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PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERISTIC OF PALM OIL MILL EFFLUENT (POME) IN NGURU : ABOH MBAISE, EASTERN NIGERIA

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ABSTRACT

Palm oil mill effluent (POME) is the only liquid discharge from palm oil extraction processes and is considered the most harmful waste for the ecosystem if discharged untreated. Physicochemical and microbiological properties are essential characteristics to be investigated before discharging POME to the recipient environment. The physicochemical properties and microbial composition of fresh and stale samples of palm oil milling effluents (POME) randomly collected at source and from a dump site in Nguru palm oil mill were evaluated using standard methods. Physicochemical characteristics for POME in the study area show gross disparity and far higher than the guidline values for vegetable oil processing industries. Heavy metal concentration in mg/L were (Cd: 0.04-0.06, Fe: 2.85-5.61, Cu: 1.21-1.45, Cr: 1.43-1.77, Ni: 0.68-0.88) and (Cd: 0.02-0.18, Fe: 4.84-6.05, Cu: 1.41-1.41, Cr: 1.28-1.56, Ni: 0.64-0.75) for fresh and stale effluents, respectively. Microbial analysis results indicate that POME contained a variety of microorganisms which include *Aspergillus niger*, *Aspergillus herbarious*, *Aspergillus tamari*, *Bacillus sp*, *Cladosporium sp*, *Fusarium sp*, *Micro cocus sp*, *Nitrobacter sp*, *Paecilomyces sp. Penicillum sp*, *Proteus sp*, *Pseudomonas and Rhzopus sp*. The mean viable counts of microorganisms (cfu/mL) in POME samples ranged from $1.2 \times 10^{-4} - 7.0 \times 10^{-4}$, which indicate relatively low counts of bacteria and fungi in the samples. Biodegradability index, BOB_5/COD ranged from 0.40-0.90 for fresh and stale effluents POME, respectively. The overall results reveal that POME characteristics were far above Environmental Health and Safety guidelines, which indicates unhealthy environment conditions with potential negative consequences for humans and the ecosystem. Therefore, there is a need for environmental agencies and governments to take appropriate preventive measures to avert potential problems due to indiscriminate dumping of POME.

Key words: POME, Oil palm effluent, Biodegradability, Contamination factors, Microorganism.

INTRODUCTION

About 50 percent of the global traded vegetable oil comes from palm oil. The palm oil industry is a major agro-based enterprise in Nigeria especially in the southern part where palm oil trees are found both in the wild and plantations[1].

Oil palm (*Elaeis guineensis*) is vastly cultivated as a source of oil in many parts of Nigeria and has contributed significantly to the economic growth of the country[2]. While palm oil is recognized for its contribution towards economic growth, its rapid development has also contributed to environmental

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pollution corresponding to large quantity of waste products from the oil extraction process. These waste products consist of fibrous materials (such as empty fruit bunches (EFB), palm pressed fibres (PPF) and palm kernel shell (PKS)) and less fibrous materials (such as palm kernel cake (PKC)) and palm oil mill effluent (POME)[3,4]. POME is the only liquid discharge from palm oil extraction processes and contains large quantities of water, which is eventually released into the environment after oil has been extracted.

POME is a colloidal suspension containing 95-96% water, 0.6-0.7% oil and grease and 4-5% total solids. It is a thick, brown liquid with a discharge temperature of between 80°C and 90°C. Large quantities of water are used during the crude oil extraction process. Up to about 1.5 cubic meters of water are characteristically used to process one tonne of fresh fruit bunch. From this quantity, about 50% of the water results in the POME, the other 50% being lost as steam, mainly through sterilizer exhaust, piping leakages, as well as wash waters[5].

In Nigeria the business of palm oil extraction is dominated by peasant farmers who used mainly the semi-mechanized method of extraction[6]. Consequently, the POME generated is discharged into available land near the mill. When the POME has acumulated considerably in the area due to continued deposition, the site is abandoned and fresh space is located. The ecological and pollution hazards associated with this disposal method in streams have severally been reported[7,8].

The raw or partially treated POME has an extremely high content of degradable organic matter, which is due in part to the presence of unrecovered palm oil[9]. Untreated POME contains high amounts of fatty acids, proteins, carbohydrates and other plant materials, which has the tendency of altering environmental parameters particularly BOD, DO, C/N ratio and COD level[10]. This highly polluting POME can cause pollution of waterways due to oxygen depletion, land use and other related effects[11]. Discharged POME on aquatic ecosystem turns the water brown, smelly and slimy and may cause the death of fishes and other aquatic organisms and deny the human inhabitant of such region's assess to good water for domestic uses.

Several palm oil extraction disposal sites have been studied[5-9]; however, no information is available for disposal site of Nguru-Aboh Mbaise, Eastern Nigeria. Therefore, this paper reports the physicochemical properties, heavy metals and microbial qualities of both fresh and stale POME obtained from Nguru village palm oil extraction sites.

EXPERIMENTAL

Material and methods

Site description: The study area is Amaohuru village Nguru of Aboh Mbaise local government area, which is a highly populated community area and lies between latitude 5º 45ˡ N and 6º 35ˡ N and longitudes 6º 35ˡ E and 7º 28ˡ E. The zone has an average annual rainfall of 2500 mm and altitude of about 100 m above sea level.

All chemicals used for this work were analytical grade chemicals purchased from Fin. Lab Owerri and were used without further purification. All glassware and media used were sterilized by autoclaving at 121°C for 15 mins at 15 pounds pressure and air drying in the hot air oven at 160°C for 2 hrs.

Fresh and stale palm oil mill effluents from five palm oil mills randomly selected from dump site coded A and B were collected and analysed separately. Both fresh and stale POME were collected using sterile glass bottles and samples transported to the laboratory using ice-packed coolers after appropriate labellings. The effluent samples for dissolved oxygen and BOD were fixed on the site by adding 1.2 mL each of Wrinkler's solution and taken to the laboratory for other physico-chemical analysis.

Temperature and pH were determined *in situ* according to method of Verla and co-workers[12]. Conductivity was determined with the Lovibond conductivity meter type cm-21 model. Total suspended solid and dissolved solids (mg/L), dissolved oxygen, biochemical oxygen demand, chemical oxygen demand were determined by adapted methods[13,14]. Reduction in Chemical oxygen demand (COD) and the ratio of biological oxygen demand (BOD_5) to chemical oxygen demand have been used as Biodegradability indices was also determined[15-17]. Total nitrogen, nitrate-nitrogen and oil and grease were differentially digested and measured according to Ahmad and co-workers[18].

Heavy metals (cadmium, nickel, copper, iron, chromium) were analyzed after digesting samples in mixture of acids and using Atomic Absorption Spectrophotometer (AAS) (APHA 301A) (Model: 5100 PC, Perkin-Elmer, Boston, USA).

Samples of fresh and old POME were also collected and analysed for their microbial content according to Collins and Lyne[19]. POME samples were serially diluted and 0.1 mL of 1 x 10^{-3} dilution was used for innoculation intriplicate. Bacterial count was determined using nutrient agar (NA) and Mac Coney aga (MCA) while potatoe dextrose agar (PDA) was used for fungal count. All NA and MCA plates were incubated at 37°C for 24 hrs while PDA plates were incubated at room temperature for 2-5 days. Plate count was carried out using, Gallenkamp digital colony chamber of microbial load as colony forming units per mL (Cfu/mL) of the sample was calculated.

RESULTS AND DISCUSSION

Physicochemical characteristics

The data obtained for physicochemical characteristics of POME reported as a mean of triplcate determinations are presented in Table 1. Temperature (°C) for fresh and stale POME ranged between 38 ± 1.7 and 43 ± 2, respectively, while pH ranged from 6.8 ± 0.22 - 8.7 ± 0.28. The temperature and pH are essential factor in the levels of microorganisms in the environment. The slightly basic condition and high temperature of the POME in the area may have resulted in the low counts of microorganisms in the samples, since most organisms do not flourish under such pH values. The pH could also further enhance microbial degradation of the contents of the POME effluents. The conductivity (µs/cm), total nitrogen (NO_3^-, mg/L) and total phosphate (PO_4^{-3} mg/L) levels in the POME investigated were 131 ± 0.41-138 ± 0.56, 6.2 ± 0 38-9.3 ± 0.42 and 19.6 ± 0.21-22.3 ± 0.33, respectively. Total suspended solid (TSS) and total dissolved solids (TDS) in the POME were found to be 58 ± 1.05-188 ± 1.25 mg/L and 43 ± 0.62-48 ± 0.66 mg/L, respectively. Dissolved oxygen levels, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were also investigated. The data show that DO ranged from 2.0 ± 0.21 to 3.2 ± 0.11 mg/L, while values for COD and BOD ranged from 27900 ± 5.11-48648 ± 8.13 mg/L and 19000 ± 2.41-28000 ± 2.22 mg/L, respectively. Comparative analysis of values obtained in this investigation with effluent levels for vegetable oil processing industries as set by U.S. Environmental Protection Agency (USEPA)[20] shows gross disparity with all characteristics far higher than the guidline values.

The Environmental Health and Safety Guidlines for vegetable oil processing are applicable to fascilities that extract and process oil and fats from vegetable sources. It covers crude oil production and refining processes from the preparation of raw materials to the bottling and packaging of final products for human consumption among other uses[21].

Table 1: Physicochemical properties of palm oil mill Effluents (POME) from Nguru mill site in Aboh-Mbaise, Imo State

Physico-chemical property	Sample A		Sample B	
	Fresh	Stale	Fresh	Stale
Temperature (^{0}C)	43 ± 2	38 ± 1.7	43 ± 1.99	41 ± 1.98
pH	8.5 ± 0.21	6.8 ± 0.22	8.7 ± 0.28	7.2 ± 0.37
Conductivity (µs/cm)	138 ± 0.56	131 ± 0.41	137 ± 0.47	132 ± 0.44
Nitrogen (mg/L)	8.5 ± 0.44	6.2± 0 38	9.3± 0.42	6.4± 0.28
Phosphate (PO_4^{-3} mg/L)	22.3 ± 0.33	19.6 ± 0.21	21.8 ± 0.25	18.2 ± 0.31
Total suspended solids (mg/L)	188 ± 1.25	68 ± 1.09	83 ± 1.99	58 ± 1.05
Total dissolved solids (mg/L)	48 ± 0.66	43 ± 0.62	48 ± 0.71	46 ± 0.68
Dissolved oxygen demand (mg/L)	3.2 ± 0.11	2.4 ± 0.27	3.1 ± 0.17	2.0 ± 0.21
Chemical oxygen demand (mg/L)	47200 ± 4.58	27900 ± 5.11	48648 ± 8.13	28660 ± 4.22
Biochemical oxygen demand (mg/L)	19000 ± 2.41	28000 ± 2.22	20090 ± 1.97	26030 ± 2.08

Biodegradability indices

A biodegradability index helps in predicting the measure of chemical stability/resistance to biological degradation of organic pollutant in the environment, which can be evaluated by the biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The strength of wastewater is judged by its BOD. This is defined as oxygen required by bacteria while stabilising the organics in the waste water under aerobic conditions at a particular time and temperature. BOD_5 account for over 70% of the total BOD most of which exist as dissolved organic matter. Chemical oxygen demand (COD) reflects the concentration of organic compounds present in wastewater[22]. COD measures the total quantity of oxygen required for oxidation of organics into carbon dioxide and water and accounts for about 95% of the total organic matter in wastewater.

The biodegradability index (BI) for POME was evaluated using equation 1 and the results presented in Table 2.

$$BI = \frac{BOD_5}{COD} \quad \ldots(1)$$

The organic nature of POME indicates a possiblity of it being biologically degradable but slowly. This corroborates result of biodegradability indices of 0.40-1.0 for sample A and 0.2-0.9 for sample B. BOD to COD ratio reveals the treatability , if the ratio of BOD_5/COD is above 0.5, the wastewater is considered to be highly biodegradable, if less than 0.3, the wastewater is deemed to undergo a chemical treatment before the routine biological treatment[12,13].

Table 2: Biodegradability of fresh and stale POME samples

Indices	Sample A	Sample B
COD reduction	16300	19988
BOD_5/COD.	0.40 - 1.00	0.20-.90

The data on the microbial counts and the different types of bacteria isolated from POME from the study area is presented in Table 3 and 4. The data showed that the POME sample contain a low density of bacterial and fungal flora. Even though, it is expected that more microorganisms will enhance biodegradabilty, the stale POME generally had more microbes than were found in the fresh POME.

Table 3: Mean counts of micro organisms (cfu/mL) in POME samples

Media used	Sample A		Sample B	
	Fresh	Stale	Fresh	Stale
Nutrient agar (NA)	1.2×10^{-4}	4.7×10^{-4}	1.3×10^{-4}	2.1×10^{-4}
Mac Conkey agar (MCA)	1.7×10^{-4}	6.7×10^{-4}	1.3×10^{-4}	2.3×10^{-4}
Potato dextrose agar (PDA)	3.6×10^{-4}	7.0×10^{-4}	3.4×10^{-4}	6.7×10^{-4}

Table 4: Microbial composition from fresh and old POME

Micro organism	Sample A		Sample B	
	Fresh	Stale	Fresh	Stale
Micro cocus sp.	+	+	+	+
Bacillus sp	+	+	-	+
Aspergillus niger	+	+	+	+
Aspergillus herbarious	+	+	+	+
Aspergillus tamari	-	+	-	+
Proteus sp	-	+	-	+
Pseudomonas	-	+	-	+
Rhzopus sp	-	+	-	+
Nitrobacter sp.	-	+	-	+
Fusarium sp.	-	+	-	+
Cladosporium sp	-	+	-	+
Penicillum sp.	-	+	-	+
Paecilomyces sp.	-	+	-	+

The colony forming units (cfu/mL) for both samples ranged between 1.2×10^{-4} to 7.0×10^{-4}. Fresh POME have pleasant odour but the high BOD soon produces anaerobic condtions. Orji[6] suggested that acclamatisation and adaptation could be the reason for isolation of more microrganisms from soil with older POME deposites. Sinnapa[23] showed that the variation of in microorganism POME sites could attributed to the nature of the environment and that the population changes along disposal channel. *Micro cocus* sp., *Bacillus* sp., *Aspergillus niger*, *Aspergillus herarious*,were present in both fresh and stale POME for both samples except *Bacillus* sp. That was not isolated in fresh POME of sample B. All other microorganism isolated were found in stale POME but absent in fresh effluent.

The data presented in Figure 1 shows the concentration of heavy metals in fresh and stale POME in the two stations. Iron was highest amongst all four samples while cadmium was not detected for stale sample B, though found in small amounts in other samples, making it the list metal for all samples analyzed. The trend in metals concentration was approximately same for all four samples.

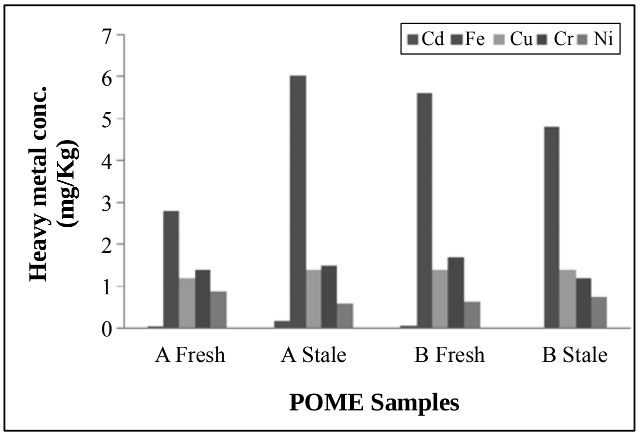

Fig. 1: Bar chart of heavy metal content of fresh and stale POME samples

CONCLUSION

Physicochemical analysis of POME reveal that most characteristics are far above EHS guidelines together with the heavy load of microorganisms therein, confirm the non existance of effluent treatement of any form. The discharge of POME without treatement has far reaching consequences because the health of the community is affected. Mitigation using the recycle and reuse concepts must be viewed as an investment for ourselves and future generations. This is so because efforts on mitigation of environmental degration will translate into a concerted effort to combat the many environmental impacts resulting from mismanagement of POME which itself is a resource. It should therefore be emphasized that the production of palm oil, and associated processing steps should be rooted in the context of sustainability, the most important issue of the moment.

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