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Impact of Palm Oil Mill Effluent on River Awemu in Ijero-Ekiti, Ekiti State, Nigeria

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Abstract: *This study was carried out with an emphasis on the effects of palm oil mill effluent (POME) on the quality of River Awemuwater between June 2015 and September 2015. Temperature, pH, turbidity, conductivity, alkalinity, total hardness, total suspended solids, total dissolved oxygen, biochemical oxygen demand, major nutrients (NO_3, PO_4) and heavy metals (Pb, Mg & K) were determined in 32 water samples collected from upper stream and lower stream locations along the river using standard laboratory procedures of APHA (1998). Data obtained were subjected to descriptive statistical analysis. Results showed significant variations in most of the chemical variables amongst the sampled points. Comparison of the variables in both the river and POME samples with the standard limit of WHO and NSDWQ for water and effluent showed great variations in pH, turbidity, temperature, alkalinity, TDS, TSS, TS, Metals & Nutrients. This shows that the river is polluted and not suitable for human use.The need for quality and environmental conservation through sustainable development of rivers in Ekiti State and Nigeria is highlighted.*

Keywords*: Palm Oil Mill Effluents, Awemu River, Pollution, Physicochemical Parameters.*

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I. Introduction

Palm oil industry is one of the main Agro-industries in Nigeria. Sylvester *et al.*(2016) reported that the fifth largest producer of oil palm in the world with domestic production of 930 metric tonnes accounting for about 15% of global output is Nigeria.Oil palm tree (*Elaeisguineensis*) is a tropical & semi tropicalmonoecious plant that bears both male and female flowers on the same tree (Tagoe*etal.,* 2012). Global interests have progressively focused on the environmental impact of economic activities and any other activity with unsustainable impacts to the ecosystem. According to Panapanaam*et al.* (2009),each oil palm tree produces compact bunches of fruitlets per bunch and the process of extracting palm oil requires significant large qualities of water to steam sterilize the palm friut bunches, clarity the extracted oil and for washing and cleaning processes in the mill. The industries producing palm oil has contributed significantly to environmental pollution as a result of large quantities of by-products generated from oil palm extraction processes (Rupani*et al.,* 2010) Edward*et al.* (2015) defined palm oil mill effluent (POME) as the voluminous liquid waste that comes from the sterilization and clarification sections of the oil palm milling process.The effluent, according to Edward*et al.*(2015) contains 90-95% water, residual oil, soil particles, suspended solids and many other polluting materials such as high BOD and colloidal particles. A more serious environmental problem caused by POME reported by Edward*et al.* (2015) was that fresh water bodies receiving POME may become anaerobic, releasing greenhouse gasses (methane and carbon dioxide) that can easily contribute to global warming. It is estimated that for one tonneof crude palm oil produced, 5-75 tonnes of water ends up as POME (Ahmad *et al.,* 2003) The POME with its attendant polluting potentials has adverse environmental impacts including land and aquatic ecosystem contamination and loss of biodiversity.Raw POME consisting of complex vegetative matters is thick, brownish, colloidal slurry of water, oil and solids including about 2% suspended solids originating mainly from cellulose fruit debris. This according to Bek-Nielson *et al.* (1999) has an extremely high content of degradable organic matters, which is due in part to the presence of unrecovered palm oil. Generally, oil palm industries has been a good source of employment around the globe especially in the producing nations and the profitability margin of the enterprise is high (Olumain et al., 2014). Specifically in Nigeria, palm oil mill effluent (POME) from the oil palm industries is a great threat to their surrounding aquatic environment and this has been raising environmental issues (Awotoye*et al.,* 2011). When POME is discharged into aquatic ecosystem, it turns the water brown, smelly and slimy which may kill fishes and other aquatic organisms and deny the human inhabitants of such region assess to good water for domestic uses (Enzemonye et al,, 2007; Okwute et al., 2007; Awotoye*et al.,* 2011). In Ekiti State, like many other palm oil producing states in the southern region, most small-scale industries producing palm oil are sited very close to rivers or streams. POMEs from these small-

scale industries are not treated before they are discharged into the surrounding environment. This however, is the case of Awemu River in IjeroEkiti. RiverAwemu is the major source of water for the people living in Odo-Oye area of IjeroEkiti. Water from this river is used for irrigating the surrounding farm lands and also for other domestic chores. The river also serves as the major source of water to the small-scale Odo-Oye palm oil industry sited near the river. The industry regularly discharges their POME into the river.The objective of the study therefore wasto assess the effect of POME pollution of River Awemu.

II. Materials & Methods

The Study Area

River Awemu is located in Odo-Oyestreet, IjeroEkiti State Nigeria. Activities around the river include palm oil production, farming, washing of clothes and bathing. The town, Ijero-Ekiti lies within the tropical rain forest zone of Southwestern Nigeria. It is located between latitude 7^{O} 49' N & Longitude 5^{O} 42'E (Fig1). The river directly receives regular discharge of effluents from the oil mill.Four sampling points designated as points "A", "B" "C"&"D" were established along the Upper stream and downstream of the river. Samples were collected bimonthly between the months of June 2015 to September 2015. On each sampling day, POME and water samples were collected between 7:00am and 10:00am in the morning.

Water Analyses

For each sampling location, 1 litre of the water sample was collected in 250 mL sterilized polyethylene bottles, stored at 4^{0}C and analyzed. The analyses covered physical and chemical parameters of water samples from each sampling. The qualitative analyses were carried out at the water laboratories of the Federal University of Technology, Akure (FUTA) chemistry department. Temperature of the water samples was determined on-site using mercury –in glass thermometer.Chemical parameters were analyzed using standard laboratory procedures of APHA (1998). Parameters analyzed were pH, Alkalinity, Temperature, TSS, TDS, TS, Dissolved oxygen (DO_2), BOD COD, Chloride, Conductivity, and Nutrients including PO_4 and NO_3. The concentrations ofmetals such as lead, magnesium, sodium and potassium in the water samples were determined with flame atomic absorption spectrophotometer. Descriptive analysis was done to calculate the mean values and standard deviations of the parameters measured. All the results were compared with the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ) values.

III. Results

The statistical comparative analysis of the mean, standard deviation, range and co-efficients of variation of River Awemuwhich were compared with World Health Organization (WHO) and Nigeria Standard for drinking water quality (NSDWQ) were shown in Tables 1and 2

Table 1: Mean and Physicochemical Parameters of POME fromRiver Awemu Compared with WHO & NSDWQ Standard.

Variables	River Awemu Mean± Std	Range	CV%	WHO	NSDWQ
pH	4.35 ± 0.25	4.00 – 50		6.5 – 8.5	6.5-8.5
Temp ^{0}C	36.10 ± 1.96	29.00 – 38.00		30 – 32	30 -32
Turbidity (NTU)	25.06 ± 1.06	21.0 – 29.03		-	-
Alkalinity ($mgCaCO_3$)	156.67 ± 3.18	15000 – 167.00		-	-
TSS (mg/L)	25.23 ± 39.92	17.94 – 30.00		≥ 10	5.00
TDS (mg/L)	96.56 ± 13.63	66.50 – 112.50		5.000 – 10.00	500
TS (mg/L)	121.79 ± 8.55	118.30 – 135.60		50 – 100	ND
Chloride mg/L	42.81 ± 9.94	38.25 – 47.69		-	≥ 1.50
PO_4 (mg/L)	1420 ± 0.70	13.20 – 26.00		350	3.50
DO_2 (mg/L)	2.93 ± 0.44	2.20 – 8.60		4.00	1.00
BOD (mg/L)	20.3 ± 1.44	12.00 – 23.00		3.00	-
COD (mg/L)	18.9 ±0.57	14.00 – 22.60		10	ND
Na (mg/L)	12.65 ± 2.59	7.50 – 19.50		-	-
K (mg/L)	45.07 ± 4.82	34.00 – 51.90		-	-
Mg (mg/L)	11.98 ± 3.94	8.20 – 22.75		0.50	0.20
Pb (mg/L)	0.35 ± 0.01	0.14 – 04		0.05	0.01

Table 2: Mean and Physicochemical Parameters of Water samples from Awemu River Compared with WHO & NSDWQ Standard.

Variables	River Awemu Mean±Std	Range (Min - Max)	CV%	WHO	NSDWQ
pH	6.13 ± 0.25	5.73- 7.90	3.41	6.5-8.5	6.5-8.5
Temp ^{0}C	26.10 ± 1.69	24.00-29.00	6.48	≥ 35	-
Turbidity (NTU)	5.21 ± 0.16	3.00-7.22	417	-	-
Alkalinity ($mgCaCo_3$)	57.67± 228	40.00-79.00	50.77	-	-
TSS mg/L	15.13 ± 2.91	11.50 – 26.10	25.74	≥ 10	5.00
TDS mg/L	72.10 ± 3.12	62.00 – 90.10	14.12	≥ 10	600-10.00
TS mg/L	87.23 ± 403	7500 - 101.30	70.13	5.00-10.00	≥ 5.00
Chloride mg/L	25.10 ± 2.52	18.70-38.20	15.27	0.50	-
PO_4 mg/L	9.85 ± 1.70	7.80-18.10	6.53	3.50	3.50
$DO_2(mgO_2/L)$	13.20 ± 075	10.60-16.00	7.23	4.00	1.00

BOD (mg/L)	5.68 ± 1.35	3.10-9.05	8.52	3.00	-
Na(mg/L)	31.22 ± 2.32	21.10-40.00	10.20	0.20	0.50
K (mg/L)	36.10 ± 2.10	27.25-49.02	11.25	-	-
Mg (mg/L)	18.10 ± 2.00	17.20-23.00	7.90	0.50	0.20
Pb (mg/L)	0.15 ± 0.02	0.12-1.95	1.25	0.05	0.01

The temperature values of River Awemu water samples ranged from 24^0C – 29^0C with a meanvalue of 26.1^0C ± 1.69 while that of the POME ranged between 29^0C-38^0C with a mean of 36.10^0C ± 1.96. It is observed that the overall mean of the water temperature is below the permissible limit of ≥ 35^0C ofWHO while the POME temperature is above the limit. The pH mean values of both the water and POME samples analyzed fell below the WHO recommended limit of 6.5-8.5 POME samples with a mean value of 4.30 ± 0.25 indicated acidity and water samples with a mean value of 6.13 ± 0.25 was also slightly acidic. POME samples were turbid than water samples with meanvalues of 25.06 ± 1.06 (NTU) and 5.21 ± 0.16 (NTU) respectively. The highest value of 29.03 NTU was recorded in the month of ne when the oil production was at the peak The mean values for the alkalinity of both POME and water samples recorded during the study are 156.67 ± 3.18 mgCaO_3/L and 57.67 ± 2.28mgCaO_3/L respectively. The total solid values of the POME sampled ranged between 118.30-135.60mg/L with overall mean value of 121.79 ± 8.5 mg/L. The TS values recorded in water samples ranged between 75.00-101.30mg/L with a mean value of 87.23 ± 4.03. The TS mean value of the water samples fell within the WHO recommended limit of 50-100mg/L while the POME mean value exceeded the limit. The overall mean values of chloride and Phosphate of the water samples which are 25.10 ± 2.52mg/L and 9.85 ± 1.70mg/L and the POME samples which are 42.81 ± 9.94 and 14.20 ± 0.70 respectively exceeded the recommended limits of both WHO and NSDWQ for drinking water. The dissolved oxygen concentration of the water samples during the study ranged between 10.60mgO_2/L-16.00mgO_2/L with mean valueof 13.20 ± 0.75. The POME samples dissolved oxygen concentration ranged between 2.20mgO_2/L to 8.60mgO_2/L with a mean value of 2.93 ± 0.44mgO_2/L. The mean value of POME sample is higher than both the WHO and NSDWQ recommended limit for drinking water. Sodium mean value of 31.22 ± 2.32mg/L water samples than 12.62 ± 2.59mg/L that was recorded in POME samples. Both values exceeded WHO & NSDWQ recommended limits of 0.20mg/L and 0.50mg/L respectively. Magnesium mean value of 18.10 ± 2.00mg/L was higher in the water samples that the POME samples where 11.98 ± 3.94mg/L was recorded. These values however exceeded both the WHO and NSDWQ recommended standards. The overall mean value of lead in water (0.15 ± 0.02mg/L) was lower than what was observed in POME (0.35 ± 0.01 mg/L).

IV. Discussion

The pH of River Awemu during the study period was slightly acidic ranging from 5.73 to 7.90. These values obtained are still within the permissible limit of NSDWQ and WHO of 6.5-8.5. The low pH values recorded in POME samples ranging fromcan be said to be the influence of the activities of the local oil producers around the study area. This observation aligned with that of Ladigbolu, *et al.*, (2011); Awotoye, et al, (2011) and Edward *et al.*, (2015). The discharge of raw palm oil mill effluent into aquatic environment has been reported by several researchers to be detrimental to the aquatic ecosystem. The effluent is acidic forming brownish colloidal suspension characterized by high suspended solids and COD (Olaleye and Adedeji 2005; Molid*et al.*, 1984). This acidic condition have strong effects on water qualities and the general well-being of the aquatic ecosystems as suggested by Ali, *et al.*(2015), Aderinola*et al.* (2009), Edward *et al.* (2015). In an established system, temperature controls the rate of all chemical reactions and affects fish and other organism's growth. It is observed in this study that the overall mean temperature of the water samples (26.10± 1.69^OC) is below the permissible limit 30^OC of WHO. This lower temperature could be related to the effects of shaded trees which receive direct sun radiation in the sampling locations. But that of the POME was higher than the recommended permissible limits of both WHO and NSDWQ…….

Alkalinity was high in all the sampling sites. This indicates that the river is rich in Calcium carbonate ($CaCO_3$) as observed by Igwe and Onyegbado (2007); Awotoye*et al.*, (2011) and Sylvester *et al.*, (2016). The values for biochemical oxygen demand which is higher in POME samples than water samples is an indication of high level of total solids, nutrients and fiber contents from the untreated POME as previously reported by Ali *et al.*, (2012) AND Edward *et al.*, (2015). The values recorded for BOD and DO in the water samples indicates the effects of the environmental organic load on the receiving river water (Mohamadreza*et al.*, 2014). The total suspended solid (TSS) in river is a straight forward measure of particular weight obtained by separating particles from a water sample. The TSS level in the river is higher than the permissible level of WHO and NSDWQ. These solids in water can easily affect water clarity and also decrease the passage of light through water plants (Ohimain*et al.*, 2012) High values of Sodium, Potassium and Magnesium recorded in the water and POME samples is an indication of high pollution from the oil mill and the surrounding local runoffs from nearby streams and farming activities near the river (Adeyemo*et al.*, 2008 and Awotoye*et al.*, 2011).

Lead concentrations in POME and water samples are slightly higher than the recommended standard given by WHO & NSDWQ. The contamination could be as a result of leaded gasoline entering the river through surface run-off. Lead in water is potentially health hazardous and toxic to most forms of life (Rupani*et al.*, 2010). Large concentration of Lead in animals and it has been reported to be responsible for chronic neurological disorders in foetus and children (Lawson, 2011).

V. Conclusion

Since water is a natural resource that touches all the aquatic and terrestrial lives, it is therefore a matter of necessity of the environmentalists to continue the study of the impact of anthropogenic activities on our water resources. This, as the strong reason behind this study has eventually shown that palm oil mill is a strong threat to all rivers and streams receiving the effluents. Due to the high concentration of BOD, metals, and nutrients in POME, discharging the effluents into the environment in its untreated form continuously will pose a big pollution problem for the environment. It is therefore a matter of urgency for the Federal, State and Local government to find a lasting solution to the problem caused by POME.

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