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Assessment of African Oil Palm (*Elaeis guineensis* JACQ) effluents on the soil, water and floristic diversity in Ituk Mbang, Uruan Local Government Area, Akwa Ibom State Nigeria

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Abstract: ***The impact of African oil palm (Elaeis guineensis, Jacq) effluent on the soil, water and floristic diversity in Ituk Mbang, Uruan, Akwa Ibom State was conducted to assess changes on soil, water constituent profile and plant occurrence in and around the oil mill. Results obtained shows that the palm oil site (location 3) located upstream had the highest electrical conductivity (299.00 µs/cm) in water and (0.116 ds/m) in soil samples. Total dissolved solids were also highest in water around oil mill site. The geochemical indices of the five metals (Pb, Cd, Fe, Zn and Ni) ranged between 0.418-800.08 in soil and 0.009-3.66 in water. Also, results show average pH values across the three sampling sites, with decreasing acidity of 6.0 (palm oil mill site) to 5.5 (Stream 1). The resultant effect of increased acidity and alkalinity, inclusive chloride ions found within the oil mill sites samples could have an effect on the nutrient status of crops and vegetation around the mill area, with cascading influence on down- stream ecosystems. Thus, proper environmental education on pretreated palm oil effluent and by-products is advocated for project community and similar palm oil producing communities. Ultimately, this will protect the health of both humans and their ecosystem.***

Keywords: Geochemical indices; Ecosystem; Acidity, Alkalinity.

1. Introduction

Small-scale palm oil mills are ubiquitous in Nigeria, particularly in the humid south climes, where there is prolific presence of the African oil palm (*Elaeis guineensis*) plantations. These plantations are important economic base for rural livelihoods as most households across the region utilize the oil for cooking. Internationally, they are fast gaining recognition as biofuels [1], thus their role in land-use management and environmental change is important. Generally, untreated effluent discharges have dire consequences on biodiversity as they affect physicochemical properties such as pH and temperature of soil and receiving water bodies. This is evident in the literature on crude oil mining activities and biodiversity [2]- [4]. But, the effect of palm oil effluent on ecosystem dynamics and pollution is under emphasized, perhaps based on available information on its role in environmental pollution. However, its soil amendment properties abound in literature with the view of utilizing controlled palm oil effluent as fertilizers [5]-[6]. Palm oil effluent from small-scale mills is mainly untreated. This is discharged directly into the environment of which water and soils are major recipients [7]. The physicochemical properties of soil for instance, are critical in determining nutrient availability to plants in any ecosystem and consequently the health of the ecosystem [8], and diversity of plants. Thus, the current study aimed at evaluating both the soil and water characteristics around an active palm oil mill in contrast to sites away from the mills.

2. Methods

2.1 Study Area

The study area was in Ituk Mbang (4˚55'17.32" N; 8˚02'09.31" E) in Uruan local Government Area of Akwa Ibom State of Nigeria. The estimated terrain elevation above sea level is 49 metres. It is bounded in the North by Nung Ikono Obio, in the South by Ibiaku Ishiet. In the West is Ikot Edun and in the East, Ndon Ebom. The topography of Ituk Mbang is undulated with shallow depression, dry valleys and few running streams. The humus covering much of the land mass produces arable field in the area. Vegetation is highly modified, mainly made up of secondary forest with the African oil palm dominating most landscapes.

2.2 Vegetation and Soil Sampling

Systematic sampling was used in obtaining samples of soil and for the vegetation analysis [9]. Species were sampled in twenty 10m x 10m quadrants, which were spaced at regular intervals of 20m. In each quadrant, plants were enumerated and identified to the species level. Vegetation measurement determined included frequency of plant species, height and density. Also, within each quadrant, a swamp 'corer' was used to obtain soil samples at opposite ends of the quadrants to a rooting of 40cm [6]The soil samples were air-dried and preserved for laboratory analysis. Samples were collected from three different locations within the study area in November, 2014 and transported to the laboratory for analysis.

2.3 Quantitative Determination of Vegetation parameter

The frequency of each species occurrence was calculated using the following formula:

Frequency = number of quadrants in which a specie occurred x 100 divided by total number of quadrants sampled.

The density of the species in the study was estimated by enumerating all woody species ≥ 3m in height present in $100m^2$ quadrants. These trees and shrubs were identified to the species level. The data from the sampling units were used to calculate means and variances of each woody species in each sampling area according to [10]. The mean taken as a proportion of the area of the quadrants to give density in m^2 was multiplied by $10,000m^2$ to give density of stem per hectare [10].

2.4 Physiochemical Analysis of Soil, Water Samples

The pH of soil samples was determined using a pocket pH meter (HANNA HI-98103). Prior to pH measurement, the pH meter was calibrated using a buffer solution of pH 4.01 and pH 7.01 (HANNA HI – 77400P). Temperature readings were measured using a pocket thermometer (HI- 98501). Similarly, Electrical Conductivity was determined using a conductivity meter model (HANNA HI 99300-99301). Other tests using standard methods and procedures [11]- [13] included; Organic carbon, total Nitrogen, Exchangeable bases and acidity, Calcium, Magnesium, Sodium, Potassium, Available Phosphorus and particle size analysis. In addition, the presence of heavy metals was also tested.

3. Results

Table 1 shows the floristic composition of three sampling locations within the study area. Sampling locations are marked by known streams, in parenthesis, within the study area. In location 1 (Idim Ikot), a total of 12 species from 12 families were found. In location 2 (Idim Step), 8 species belonging to 8 families were recorded whereas in location 3 (The Oil mill site, Usung Idim Amayo), 10 species were found from 10 families. The result shows that in location 1, *Bambusa vulgaris* (200 st/ha) and *Pteridium aquaticum* (200st/ha) occurred as the least in terms of numerical strength while *Costus afer* (1500st/ha) dominated the wetland. Also in location 2, A*lbizia zygia* (200st/ha) occurred as the least in terms of density while *Bambusa vulgaris* (1500st/ha) dominated the plot. Contrary to previous instances, location 3 had *Pterocarpus* sp. (400st/ha) occurred as the least in terms of density while *Elaeis guineensis* (2000 st/ha) dominated the plot in this site.

Table 1: Floristic variability of Ituk Mbang Village

Plant Family	Species	Sampling Location (st/ha)		
		1 (Idim Ikot)	2 (Idim Step)	3 (Usung Idim Amayo, palm oil mill site)
ACANTHACEAE	*Asystasia gigiantica* (L.)T. Anders	-	+ (700)	-
	Eremomastax polysperma (Benth) Dandy	-	+ (600)	-
APOCYNACEAE	*Alstonia booneii* De Wild	+ (300)	-	-
ARACEAE	*Colocasia esculenta (L.)* Schott	-	-	+ (600)
	Nephthytis afzelii Schott	-	+ (300)	-
ARECACEAE	*Elaeis guineesis* Jacq.	+ (800)	-	+ (2000)
COMMELINACEAE	*Anielema beniniense* (P. Beauv.) Kunth	-	+ (700)	-
CONVOLVULACEAE	*Ipomea involucrate* P. Beauv.	-	-	+ (800)
COSTACEAE	*Costus afer* Ker Gawl	+ (1500)	+ (400)	-
DENNSTAEDITIACEAE	*Pteridium aqualinum* (L.) Kuhn	+ (200)	-	+ (600)
EUPHORBIACEAE	*Alchornea cordifolia* (Schum & Thonn.) Mull. Arg	+ (300)	-	-
FABACEAE	*Anthonotha macrophylla* P. Beauv.	-	-	+ (600)
	Pterocarpus sp. Jacq.	-	-	+ (400)
	Albizia zygia (DC.) Macbr.	-	+ (200)	-
	Desmodium scorpiurus (Sw.) Desv.	-	-	+ (800)
	Lonchocarpus sp. Kunth	+ (300)	-	+ (700)
MELASTOMATACEAE	*Heterotis rotundifolia* (Sm.) Jac. Fel.	-	-	+ (1800)

MORACEAE	*Musanga cercropiodes* R. Br	+ (400)	-	-
NEPHROLEPIDACEAE	*Nephrolepsis undulata* (Afzel ex Sw.) J. Sm.	+ (400)	-	-
	Nephrolepsis biserrata (Sw.) Schott	-	+ (1200)	+ (1000)
NYMPHACEAE	*Nymphea lotus* L.	+ (600)	-	-
ONAGRACEAE	*Ludwiga decurens* Walt. Syn.	+ (300)	-	-
POACEAE	*Bambusa vulgaris* Schrad. ex J.C.Wendl.	-	+ (1500)	-

Notes: + Present; - Absent

Table 2 shows the mean characteristics of the soil properties of the three locations within the study area. There were consistent pH gradient from Location 1 (5.5) to location 2 (5.6) and then location 3 (6). Calcium was the most abundant cation , while Sodium the least.

Table 2: Physicochemical Characteristics of Soil from Study Area

Parameters	Sampling Location		
	1	2	3
pH	5.5	5.6	6
Electrical conductivity ds/m	0.00	0.110	0.116
Organic matter %	2.5	1.84	2.41
Total Nitrogen %	0.06	0.05	0.07
Available Phosphorus cmol/kg	18.66	2.4	1.66
Calcium cmol/kg	2.8	4	2
Magnesium cmol/kg	1.4	1.6	1.4
Sodium cmol/kg	0.06	0.07	0.06
Potassium cmol/kg	0.1	0.09	0.09
Exchangeable acidity	2.56	2.6	2.3
Effective Cation Exchange Capacities (ECEC) cmol/kg	6.92	8.36	5.85
Base saturation %	63.01	68.89	60.68
Sand %	82.8	66.8	82.8
Silt %	5	13	5
Clay %	12.20	20.20	12.20

Table 3 shows the mean characteristics of water properties gotten from three locations/streams in Ituk Mbang, Uruan LGA, Akwa Ibom State. The table revealed that with respect to parameters analysed, total dissolved solid and acidity was the highest with mean values of 373.00 in location 3. There were consistent pH gradient from location 1(5.60) to location 2 (5.90) and then location 3 (7.30). Electrical conductivity ranged between 7.0 in location 1, 8.00 in location 2 and 299.00? in location 3. Chloride also had high values ranging from 66.17 to 99.20 to 211.79 in locations 1, 2 and 3 respectively. Sodium had the least values sampled with 1.090 in location 1 and 2 and 3.00 in location 3.

Table 3: Physicochemical Characteristics of Water from Study Area

Parameters	Sampling Location		
	1	2	3
pH	5.60	5.90	7.30
Temperature ^oC	28.10	29.00	29.20
Electrical conductivity µs/cm	7.00	8.00	29.00
Dissolved Oxygen mg/l	5.60	6.00	4.00
Biochemical Oxygen Demand mg/l	2.10	3.30	1.20
Total Dissolved Solid mg/l	3.00	3.00	373.00
Acidity mg/l	133.32	159.98	373.00
Alkalinity mg/l	39.99	46.66	199.99
Hardness mg/l	6.80	8.80	4.80
Turbidity mg/l	8.80	8.00	48.00
Chloride mg/l	66.17	99.26	211.79
Sulphate mg/l	15.99	12.95	201.90
Phosphate mg/l	0.160	0.16	2.99
Nitrate mg/l	1.205	1.55	1.56
Ammonium mg/l	11.250	12.50	45.00
Calcium mg/l	19.20	32.00	32.14
Magnesium mg/l	3.84	6.40	8.80
Sodium mg/l	1.00	1.00	3.00
Potassium mg/l	2.40	2.50	5.10

Table 3 shows the heavy metal concentrations in the soil samples analysed.. Iron concentration appears highest in location 3 (palm oil mill site) with Cadmium showing the lowest concentration of the five metals tested in location 2 (Idim Step).

Table 3: Heavy Metal Concentrations in Soil and Water Samples

Metals (mg/kg)	Sampling Location					
	1		2		3	
	S	W	S	W	S	W
Zinc (Zn)	48.40	2.10	50.00	2.08	49.90	4.14
Lead (Pb)	2.17	0.33	1.83	0.25	2.24	3.35
Cadmium (Cd)	0.65	0.01	0.42	0.01	0.67	2.01
Nickel (Ni)	5.77	0.14	4.82	0.23	6.11	4.10
Iron (Fe)	781.66	1.61	790.33	1.81	800.08	5.67

Notes: S – Soil Samples; W – Water Samples

4. Discussion

The vegetation attributes of the ecosystem as represented in Table 1, which shows clearly that the study area supports a good number of plant species, however; the presence of plant species such as *Musanga cercropiodes*, *Elaeis guineensis* and *Bambusa vulgaris* is indicative of high level of human influence on the vegetation profile of the area. Instructively, the plant variation across the three sites within the study area could be related to several factors inclusive elevation, topography and soil. Generally, the physicochemical parameters of the soil show slight variations across the three sites, with the oil palm mill site having the highest pH value of 6. The results for soil characteristics were in consonance with water parameters with the palm oil site (location 3) been more alkaline , perhaps due to biodegradation of the palm oil effluent as noted by several researchers e.g. [14]. The high level of electrical conductivity obtained from the palm oil mill samples corresponds with the total dissolved solid values, indicative of the accumulation of soluble salts and organic matter in the soil from the processes of the oil mill [15].

Overall, water samples values gives a clearer picture of the effect of the oil effluent on biological receptacles. For instance, are the extremely high values of Acidity, Alkalinity, Total Dissolved Solids, Chloride, Sulphate and others (see table 3). The initial acidity nature of raw palm oil mill effluents is of grave consequences on ill adapted micro-flora and fauna [14]. Thus, it becomes important to reclassify palm oil mill effluent discharges under the current national Environmental Impact Assessment (EIA), particularly in communities whose sole industries are Oil mills.

5. Conclusion

Our study has clearly shown the alteration in the physic chemical properties of receiving streams and soils in and around oil mill processing. Since palm oil mill effluent has an initial acidic property, it is therefore advisable that some initial treatment is applied before discharging into surrounding environment. Additionally, the resultant effect of increased acidity and alkalinity, inclusive chloride ions found within the oil mill sites samples could have an effect on the nutrient status of crops and vegetation around the mill area, with cascading influence on down-stream ecosystems. Thus, proper environmental education on pretreated palm oil effluent and by-products is advocated for project community and similar palm oil producing communities. Ultimately, this will protect the health of both humans and their ecosystem. .

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