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Effect of spent palm oil processing water on soil properties and maize yield in Abakaliki

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Abstract

The study was carried out to evaluate the effect of spent palm oil processing water on soil properties and maize yield in Abakaliki. A randomized complete block design (RCBD) experiment was set up. The experiment was laid out with 5 replications and 4 treatments - T_1 = 0 kilolitres/ha (control), T_2 = 5 kilolitres/ha, T_3 = 10kilolitres/ha, T_4 = 15 kilolitres/ha. Soil properties studied were particle size distribution, organic C, total N, C/N ratio, pH, available P, exchangeable bases, exchangeable acidity, ECEC and base saturation. Whereas maize parameters studied were maize height, leaf area index and maize grain yield. The results showed that the spent palm oil processing water contribute to decrease in soil productivity which translated to low maize height, leaf area index and maize grain yield. Therefore, spent palm oil processing water despite the fact that it is easily and cheaply available in the study area should not be used as soil amendment since it decreased soil productivity.

Keywords: Fibre; Pollution; Processing; Spent; Wastes

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1. Introduction

Oil palm production in Nigeria has risen from 8.2 million tonnes in 1990 to 9 million metric tonnes in 2001 (FAO, 2002). About 43 – 45% of this is always a mill residue in the form of Empty fruit bunches, shell fibre and palm oil processing water. These residues will continue to accumulate with increasing production (Chan et al., 1980). Efforts are making towards these waste materials by converting these materials into useful products in energy production, animal feed stock and organic fertilizer (Hartlay, 1988).

The process to extract oil requires significant large quantities of water to steam sterilize the palm fruit bunches and clarify the extracted oil (Ahmed et al., 2003). The separated waste water sludge commonly referred to as palm oil mill effluent is brown slurry which is composed of 4 - 5% solid (mainly organic), 0.5 – 1% residual oil and about 90% water and high concentration of organic nitrogen (Onyia et al., 2001). This effluent is a serious land and aquatic pollutant when discharged immediately into the environment (Bek-Nielsen et al., 1999). Beside the presence of lipids and volatile compounds, the inhibitory effects of palm oil effluent on living tissues could also be due to present of water – soluble phenolic compounds (Radzia, 2001). Regardless that palm oil processing water is a pollutant as far as the palm oil industry is concerned, it has enormous potentials for animal feed improvement and soil amendment (Wood, 1977).

Palm oil mills release in tremendous volumes with its attendant polluting potential (Kwon et al., 1989). Therefore, palm oil processing water requires proper management and handling strategies by industries and government authorities (Maleswaran and Singam, 1977). Proper management of palm oil processing water has been poorly practiced in Nigeria as many oil mills dispose their palm oil mill effluent on soils or dump them in special pits that could later drain to surface and ground water.

The main objective of the study was to evaluate the effect of spent palm oil processing water on soil properties and maize yield in Abakaliki.

2. Materials and method

2.1. The study area

The experiment was carried out in Abakaliki Urban which lies at latitude 6°04'N and Longitude 08°6'E in the derived savannah of the South east agro ecological zone of Nigeria. It has a mean annual rainfall of 1700 – 1800 mm. The rainfall pattern is bimodal between April – July and September – November with short spell in August. The minimum and maximum temperature of the area are 27°C and 31°C, respectively (Ofomata, 1995). The relative humidity of the area is between 40 – 80%. The soil belongs to the order Ultisol and is classified as typic Haplustult (Federal Department of Agriculture and Land Resources, 1987).

2.2. Land preparation, experimental design and field layout

The area of the land was measured 15m x 12m for the study and the vegetation was cleared manually and tillage operation was done using traditional hoe. The spent palm oil processing water was uniformly applied in each plots and cover with soils immediately after cultivation.

The area of each plot was 3 m x 2 m and distance between each plot from another was 0.5 m while the distance between each block from another was 1 m. Each treatment was replicated five times using Randomized Complete Block Design (RCBD). Maize seed was planted 2 per hole at the inter and intra row spacing 75 cm and 25 cm, respectively.

2.3. Treatment details

Treatment details are as follows:

T_1 = 0 litre/ha (control – Non-Application of amendment)

T_2 = 5 kilolitres/ha (3 litres/plot)

T_3 = 10 kilolitres/ha (6 litres/plot)

T_4 = 15 kilolitres/ha (9 litres/plot)

2.4. Soil sampling

Auger soil samples were collected 90 days after planting at the depth of 0 – 20cm for soil analysis. These soil samples were properly labeled, air-dried for 3 days, sieved using a 2mm sieve and taken to laboratory for analysis

2.5. Laboratory analysis

The soil samples were analyzed using the following methods:

a. Particle size distribution was determined using Bouyoucous method while soil texture was determine using textural triangle (Agbenin, 1995).
b. Soil pH was determined by the method of Brady and Weil (1990).
c. Organic carbon was determined by the method described by Batjes (1996).
d. Total nitrogen by the method of Bremmer and Mulvancy (1982).
e. Available phosphorus was determined by the method Olsen and Sommers (1982).
f. Exchangeable acidity by the method of Skyllberg (1993).
g. Exchangeable bases were determined by the method described by Oviasogie and Aghimien (2002).
h. Total exchangeable bases (TEB) was the sum of all the exchangeable bases.
i. Exchangeable base was determined by the titration method (Jou, 1979).

j. Effective cation exchange capacity was determined by summation of total exchangeable bases exchangeable and exchangeable acidity
k. Base saturation was calculated as follows: TEB/ECEC × 100,

Where;

TEB = Total exchangeable bases,

ECEC = Effective Cation Exchangeable Capacity.

2.6. Data analysis

The data generated were statistically analyzed using the analysis of variance (ANOVA) and mean values gotten were separated for significant differences using Least Significant Differences (LSD) at probability level of 5% as described by SAS Institute Inc. (1999).

3. Results and discussion

3.1. Effect of spent palm oil processing water on soil particle size distribution and textural class

Table 1 showed the effect of spent palm oil processing water on soil particle size distribution and textural class of the soil studied. The soil studied was sandy loam and there was non-significant ($p < 0.05$) changes in particle size distribution among treatments studied. This non-significant change in particle size distribution showed that the application of spent palm oil processing water do not have effect on particle size distribution. This might be attributed from the fact that particle size distribution is mainly of mineral dependent.

3.2. Effect of spent palm oil processing water on soil pH, available P, Total N, organic C and C/N ratio

Results of effect of spent palm oil processing water on soil pH, available P, total N, organic C and C/N ratio were presented in Table 2. There was a significant ($p < 0.05$) changes among the treatments studied with respect these above parameters. The highest pH value of 5.90 was recorded in T_2. This observed pH value in T_2 was higher than that of soil sample T_1, T_3 and T_4 by 3.39, 1.69 and 3.3%, respectively. The decrease order of available P was $T_2>T_1>T_3>T_4$. Also, the increase order of nitrogen was $T_2<T_3<T_4<T_1$. Organic C was lowest in T_1 (1.34%). This observed organic C in soil T_1 was lower than organic C in T_2, T_3 and T_4 by 2.24, 8.96 and 8.96%, respectively. The order of decrease in C/N ratio was $T_2>T_4>T_1>T_3$.

Table 1. Effect of Spent Palm Oil Processing Water on Soil Particle Size Distribution and Textural Class

Treatment	Sand gcm^{-3}	Silt gcm^{-3}	Clay gcm^{-3}	Textural Class
T_1	492	342	166	Sandy Loam
T_2	482	352	166	Sandy Loam
T_3	482	342	176	Sandy Loam
T_4	472	352	176	Sandy Loam
F-LSD ($p < 0.05$)	NS	NS	NS	

Where: T_1 = 0 litre/ha (control), T_2 = 5 kilolitres/ha (3 litres/plot), T_3 = 10 kilolitres/ha (6 litres/plot), T_4 = 15 kilolitres/ha (9 litres/plot) and NS = Non-significant

Table 2. Effect of Spent Palm Oil Processing Water on Soil pH, Available P, Total N, Organic C and C/N Ratio

Treatment	pH	Available P($mgkg^{-1}$)	Total N (%)	Organic C (%)	C/N Ratio
T_1	5.70	42.60	0.112	1.34	11.96
T_2	5.90	45.90	0.098	1.37	13.97
T_3	5.80	22.50	0.156	1.46	9.36
T_4	5.70	22.10	0.140	1.46	10.43
F-LSD ($p < 0.05$)	0.25	1.96	0.02	0.05	1.23

Where: T_1 = 0 litre/ha (control), T_2 = 5 kilolitres/ha (3 litres/plot), T_3 = 10 kilolitres/ha (6 litres/plot), T_4 = 15 kilolitres/ha (9 litres/plot) and NS = Non-significant

3.3. Effect of spent palm oil processing water on exchangeable bases

Table 3 showed significant ($p < 0.05$) changes on the results of effect of spent palm oil processing water on exchangeable bases. The highest Ca value of 2.00 $cmol_{(+)}kg^{-1}$ was recorded in T_4. This observed Ca value in T_4 was higher than Ca value in T_1, T_2 and T_3 by 20%, 20% and 40%, respectively. The magnesium value ranged between 0.40 – 0.80 $cmol_{(+)}kg^{-1}$ with lowest value recorded in T_1 and T_4 and highest value recorded in T_2 and T_3, respectively. Similarly, potassium recorded the lowest value of $cmol_{(+)}kg^{-1}$ in T_2. This observed K value in T_2 was lower than K in T_1, T_3 and T_4 by 66.67, 100 and 33.33%, respectively while the order of increase in exchangeable Na was $T_2<T_3<T_1<T_4$.

Table 3. Effect of Spent Palm Oil Processing Water on Exchangeable Bases

Treatment	Ca $cmol_{(+)}kg^{-1}$	Mg $cmol_{(+)}kg^{-1}$	K $cmo_{(+)}lkg^{-1}$	Na $cmol_{(+)}kg^{-1}$
T_1	1.60	0.40	0.05	0.250
T_2	1.60	0.80	0.03	0.167
T_3	1.20	0.80	0.06	0.237
T_4	2.00	0.40	0.04	1.176
F-LSD ($p < 0.05$)	1.72	0.53	2.10	2.41

Where: T_1 = 0 litre/ha (control), T_2 = 5 kilolitres/ha (3 litres/plot), T_3 = 10 kilolitres/ha (6 litres/plot), T_4 = 15 kilolitres/ha (9 litres/plot) and NS = Non-significant

3.4. Effect of spent palm oil processing water on TEB, EA, ECEC and base saturation

The effect of spent palm oil processing water on TEB, EA, ECEC and base saturation is as shown in Table 4. There was a significant ($p < 0.05$) changes among the treatments studied with respect to TEB, EA, ECEC and base saturation. Control recorded the lowest TEB value of 2.29 $cmol_{(+)}kg^{-1}$ while that of treated plots ranged between 2.30 – 3.61 $cmol_{(+)}kg^{-1}$. The order of decrease in exchangeable acidity was T1<T2<T3<T4. Also, the effective cation exchange capacity recorded the highest value of 2.94 $cmol_{(+)}kg^{-1}$ in T_4. This observed value of effective cation exchange capacity in T_4 was higher than the value of effective cation exchange capacity in T_1, T_2 and T_3 by 16.21, 2.35 and 13.59%, respectively. The order of increase in BS was $T_4<T_3<T_2<T_1$.

Table 4. Effect of Spent Palm Oil Processing Water on TEB, EA, ECEC and Base saturation

Treatment	TEB $cmol_{(+)}kg^{-1}$	EA $cmol_{(+)}kg^{-1}$	ECEC $cmol_{(+)}kg^{-1}$	BS (%)
T_1	2.29	0.16	2.46	93.09
T_2	2.60	0.24	2.87	90.59
T_3	2.30	0.25	2.54	90.55
T_4	3.61	0.32	2.94	81.44
F-LSD ($p < 0.05$)	0.95	0.03	1.32	7.96

Where: T_1 = 0 litre/ha (control), T_2 = 5 kilolitres/ha (3 litres/plot), T_3 = 10 kilolitres/ha (6 litres/plot), T_4 = 15 kilolitres/ha (9 litres/plot), NS = Non-significant, TEB = total exchangeable bases, EA = exchangeable acidity, ECEC = Effective cation exchange capacity and BS = Base saturation

3.5. Effect of spent palm oil processing water on maize height, leaf area index and grain yield

The effect of spent palm oil processing water on maize height, leaf area index and grain yield is presented on Table 5. There was a significant ($p < 0.05$) changes among the treatments studied with respect to maize height, leaf area index and grain yield. The highest plant height of 83.40 cm was observed in control. This plant height observed in control was higher that plant in T_2, T_3 and T_4 by 12, 6 and 4%, respectively. The order of increase in leaf area index grain yield was $T_4<T_3<T_2<T_1$. This showed that the higher the application of spent palm oil processing water the lower the maize height, leaf area index and grain yield.

Table 5. Effect of Spent Palm Oil Processing Water on Plant Height, Leaf Area Index and Grain Yield

Treatment	Maize height (cm)	Leaf area index	Grain yield (tons/ha^{-1})
T_1	83.4	4.86	24.8
T_2	73.1	4.71	22.3
T_3	79.8	4.50	21.1
T_4	80.4	4.16	20.0
F – LSD ($P < 0.05$)	8.00	0.15	5.00

Where: T_1 = 0 litre/ha (control), T_2 = 5 kilolitres/ha (3 litres/plot), T_3 = 10 kilolitres/ha (6 litres/plot), T_4 = 15 kilolitres/ha (9 litres/plot) and NS = Non-significant,

4. Conclusion

The results showed that spent palm oil processing water did not improve soil properties and maize yield. Spent palm oil processing water decreased soil productivity which is translated low crop yield. The disposal of this waste in agricultural soils should be avoided since this kind of waste is a pollutant.

It is recommended that proper use and safe disposed of spent palm oil processing water in the land environment could lead to improvement in aesthetic environment and soil fertility.

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