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Assessment of some Chemical Composition and Physical Properties in Palm Oil Mill Effluent Dumpsites and its Implication on Soil Fertility

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Abstract

Field profile pits were dug in five selected palm oil mill effluent dumpsites in five villages in Mkpat Enin Local Government Area of Akwa Ibom State. The study was aimed at assessing some chemical composition and physical properties. One (1) profile pits were dug in each of the five locations, samples were designated and collected at depths namely; 0 - 20, 20 – 40, 40 – 60, 60 – 80 and 80 – 100 cm, respectively. Data obtained were statistically analysed using descriptive statistics, analysis of variance and Duncan's multiple range test (DMRT). Results showed that effluent was strongly acidic in reaction with mean pH of 4.2 ±0.13 while organic carbon content was 39.45 ± 1.01 gkg^{-1}. The contents of total N was very high with mean of 30.44 ± 0.61 gkg^{-1}, total P level was low averaging 10.42 ± 0.53 mgkg^{-1}) and electrical conductivity was fairly high (1.22 ± 0.16 dSm^{-1}). Palm oil mill effluent soils also had the highest organic carbon content (31.19 ± 6.30 gkg^{-1}), total nitrogen (1.35 ± 0.30 gkg^{-1}) and exchangeable Ca (8.85 ± 2.50 cmolkg^{-1}), Mg (2.95 ± 0.80 cmolkg^{-1}) and K (0.60 ± 0.50 cmolkg^{-1}). It was therefore concluded that application of palm oil mill effluent has adequately increased soil macronutrients.

Keywords: *Chemical composition, physical properties, fertility.*

Introduction

Palm oil mill effluent is one of the major wastes obtained from the oil palm industry and it has the most problematic environmental pollution potential among the palm oil mill wastes (Orji *et al.*, 2006). It is the residual liquid waste product obtained after extraction of oil from the fruits of the oil palm (Orji *et al.*, 2006). Often, palm oil mill effluent is discharged indiscriminately into the environment, particularly on farm lands (Ogboghodo *et al.*, 2001).

During processing, large quantities of palm oil effluents are discharged into the soil. This has been the practice of the people for decades, but little do the people know of the ameliorating effect of this effluent or waste on their soil. Studies have shown that the application of organic wastes (such as effluents, compost and sewage sludge) to soil increases plant growth, and that organic wastes contain considerable amounts of plant nutrients including macronutrients that are beneficial to plant growth (Macci et al. 2009). However, since palm oil mill effluent is organic in nature, it may have tremendous effects on the supply of nutrient elements to soil. According to Odu and Mba (1991), inorganic fertilizers supply nutrient elements through microbial assistance but also help in the improvement of soil physical properties. The characteristics of palm oil mill effluent depend on the quality of the raw material and palm oil production processes in palm oil mills (Osemwota, 2010).

Although agricultural application of palm oil mill effluent is generally considered as being detrimental to soil management due to its toxic effects resulting from the presence of phenol and some organic acids. Chemical fertilizers which are known to increase crop yields on application to soils are sometimes very necessary and mostly unaffordable. Palm oil mill effluent is known to contain some elements that are useful for plant growth therefore, the effluent can be used as supplement and increase crop yield by small holder farmers in the absence of inorganic fertilizer to improve their soil fertility.

Objectives of the Study

The study was aimed at assessing some chemical composition and physical properties in the soils under palm oil mill effluent dumpsites.

The objectives of this study were to:

(i) determine the composition of palm oil mill effluent.

(ii) determine some physicochemical properties of soils impacted with palm oil mill effluent.

(iii) evaluate the fertility level of soils impacted with palm oil mill effluent.

Materials and Methods

Field Studies

Five (5) profile pits were sited within five villages in Mkpat Enin Local Government Area. One profile pit was dug at palm oil mill effluent soil giving one (1) profile pits per location and five (5) profile pits for the five (5) locations studied. The five locations were Miyak Ntak, Ikot Abasi Akpan, Ikot Ekpuk, Ikot Abia Enin and Nyadiong. Each profile pit was described based on designated horizon. The samples were placed in properly labelled polyethylene bags and transported to the laboratory for preparation and analyses.

Laboratory Analysis

The soil samples were air-dried, crushed and sieved using a 2mm sieve; the samples were relabelled and stored for the following analyses:

Particle Size Distribution

Particle size distribution was determined using Bouyoucos hydrometer method (Klute, 1986), sodium hexametaphoshate (calgon) was used as dispersing agent.

Determination of Chemical Parameters of Palm Oil Mill Effluent

Standard methods were used in determining the chemical composition of the raw palm oil mill effluent. The pH of palm oil mill effluent was measured using glass electrode pH meter while the electrical conductivity bridge was used to measure the conductivity. The organic carbon content was determined by dichromate oxidation method of Walkley and Black (Nelson and Sommers, 1996). Total nitrogen was determined using Kjeldahl method (Udo *et al.,* 2009). Potassium was measured by flame analyser, while Ca and Mg were obtained by EDTA (ethylenediamine tetra acetic acid) titration method.

Statistical Analysis

Chemical compositions of palm oil mill effluent were summarized using the descriptive statistics of range, mean, standard deviation and coefficient of variation. A Comparison of the physicochemical properties of five depths of palm oil mill effluent soil was achieved using the analysis of variance and significant means were separated using the Duncan's multiple range test.

Chemical Composition of Raw Palm Oil Mill Effluent

The composition of palm oil mill effluent used in the study from various locations are presented in Table 4.1. The effluent was found to be strongly acidic in reaction with mean pH value of 4.2 ±0.13. Organic carbon content in the five locations studied were similar and ranged from 39.2 to 39.6 g kg^{-1}. Total N levels ranged from 30.1 to 30.5 g kg^{-1}. The contents of total N was relatively high with mean value of 30.44 ± 0.61 gkg^{-1} while available P level averaged 10.42 ± 0.53 $mgkg^{-1}$). The effluent had a mean K content of 48.05 ± 8.1 mgl^{-1}, mean Ca 493.85 ± 141.44 mgl^{-1} and Mg content of 201.71 ± 48.1 mgl^{-1}.

Physical Characteristics of the Palm Oil Mill Effluent Impacted Soil

Particle Size Distribution

The highest concentration of sand in the palm oil mill effluent dumpsite soil were obtained at 0 – 20 cm(937 g kg^{-1}) and 20 – 40 cm(849 g kg^{-1}) soil depths as shown in Table 4.2. The sand concentrations of 40 – 60 cm (818.48 g kg^{-1}), 60 – 80 cm(761.36 g kg^{-1}) and 80 – 100 cm (777.76 g kg^{-1})dumpsite soil depths were equal with that of 20 – 40 cm but significantly ($P \leq 0.05$) lower than that of 0 – 20 cm dumpsite soil depth.

Table 1: Mean chemical composition of palm oil mill effluent

Location	pH	EC (dSm^{-1})	OC (g kg^{-1})	Total N (g kg^{-1})	P (mg kg^{-1})	K (mgL^{-1})	Ca (mgL^{-1})	Mg (mgL^{-1})
MNY	4.3	1.2	39.6	30.4	10.4	48.5	493.8	201.7
IAA	4.3	1.1	39.4	30.3	10.6	47.3	492.0	203.3
IEK	4.5	1.3	39.6	30.1	10.5	47.6	485.9	210.5
IAE	4.1	1.2	39.2	30.3	10.3	48.3	498.1	203.2
NYD	4.4	1.3	39.3	30.5	10.5	48.2	487.3	205.3
Range	4.1 - 4.5	1.1 -1.3	39.2 - 39.6	30.1 - 30.5	10.3 - 10.6	47.3 - 48.5	485.9 - 498.1	201.7 - 210.5
Mean	**4.32**	**1.22**	**39.42**	**30.32**	**10.46**	**47.98**	**491.42**	**204.80**
Sd (±)	0.15	0.08	0.18	0.15	0.11	0.51	4.95	3.43
Cv (%)	3.43	6.86	0.45	0.49	1.09	1.06	1.01	1.68

Sd = Standard Deviation, Cv = Coefficient of variability, OM = organic matter, K Potassium, Ca = Calcium, Mg = Magnesium
Source: Field Data, (2018).

Table 2: Particle size distribution of palm oil mill effluent

Depth of soil profile (cm)	**Sand**	**Silt**	**Clay**
	gkg^{-1}		
		Dumpsite	
0-20	937.00 a	16.16 b	46.84 b
20-40	849.00 ab	79.80 a	71.20 b
40-60	818.48 b	119.12 a	62.40 b
60-80	761.36 b	122.64 a	116.00 a
80-100	777.76 b	97.00 a	125.24 a

Source: Field Data, (2018).

Silt content of 0 – 20 cm dumpsite soil depth (16.16 g kg^{-1}) was significantly ($P \leq 0.05$) lower than those of the lower soil depths and all other soil depths lower than 0 – 20 cm depth had silt contents that were statistically equal.

In the palm oil mill effluent dumpsite, clay content of 60 – 80 and 80 – 100 cm were the highest and did not differ significantly from each other. The upper soil depths (0 – 20, 20 – 40 and 40 – 60 cm) also had equal clay concentrations that were significantly lower than those obtained from the lower soil depths.

Physicochemical properties of palm oil mill effluent soils

Location	Depth	Sand	Silt	Clay	pH	EC	OC	TN	Av.P	Ca	Mg	Na	K	EA	ECEC	BS
		gkg^{-1}	gkg^{-1}	gkg^{-1}		dSm^{-1}	gkg^{-1}	gkg^{-1}	$mgkg^{-1}$	←		$cmolkg^{-1}$			→	%
MNY																
	0-20	928.0	14.0	58.0	6.7	1.67	41.0	1.77	58.67	10.0	3.33	0.19	1.05	1.6	16.17	90.10
	20-40	951.4	8.6	40.0	7.1	0.8	32.3	1.40	56.01	10.0	3.33	0.13	0.73	1.12	15.31	92.68
	40-60	942.8	17.2	40.0	6.2	0.63	38.9	1.68	60.01	4.8	1.60	0.12	0.65	1.12	8.29	86.48
	60-80	764.0	76.0	160.0	6.0	0.37	23.7	1.02	75.37	8.0	2.66	0.07	0.39	1.28	12.4	89.67
	80-100	762.8	37.0	200.2	6.2	0.47	26.2	1.13	66.01	7.2	2.4	0.20	0.46	1.28	11.54	88.90
	Mean	**869.8**	**30.56**	**99.64**	**6.44**	**0.78**	**32.42**	**1.4**	**63.21**	**8.0**	**2.664**	**0.142**	**0.65**	**1.28**	**12.74**	**89.56**
	Sd	97.5	27.6	75.2	0.5	0.5	7.6	0.3	7.7	2.2	0.7	0.1	0.3	0.2	3.2	2.2
	Cv	11.2	90.2	75.4	7.0	65.9	23.4	23.5	12.2	27.2	27.1	37.7	39.6	15.3	24.7	2.5
IAA																
	0-20	942.8	13.0	44.2	5.9	1.37	41.4	1.79	73.34	6.4	2.13	0.14	0.77	1.28	10.72	88.05
	20-40	906.8	5.2	88.0	6.1	0.50	39.5	1.71	60.67	4.8	1.6	0.08	0.41	1.6	8.49	81.15
	40-60	834.8	121.2	44.0	6.4	0.25	29.0	1.25	50.01	8.0	2.66	0.32	1.93	1.28	14.19	90.97
	60-80	762.8	137.2	100	6.1	0.38	25.6	1.11	41.34	14.0	4.66	0.08	0.43	0.64	19.81	96.76
	80-100	726	124.0	150	6.6	0.34	25.6	1.11	22.67	7.2	2.40	0.07	0.37	1.6	11.64	86.25
	Mean	**834.6**	**80.12**	**85.24**	**6.22**	**0.568**	**32.22**	**1.39**	**49.60**	**8.08**	**2.69**	**0.13**	**0.78**	**1.28**	**12.97**	**88.63**
	Sd	92.0	65.2	44.2	0.3	0.5	7.7	0.3	19.2	3.5	1.2	0.1	0.7	0.4	4.3	5.8
	Cv	11.0	81.3	51.8	4.5	80.5	23.8	23.8	38.8	43.5	43.5	76.4	84.6	30.6	33.4	6.5
IEK																
	0-20	942.8	13.2	44	5.7	0.67	41.4	1.79	58.01	8.0	2.66	0.12	0.64	1.6	13.02	87.71
	20-40	906.8	49.2	44	6.6	0.27	30.7	1.33	43.34	8.8	2.93	0.14	0.70	1.44	14.01	89.72
	40-60	720	188	92	6.5	0.35	33.8	1.46	46.01	6.0	2.0	0.11	0.58	1.6	10.29	84.45
	60-80	800	108	92	6.5	0.19	28.1	1.21	52.67	12	4.0	0.1	0.49	0.8	17.39	95.39
	80-100	920	32.0	48	6.2	0.18	26.9	1.16	57.36	10	3.33	0.09	0.45	0.8	14.67	94.13
	Mean	**857.9**	**78.0**	**64**	**6.3**	**0.33**	**32.18**	**1.39**	**51.47**	**8.96**	**2.98**	**0.11**	**0.572**	**1.24**	**13.87**	**90.28**
	Sd	94.6	71.0	25.6	0.4	0.2	5.8	0.3	6.6	2.2	0.7	0.0	0.1	0.4	2.6	4.5
	Cv	11.0	90.9	40.0	5.8	60.6	18.0	18.1	12.8	25.0	25.0	17.2	18.1	33.2	18.6	5.0

MNY = Miyak Ntak, IAA = Ikot Abasi Akpan, IEK = Ikot Ekpuk

Location	Depth	Sand	Silt	Clay	pH	EC	OC	TN	Av.P	Ca	Mg	Na	K	EA	ECEC	BS
		gkg^{-1}	gkg^{-1}	gkg^{-1}		dSm^{-1}	gkg^{-1}	gkg^{-1}	$mgkg^{-1}$	←		$cmolkg^{-1}$			→	%
IAE																
	0-20	920	32.0	48.0	4.0	0.37	39.9	1.72	59.34	10.0	3.33	0.04	0.08	1.60	15.05	89.36
	20-40	760	148	92.0	4.5	0.29	29.4	1.27	72.01	12.0	4.0	0.05	0.16	1.28	17.49	92.68
	40-60	760	148	92.0	5.1	0.17	22.8	0.99	72.01	12.0	4.0	0.05	0.12	1.76	17.93	90.18
	60-80	760	104	136	5.4	0.13	20.9	0.9	64.67	10.0	3.33	0.03	0.13	1.76	15.25	88.45
	80-100	720	144	136	6.1	0.22	30.9	1.34	39.34	10.0	3.33	0.08	0.43	1.60	15.44	89.63
	Mean	**784**	**115.2**	**100.8**	**5.02**	**0.23**	**28.78**	**1.24**	**61.47**	**10.8**	**3.59**	**0.05**	**0.18**	**1.60**	**16.23**	**90.06**
	Sd	78.0	50.1	36.8	0.8	0.1	7.5	0.3	13.5	1.1	0.4	0.0	0.1	0.2	1.4	1.6
	Cv	9.9	43.5	36.5	16.1	40.6	26.1	26.0	21.9	10.1	10.2	37.4	76.3	12.2	8.4	1.8
NYD																
	0-20	951.4	8.6.0	40	7.1	0.80	32.3	1.40	56.01	10	3.33	0.13	0.73	1.12	15.31	92.68
	20-40	720.0	188.0	92	6.5	0.35	33.8	1.46	46.01	60	2.0	0.11	0.58	1.60	10.29	84.45
	40-60	834.8	121.2	44	6.4	0.25	29.0	1.25	50.01	80	2.66	0.32	1.93	1.28	14.19	90.97
	60-80	720.0	188.0	92	6.5	0.35	33.8	1.46	46.01	60	2.0	0.11	0.58	1.60	10.29	84.45
	80-100	760.0	148.0	92	5.1	0.17	22.8	0.99	72.01	12	4.0	0.05	0.12	1.76	17.93	90.18
	Mean	**797.24**	**130.76**	**72**	**6.32**	**0.38**	**30.34**	**1.31**	**54.01**	**8.4**	**2.79**	**0.14**	**0.78**	**1.47**	**13.60**	**88.54**
	Sd	98.1	73.9	27.4	0.7	0.2	4.6	0.2	10.9	2.6	0.9	0.1	0.7	0.3	3.3	3.8
	Cv	12.3	56.5	38.1	11.6	63.7	15.3	15.2	20.1	31.0	31.1	71.4	86.1	17.9	24.4	4.3

IAE = Ikot Abia Enin, NYD = Nyadiong.

Source: Field Data, (2018).

Table 3: Rating of soil fertility in palm oil mill effluent

Soil Characteristics	Palm oil mill effluent soil	Rating
pH	6.06	Moderately acidic
Organic carbon (gkg^{-1})	31.19	Very High
Total Nitrogen (gkg^{-1})	1.35	High
Available P ($mgkg^{-1}$)	55.96	Very High
Exchangeable Ca ($cmolkg^{-1}$)	8.85	Very High
Exchangeable Mg ($cmolkg^{-1}$)	2.95	High
Exchangeable K ($cmolkg^{-1}$)	0.60	Medium
ECEC ($cmolkg^{-1}$)	13.88	High

Values are average of soil properties in five soil profile depths in five locations in the study area

FFD/FMARD, (2012).

Discussion

The study has shown that raw palm oil mill effluent is highly acidic, electrical conductivity and organic matter. The high acidity level of palm oil mill effluent may be attributed to the presence of organic acid produced during the fermentation process (Rupani *et al.*, 2010) and could act as a serious aquatic pollutant if introduced to water bodies (Dhowb *et al.*, 2006). Palm oil mill effluent created environmental problems due to discharge of effluents consisting of low pH, high electrical conductivity, total nitrogen and phosphate contents. The high electrical conductivity of Palm oil mill effluent have been found to alter the chelating properties of receiving water system, thereby creating favourable conditions for metal availability to flora and fauna (Nanda *et al.*, 1999). The high electrical conductivity and low pH can be ascribed to acidic nature of palm oil mill effluent having high available free ion (Singh *et al.*, 2010). The high organic matter content of palm oil mill effluent could be attributed to the microbial degradation of the plant's fibres or palm oil residues. Nitrogen and phosphorus are considered essential or crucial plant nutrients for growth.

Organic C, total N and available P were generally lower in deeper soil depths because when the palm oil mill effluent is discharged into the soil, the surface soil receives most of its content. However, the palm oil mill effluent becomes dissipated as it moves to the lower soil horizons. The concentrations of exchangeable bases in palm oil mill effluent dumpsite soils were higher than the critical levels of >5, >1.6, >0.1, 0.5 cmol/kg for Ca, Mg, K and Na respectively. It could therefore be inferred that palm oil mill effluent soil was high in exchangeable bases compared to the control soil and may support high crop production without further amendment. The high level of exchangeable bases obtained in palm oil mill effluent soils may suggest less saturation of the exchange complex with acidic cations (Al^{3+} and H^{+}). Exchangeable cations showed increased concentrations in the deeper depths of the soil in both the palm oil mill effluent dumpsite and control due to leaching of basic cations down the soil profile.

The effluent also contains macronutrients especially, organic matter and total nitrogen which qualifies as a very useful source of soil amendment for crop production. However, the nutrient status of palm oil mill effluent used in the study was fairly high suggesting that the palm oil mill effluent has the capacity to build soil fertility status. Generally, elemental variability of the effluent is very low as indicated by values of coefficient of variability. The highest value of coefficient of variability was 13.47 % for electrical conductivity which is classified low. It implies that the chemical composition of palm oil mill effluent is almost similar despite the location where there are being produced. Hence, similar result could be obtained from effluent of other locations.

The dominance of sand content in the area is attributed to the sandy parent material from which soils of the area are derived. It has been reported that textures of soils are influenced by the type parent materials from which they were derived (Akamigbo and Asadu, 1983).

Conclusion

The study has revealed that palm oil mill effluent used in the study contained good amounts of plant nutrients which could make them very effective in soil fertility management. Physicochemical properties of soil impacted by palm oil mill effluent were significantly improved the nutrient content of the soil especially organic matter, exchangeable bases and pH. It has also improved the microbial population of the soil which is very essential for decomposition of organic material to release the needed nutrients to the soil.

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