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Impact of Palm Oil Mill Effluent (POME) on Soils in Isialangwa, Abia State, Nigeria

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Abstract

The soil physico-chemical properties and enzyme concentrations in soils receiving palm oil mill effluent (POME) in communities in Isialangwa, Abia State were investigated. Results show that there were significant increase in the activities of urease, hydrogen peroxidase, lipase, alkaline phosphatase and acid phosphatase in the soils receiving POME relative to the control site. Soil temperature, organic carbon (OC), organic matter (OM), exchange acidity (EA) were significantly higher in the POME impacted soils. Peak values for nitrate (NO_3), sulfate (SO_4) and phosphate (PO_4) were 5.74, 2.67, and 24.60% respectively. The results suggest that the soil is not suitable for agricultural activity but that the POME could aid soil mineralization if properly and moderately administered.
Key words : Palm oil mill effluent, Soil, Impact, Mineralization.

Environmental pollution problems are global issues due to the devastating effects of toxic pollutants on both non-living and living environment (1). Oil palm (*Elaeis guineensis*) is among the most economically viable plants in the developing countries such as Nigeria and Malaysia (2). The process of palm oil extraction is generally left in the hands of peasant farmers who use mainly crude and laborious methods of extraction (3). However some palm oil mills that process faster and large quantities have been established by few individuals. Palm oil mill effluent (POME) is the residual liquid waste product obtained after extraction of oil from the fruits of the oil palm; it is a colloidal suspension of water and unrecovered oil (4, 5). The POME is usually discharged on the surrounding soils around the plam oil mills. There is a growing interest on the changes in soil physico-chemical and enzymatic structure and diversity due to land pollution (6—8). These changes in soil enzymes result in changes in soil activities and functions. The soil activities and fertility are based on the soil microbial enzymes as the activities are mainly biogeochemical in nature (6, 9—11). Most of the enzymes involved in soil functions and fertility are the oxidoreductase group involving the dehydrogenase, phosphatase, urease and lipase (12, 13). Soil enzymatic activities and physico-chemical properties are directly related to soil functions and thus could be explained in terms of soil health with reference to pollution and usage (6, 14). This work reports the physico-chemical properties and some enzyme activities in soils receiving palm oil mill effluents in Isialangwa area of Abia State, Nigeria.

Methods

The study area is Isialangwa North Local Gevernment area of Abia State, Nigeria. The areas lie between latitude 5°15´ S and 5°30´ N and longitude 7°15´ W and 7°33´ E with tropical climatic conditions. The population is dominated by peasant farmers with cassava, yam and plam plantation as the major crops planted.

Soil Samples and Description

Soil samples were collected from four POME polluted sites and a control site at two different depths (0—15 and 15—30 cm) respectively. Each zone in the study area and control was divided into four quadrants. Soil samples at a depth of 10—15 cm (top soil) and 15—30 cm (subsurface soil) were collected at ran-

Table 1. Soil characteristics of the various soil samples examined. Values are means ± standard deviations of triplicate determinations. Values in the same row with same superscripts are not significantly different at 5% level ($P<0.05$).

Soil characteristics	Sites I	II	III	IV	Control
pH	8.90 ± 0.01[e]	8.70 ± 0.01[d]	8.50 ± 0.01[c]	8.30 ± 0.01[b]	6.90 ± 0.01[a]
Temperature	29.0 ± 0.01[b]	31.0 ± 0.01[d]	32.0 ± 0.01[e]	30.0 ± 0.01[c]	27.0 ± 0.01[a]
Organic carbon (%)	0.280 ± 0.001[b]	0.938 ± 0.002[e]	0.799 ± 0.01[d]	0.719 ± 0.001[c]	0.079 ± 0.001[a]
Organic Matter (%)	0.484 ± 0.002[b]	1.623 ± 0.002[e]	1.381 ± 0.002[d]	1.243 ± 0.002[c]	0.137 ± 0.002[a]
Moisture content (%)	21.52 ± 0.10[b]	49.29 ± 0.01[e]	31.22 ± 0.02[c]	37.01 ± 0.02[d]	18.80 ± 0.001[a]
Exchange acidity	0.89 ± 0.03[d]	0.33 ± 0.01[b]	0.13 ± 0.01[a]	0.71 ± 0.01[c]	0.04 ± 0.02[a]
Sulfate (%)	5.51 ± 0.07[bc]	5.74 ± 0.02[bc]	2.35 ± 0.11[ab]	0.52 ± 0.02[a]	0.43 ± 0.01[a]
Phosphate (%)	22.10 ± 0.002[d]	20.79 ± 0.001[c]	24.60 ± 0.004[e]	17.83 ± 0.03[b]	15.74 ± 0.003[a]
Nitrate (%)	4.34 ± 0.03[d]	5.14 ± 0.03[e]	4.20 ± 0.01[c]	3.08 ± 0.02[b]	1.52 ± 0.02[a]

dom from each quadrant by using a metal auger. The samples collected were pooled for each depth and mixed to ensure homogeneity. Samples were taken and kept in plastic bags. The samples were transported down to Abia State University, Uturu laboratory, kept immediately in refrigerated coolers to arrest microbial growth. Some physical and chemical properties of the soil samples were analyzed. These include pH, moisture, organic carbon and total nitrogen contents. Others were total phosphorus and potassium. These analyses were done according to the methods of Tabatabai (15) as modified by Li et al. (6).

Physico-chemical Parameters

The physico-chemical parameters measured include pH, temperature, sulfate (SO_4), phosphate (PO_4), nitrate (NO_3). The pH and temperature were measured *in situ* using multipurpose tester (Jenway, HANNA 1910 model). The SO_4, PO_4 and NO_3 were determined using the spectrophotometric method with HACH/DR/2010 spectrophotometer.

Soil Enzymatic Activities

The enzymes whose activities were analyzed include urease, hydrogen peroxidase, lipase, acid phosphatase and alkaline phosphatase. The urease activity was determined by the colorimetric method based on the formation of NH_3-N in the urea amended soil samples (after 24 h incubation at 37 C). This was expressed as mg NH_3-N/g dry soil 24 h (16, 17). Soil hydrogen peroxidase activity was estimated with titration method according to Alef and Nannipieri (18). Methanol extract of 5.0 g of the dried soil was obtained by allowing the soil samples and 10 ml of methanol to stand for about 30 min after vigorous shaking. Exactly 20 ml of the extract was pipetted into a conical flask and acidified by adding 5 drops of dilute sulfuric acid. Two drops of methylene blue indicator was added and the content of the flask was titrated against 0.1 ml $KMnO_4$ until solution turns light purple. The lipase activity was determined according to the method of Macedo et al. (19). Exactly 5.0 g of the dried soil sample was amended with 1 ml of 0.02 M phosphate buffer (pH 7.0), 0.5 ml of 0.3 M $CaCl_2$ solution and 0.5 ml of olive oil emulsion. The mixture was incubated at 40 C for 40 min and the reaction was stopped by the addition of 10 ml fo acetone-ethanol mixture (1 : 1). The sample mixtures were titrated with 0.02N NaOH solution to neutralize the liberated fatty acids using phenolphthalein as indicator. Blanks were prepared using reagent mixture and titrated as described above. The activities of acids phosphatase and alkaline phosphatase were determined as described by Tabatabai and Bremear (20) involving the use of nitrophenyl phosphate.

Results

Results of the soil characteristics are shown in Table 1. There was noticeable increase in the pH of the polluted sites compared to the control. The pH of the polluted sites tends towards alkalinity while the control site was almost at neutral point. Temperature was uniformly higher at the polluted sites. Statitical analysis ($P<0.05$) show that percentage organic carbon, organic matter and percentage moisture content were higher at the polluted sites. The exchangeable acidity, SO_4, PO_4 and NO_3 were also significantly different in the polluted sites and lowest at the control site. The soil enzymatic activities are shown in Table

Table 2. Soil enzymatic activities in the POME receiving soils and control. Values with the same subscripts for each enzyme are not significantly different.

	Sites				
Enzymes	I	II	III	IV	Control
Acid phosphatase (mg/g dry soil/h)	0.97^{b}	2.39^{a}	2.54^{d}	1.97^{c}	0.61^{a}
Alkaline phosphatase (mg/g dry soil/h)	1.68^{b}	2.55^{d}	2.62^{e}	2.41^{c}	1.10^{a}
Urease (mg/g dry soil/h)	1.45^{b}	4.14^{d}	4.29^{e}	2.92^{c}	1.01^{a}
Hydrogen peroxidase (mg/g dry soil/h)	0.85^{a}	3.99^{d}	4.12^{e}	2.17^{c}	0.94^{b}
Lipase (mg/g dry soil/h)	1.43^{b}	4.05^{d}	4.41^{e}	3.15^{c}	1.13^{a}

2. The effluents increased the activities of the enzymes analyzed. Generally the lowest enzymatic activity values were observed in the controlled sites. Statistical analysis using ANOVA (P>0.05) show that there were significant differences in the enzyme activities of the polluted sites and control. The most sensitive enzymes were urease, hydrogen peroxide and lipase which had the peak values of 4.29 mg/g, 4.12 mg/g and 4.41 mg/g respectively at the polluted sites.

Discussion

The results show that the soil physico-chemical properties changed noticeably with the impaction of plam oil mill effluent (POME) on the soil. The temperature of the polluted soils though lower than the Federal Environmental Protection agency and the Department of Petroleum resources (DPR) interim effluent limitation guidelines for petroleum exploration and production industries are higher than that of the control sites. They are also higher than the values reported by Onyeike and Ogbuja (21) for Ogoniland and Isiokpo by Osuji and Adasin (22). However, the values observed in this study were similar to that reported for industrial effluents by Alabaster and Lloyd (23).

Soil pH increased in the polluted soil sites compared to the control site. The elevated pH values observed in the polluted soil could be ascribed to the decaying organic matter which release ammonia into the soils. There were significant increases (P>0.05) in organic carbon and organic matter of the polluted sites, these may be attributed to the metabolic processes following POME discharge that facilitates agronomical addition of organic carbon thereby increasing the carbon mineralizing capacity of the microflora. High organic matter content may strongly affect the soil fertility by increasing the availability of plant nutrients (24).

The higher percentage moisture content of the POME receiving soils compared to the control sites is a good approximation of the higher water content of POME and suggests abundance of mineralization products from organic matter as a results of roles of moisture on the microbial diversity (25). The effects of POME on the sulfate phosphate and nitrate also varied significantly (P>0.05) with the control values. The percentage phosphate was more abundant which is a good evidence that suggests that phosphorus is the dominant element controlling carbon and nitrogen immobilization (4) and this equally agrees with the observation of Yeop and Poop (26) that land application of POME improve soil fertility.

The findings of the enzymatic activities in the polluted sites and control seem to be supportive evidence to the outcome of the physico-chemical property analyses reported earlier. The high values of the parameters moisture, organic matter, phosphate and nitrate at the polluted sites than their corresponding control is a clear implication of the biogeochemical disposition of soil enzymes at these sites. This agrees with Orji et al. (2) that organic matter encourages microbial diversity and enzymatic activities which reflects that soil enzymes are of classical microbial origin (27). The sensitivity of urease has resulted in their extensive use in pollution studies (6).

Lipase, hydrogen peroxide, urease, acid phosphatase and alkaline phosphatase positively correlated with POME impaction that is higher POME higher enzymatic activities. The pollution of soil with POME increased soil enzymatic activities. This resulted in high microbial prevalence and diversity which in turn affected the activities of the enzymes analysed. This work therefore agrees that soil enzymatic activities could be used to access soil health or quality (16). More so the addition of small quantities of organic matter could activate soil enzymatic activities (28). This was observed in this work as the enzymatic activities of the impacted soils was uniformly higher than the control site. This observation therefore indicated that small quantities of the POME could be discharged into the farmlands at different points in small amounts to increase soil enzymatic activities.

In conclusion, the POME impaction caused adverse effects only on some physico-chemical properties but encouraged enzymatic activities. This suggests that POME could aid soil mineralization if properly and moderately administered.

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