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Impact of Palm Oil (*Elaeis guineensis Jacq; Banga*) Mill Effluent on Water Quality of Receiving Oloya Lake in Niger Delta, Nigeria

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Abstract: Water samples from Oloya lake receiving palm oil mill effluents were characterized and compared with raw palm oil effluents to determine the level of contamination. The ranges of nutrients and heavy metal concentrations in palm oil effluent were 450-590 mg L^{-1} N, 92-104 mg L^{-1}P, 1246-1262 mg L^{-1}K, 249-271 mg L^{-1}Mg, 0.06-0.10 mg L^{-1}Cd, 0.25-0.63 mg L^{-1}Pb, 5.58-6.32 mg L^{-1}Cu and 1.25-1.35 mg L^{-1}Cr while the ranges of concentrations in water were 1.08-1.16 mg L^{-1} N, 0.88-1.02 mg L^{-1} P, 8.65-8.95 mg L^{-1} K, 0.97-1.07 mg L^{-1} Mg, 0.05-0.07 mg L^{-1} Cd, 0.03-0.05 mg L^{-1} Pb, the concentrations of Cu and Cr (0.01 mg L^{-1}) did not vary. POME was found to contain high concentrations of plant nutrients. The concentrations of the parameters were higher in palm oil mill effluents than in the water. Analysis of variance showed significant difference ($p>0.05$) between the levels of the parameters in palm oil mill effluents and water and in minerals and heavy metals. Appreciable levels of the nutrients N, P, K were measured with K as the most prevalent nutrient. The results generally showed that POME has polluting effects and high volumes of such effluents are not fit to be discharged into water bodies.

Key words: Palm oil, effluent, water, nutrients, mill, heavy metal

INTRODUCTION

Palm Oil Mill Effluent (POME) is the final mixed waste stream from the sterilization, clarification and hydrocyclone processes in a typical oil mill. POME is thick brownish slurry with obnoxious odour and highly polluting (Ma, 1993).

Many researchers have shown that POME, in both raw and treated forms, contains very high level of nutrients such as N,P, K and Mg with ranges of 689-948, 152-160, 1300- 1958 and 345-1020 mg L^{-1}, respectively (Lim, 1987; Lim *et al.*, 1984; Tajudin and Zin, 1984; Dolmat *et al.*, 1987).

In Malaysia statutory and non-statutory strategies have been put in place to manage river water quality and monitor pollution from palm oil and rubber industries (Hussin, 1996). Such strategies are however, either lacking or not effective in Nigeria. According to Ma (1993) land application of POME is allowed in Malaysia if the BOD of the effluent is less than 5000 mg L^{-1}. The application of POME to land has been shown to be beneficial to the soil and crops. It has also been established that the water quality in the applied areas is not affected (Dolmat *et al.*, 1987). These may depend on the volume of POME discharged into the water body.

In Nigeria palm oil is processed industrially and locally throughout the oil palm belt stretching from Cross River to Lagos states. The Risonpalm oil mill at Ubima, Rivers state is the largest in Nigeria. In Rural communities in Nigeria individuals and cooperative societies set up local oil mills. In most cases, POME from these local mills is discharged directly untreated on nearby agricultural lands or into surface water bodies. The Oloya lake water which is commonly used for fishing, drinking and other domestic purposes is usually black in colour and covered by grasses and water hyacinths. The effluent could be source of food for fishes like *Clarias anguillaris* and *jaensis* (catfish), *Heterotis niloticus* (African bony tongue) and *Gymnarchus niloticus* (Trunkfish) but may affect the quality of the water for other uses. Thus this study assesses the POME produced and discharged into Oloya lake in Oshika community with emphasis on its influence on the mineral composition and quality of the water. The approach in this study, was to collect and

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characterize both water and POME samples from the local mill using standard methods and comparing with local and international permissible limits.

The study area located in Oshika lies between longitude 6° 56' 59" E and latitude 5° 11' 58" N. The bulky organic waste when discharged into the environment untreated might have serious ecological effects.

MATERIALS AND METHODS

The samples for this study were collected in 2004 and 2005 in Oshika, Nigeria. Samples of fresh POME were collected directly into polyethylene bottles at the discharge point from the oil mill at Oshika. Samples for DO were collected into dark amber bottles and fixed with manganese sulphate solution and alkali-iodide acid reagent and analyzed immediately while samples for BOD were collected into dark amber bottles sealed with aluminum foil and incubated at 20°C for 5 days before analysis. Water samples were collected from the receiving Oloya lake. The water samples were collected at the receiving point and 1 km away along the lake. 0.5 mL manganese sulphate solution and 0.5 mL alkali-iodide acid reagent were added to BOD samples. Twenty five mililiter of the sample mixture was measured into conical flask and 5 mL H_2SO_4 and starch solution were added and titrated with 0.025 N sodium thiosulphate. Similar procedure was used for DO samples. Twenty mililiter sample for COD analysis was measured into a 500 mL conical flask. Boiling chips, 0.4g $HgSO_4$, 10 mL 0.25 N $K_2Cr_2O_7$ solution and 30 mL H_2SO_4 were added fluxed for 3 h. The mixture was cooled and diluted to 140 mL with distilled water. Three drops of ferroin indicator was added and titrated with standard $Fe\ (NH_4)_2(SO_4)_2$ solution. Sample for Volatile Fatty Acid (VFA) analysis was thoroughly mixed and placed into a 250 mL conical flask. The mixture was treated with 50 mL neutralized ethanol, heated to 40°C with a hot plate, swirled gently and titrated with 0.1 N NaOH solution using phenolphthalein indicator. Twenty five mililiter of sample for the determination of alkalinity was measured into a conical flask; methyl orange indicator was added and titrated with 0.02N H_2SO_4. Total nitrogen concentration was determined using the micro -kjeldahl method (Bremner, 1996). Phosphorus determination was done spectrophotometrically, using Bray No. 1 method, modified by Olsen and Sommers (Olsen and Sommers, 1982). Sample for K analysis was shaken with 30 mL 1N ammonium acetate solution for 2 h on a mechanical shaker and determined using a flame photometer while Mg was determined by atomic absorption spectrophotometry. Total solids (suspended and dissolved) were determined by gravimetric method. The sample was filtered through a 0.45 μm membrane filter, evaporated and dried to a constant weight in an oven at 103-105°C. Temperature and pH of POME and water were measured in situ using thermometer and pH meter respectively. One litre of POME or water sample for metal analysis was acidified with 5 mL concentrated HNO_3. Five milliliter 50% HCl was added to 100 mL of the acidified sample and heated for 15 min on a hot plate. The content was filtered into a 100 mL volumetric flask and made up to the mark with deionized water. A buck scientific atomic absorption spectrophotometer was used to determine the concentrations of heavy metals in POME and water samples.

RESULTS AND DISCUSSION

The mean concentrations of the parameters in POME and water samples are presented in Table 1. The table also compares the mean concentrations of minerals in POME and the recipient river water. The trend, N>P<K>Mg observed in the results was similar in both POME and water. This implies that POME contributed to the concentrations of the nutrients in the water.

The pH level was 6.4 in water and 5.4 in POME. This shows that POME is generally more acidic than the water. The acidity of POME could be attributed to its high fatty acid content of 1020 mg L^{-1}. pH has profound effects on water quality. It affects metal solubility, alkalinity and hardness of the water. Aquatic organisms are also affected by pH because most of their metabolic activities are pH dependent (Wang *et al*., 2002; Chen and Lin, 1995). DO was very low in POME. This is attributed to the high level of nutrients and total solids contents in POME. DO indicate the degree of freshness of a river and is very important for the survival of aquatic organisms. The DO level, 6.5 in the water could sustain aquatic lives. In terms of BOD, POME from the mill is polluting with high organic matter content. The level of Total Suspended Solids (TSS) in POME (1620 mg L^{-1}) was significantly higher than the level in water (657 mg L^{-1}). Deposition of solids into the river body could lead to the reduction in the volume of the water and also impede the free flow of the river. Long term deposition of materials in the river could result in flooding, particularly during heavy rainfall which could have both economic and ecological implications (Fakayode, 2005). Heavy metals, Cd, Pb, Cu, Cr were found in POME but only Cd and Pb were appreciably present in the lake. The water from the lake is used for irrigation of food crops in the community because of its high nutrient contents. Accumulation of heavy metals by crops receiving such contaminated water for irrigation is common and metals could be biomagnified along the food chain and hazardous to humans.

Table 1: Physico-chemical parameters of water and palm oil mill effluent

			Permissible limits		
Parameter	Pome	Water	WHO	Malaysia	FMEnv.
BOD_5 (mg L^{-1})	92	25	0.5	100	-
DO (mg L^{-1})	0.5	6.5	4 -12	-	-
COD (mg L^{-1})	9.360	1.265	--	--	--
TDS (mg L^{-1})	2.080	1.850	1500	--	850
TSS (mg L^{-1})	1.620	657	--	400	--
ALK (mg L^{-1})	146	84	--	--	<250
VFA (mg L^{-1})	1020	300	--	--	--
pH (mg L^{-1})	5.4	6.4	6.5-8.7	5.0-9.0	6.5-9.2
Temperature (°C)	35.5	30.5	--	45	--
TN (mg L^{-1})	225	82	--	200	--
N (mg L^{-1})	520	1.12	0.5	150	--
P (mg L^{-1})	98	0.95	--	--	--
K (mg L^{-1})	1254	8.80	--	--	--
Mg (mg L^{-1})	260	1.02	150	--	150
Cd (mg L^{-1})	0.08	0.06	0.01	--	0.01
Pb (mg L^{-1})	0.44	0.04	0.05	--	0.05
Cu (mg L^{-1})	5.95	<0.01	1.5	--	1.5
Cr (mg L^{-1})	1.30	<0.01	0.05	--	0.05

WHO-World Health Organization VFA-Volatile Fatty Acid, FMEnv.-Federal Ministry of Environment, ALK-Alkalinity TDS-Total Dissolved Solid TN-Total Nitrogen, BOD-Biological Oxygen Demand COD- Chemical Oxygen Demand, TSS- Total Suspended Solid

The results are compared with standards and permissible limits set by the World Health Organization (Public Health Service, 1962) and Federal Ministry of Environment (FMEnv., 1991) for water and the Department of Environment in Malaysia for POME discharged into water bodies (Ma, 1993). The concentrations of the metals were generally below the limits, indicating that POME is not the main source of heavy metals in the area. The results further showed that Cd in water and Mg, N, TDS, TSS, BOD and TN in POME exceeded permissible limits. The parameters of POME in the mill significantly exceeded the standards except in the case of temperature. Thus POME from the mill is not fit for discharge into water bodies.

CONCLUSION

POME from palm oil mills contains high levels of nutrients, heavy metals and polluting effects. The acidic pH is ecologically detrimental, as it will increase the acidity of the water leading to harmful effects on aquatic lives and humans. With increased public awareness of environmental pollution and the fact that POME from all the mills are discharged on land and or water bodies, management of mills should both socially and aesthetically treat their effluents before discharge.

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