). Oil palm improvement in Igalaland In: B. Dawtrey (ed.) Elaeis: A Journal of Igalaland, 2 (2): 8-11.

Ahmad A, Ismail S, Bhatia S (2003): Water recycling from palm oil mill effluent (POME) using membrane technology. Desalination, 157:87-95.

AOAC (2012): Official methods of Analysis, 19th ed. (Association of Officials Analytical Chemists, Arlington, VA) Pp. 69- 88.

APHA (2005): Standard Methods for the Examination of Waste water, American Public Health Association, Washington DC, USA.

Batjes N.H. (1996). Total carbon and nitrogen in the soils of the world. European J. of Soil Sci. 47 (2): 151-163.

Bek-Nielsen, C., Singh, G, & Toh, T.S. (1999). Bioremediation of Palm Oil Mill Effluent. In: Proceedings Porim International Palm Oil Congress 16th February 1999, Kuala Lumpur, Malaysia.

Chin, M.J., Poh, P.E., Tey, B.T., Chan, E.S., Chin, K.L., (2013). Biogas from palm oil mill effluent (POME): opportunities and challenges from Malaysia's perspective. Renew. Sustain. Energy Rev. 26, 717e726.

Deiana, A.M., Salvadori, S. and Cau, A. (1990) The Characterization of Somatic Chromosomes of Gymnothorax unicolor (Delaroche 1809) by C-banding and NOR staining (Osteicgthys, Anguilliformes) Genetica; 81:17 – 20.

Eno, E.O., Antai. S. P. & Tiku, D. R. (2017). Microbiological and Physicochemical impact of Palm Oil Mill Effluent on the Surrounding Soil at Selected Location within Calabar and Uyo. Imperial Journal of Interdisciplinary Research (IJIR). 3 (10): 760-773

Eze, V. C., Owunna, N. D. & Avoaja, D. A. (2013). Microbiological and Physicochemical Characteristics of Soils Receiving Palm Oil Mill Effluent in Umahia, Abia State, Nigeria. *Journal of Natural Sciences Research.* 3 (7): 163 – 169.

Hajek B.F., Karlen D.L., Lowery B., Power J.F., Schumaker T.E., Skidmore, E.L., Sojka T. (1990). Erosion and Soil Properties In: W.E. Larson, G.R. Foster, R.R. Allmaras and G.M. Smith (eds.) Research Issues in Soil Erosion Productivity pp.23-40.

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

Inaoka, T., Okubo G., and Yokota, M. (1999): Nutritive value of housefly larvae and pupae fed on chicken feces as food source for poultry. *J.Pollut. Sci.,* 36, 174 – 180.

Izah, S. C, Tariwari Angaye, C. N. & Ohiimain, E. (2016). Environmental impact of Oil Palm Processing in Nigeria. Journal of Biotechnological Research 2 (3): 132 – 141

Mills, A., Breuil, Lu C. & Colwell, R. R (1978). Enumeration of petroleum degrading marine and estuarine microorganisms by the most probable number method, *Canadian Journal of Microbiology*. 24: 552 – 557.

Mohammadreza Soleimaninanadegani and **Soheila Manshad (2014).** Enhancement of Biodegradation of Palm Oil Mill Effluent by local Isolated Microorganisms. International Scholarly Research Notices, Vol. 2014 Article ID 727049, 8 pages. https//doi.org/10.1155/2014/727049.

Nelson, D.W. and Sommer, L.E. (1982). Total Carbon, Organic Carbon and Organic Matter. Methods of Soil Analysis, Part2. Chemical and Microbiological Properties, 2nd Edition. ASA-SSSA, Madison, 595-579.

Nur, M., (2012). Potential of palm oil mill effluent (POME) as medium growth of Chlorella sp for bioenergy production. Int. J. Environ. Bioenergy 3, 67e74.

Nwago, T. & Okolo, B. (2011). Effects of palm oil mill effluent (POME) on soils bacteria flora and enzyme activities in Egbema. *Plant Products Research Journal.* 12: 10-13.

Nwoko, O.C., Ogunyemi, S., Nkwocha, E., (2010). Effect of pre-treatment of palm oil mill effluent (POME) and cassava mill effluent (CME) on the growth of tomato (*Lycopersicum esculentum*). J. Appl. Sci. Environ. Manag. 14, 67e72.

Nwuche, C.O., Aoyagi, H., Ogbonna, J.C., (2014). Treatment of palm oil mill effluent by a microbial consortium developed from compost soils. Int. Sch. Res. Notices 2014, 8.

Okpokwasili, G. C. & Amanchukwu, S. C. (1988). Petroleum hydrocarbon degradation by Candida species. *Environmental International*. 14: 243 – 247.

Okwute, O.L. and Isu, N.R., (2007). Impact analysis of palm oil mill effluent on the aerobic bacterial density and ammonium oxidizers in a dumpsite in Anyigba, Kogi State. Afr. J. Biotechnol. 6, 116e119.

Oswal, N., Sarma, P.M., Zinjarde, S.S., Pant, A., (2002). Palm oil mill effluent treatment by a tropical marine yeast. Bioresour. Technol. 85, 35e37.

SAS (1999). Statistical Analytical System, SAS/ STAT User's guide, SAS institute Inc., Cary, North Carolina U. S. A.

Van Soest, P. J. (1994). Nutritional Ecology of Ruminants, 2nd edn. Cornell University Press,476 pp.