African Journal of Environment and Natural Science Research
ISSN: 2689-9434
Volume 4, Issue 1, 2021 (pp. 45-52)
www.abjournals.org

ASSESSMENT OF WATER QUALITY IN RELATION TO PALM OIL MILL EFFLUENT DISCHARGE, OGELE STREAM, OGBADIBO, BENUE STATE, NIGERIA

Yuguda Abubakar Umar*, Jalam Abdullahi Muhammed, Ibrahim Hussaini Gital, Sadiq Lukman Shinji, Garba Mijinyawa and Natu Bemshima Simon

Department of Environmental Management Technology, Abubakar Tafawa Balewa University, P. M. B. 0248, Bauchi- Nigeria.

*Corresponding Author Email: abkyuguda@gmail.com

ABSTRACT: *The processes of palm oil production generated a huge amount of contaminated water usually referred to as palm oil mill effluent. Waste generated from palm oil milling or manufacturing process is often discharged untreated into nearby streams, rivers, and lands. In this study, the quality of the Ogele water stream was assessed in relation to Palm Oil Mill Effluent (POME) Discharge. Stream water samples were collected using simple surface-grab methods from the three-segmented portions of the stream level as Upstream, midstream, and downstream. Laboratory analysis of Physico-chemical and bacteriological parameters that include pH, temperature, turbidity, EC, TSS, TDS, BOD, COD, Cr, Pb, Cu, Mn, Mg, and TBC were conducted. Mean differences between the sampling points were tested with one-way analysis of variance with fisher's exact test for the least significant difference at* $p \leq 0.05$*. The results indicate that measured parameters that include pH, temperature, EC, TSS, TDS are all within the normal range of the WHO threshold limit. But turbidity in all the sampling points exceeds the WHO limit of 5 NTU. Also, the minimum and a maximum mean of 44.67 and 69.33 for TBC in all the sampling points significantly exceed the WHO threshold limit of 10 cfu/ml. A relatively low BOD, COD, TSS, TSD was observed in all the sampling point. Moreover, a significant decrease was observed in values of pH, temperature, and EC with sampling points between Upstream, midstream, with downstream. The heavy metals analysis shows that Cr, Pb, Mn, and Mg all exceed the threshold limit of WHO. The water quality of the ogele stream is fit to support aquatic life but not adequately suitable for domestic consumption. The impact of discharging untreated palm oil mill effluent into our water bodies cannot be overemphasized. hence the need for the treatment actions to lessen these impacts prior to discharge.*

KEYWORD: Palm-Oil, Physio-Chemical, Heavy Metals, Effluent

INTRODUCTION

Water is an essential commodity for living organism on the earth and its usefulness rely on its intended usage (Boukori *et al.*, 1999). Water is contaminated if its chemical and physical properties are altered and these alterations affect the quality of life it supports (Eletta, 2007). Extraction of palm oil involves a process that requires large quantities of water. For this reason, a significant quantity of water is utilized in the process of extracting oil from palm fruits. It was estimated that 90 – 95 % of the used water in the extraction of crude palm oil from the fresh fruits end as residual effluent together with oil, soil particles, and suspended solids (Ahmad *et al.,* 2003). It is projected that for every 1000 liters of crude palm oil produced, 500 liters of water end up as POME (Okwute and Isu, 2007; Wu *et al.,* 2009). Due to the high production rates of palm oil, a large quantity of polluted wastewater is always generated.

POME is not the only waste generated during the processing of palm oil. Others include liquid (oil residue) containing proteins, carbohydrates, nitrogenous compounds, phenols as well as organic acid (Ma, 2000; Madaki and Seng 2013). These materials tend to alter environmental parameters particularly BOD and COD level (Ngan *et al.,* 1996; Okwute and Isu, 2007).

In both conventional and traditional milling settings, these solid waste products are all put to economically useful purposes such as fuel material and mulch in agriculture, but the liquid mill effluent is mostly discharged into the environment usually untreated (Bolaji *et al.,* 2015).

The palm oil industry always found the treatment of effluent a burden rather than as part of the production process (Ma.1999). For these obvious reasons, raw effluent or partially treated effluent is being discharged into nearby rivers, streams, lakes, or land, as this is the easiest and cheapest method for disposal (Mohd Ridzuan Othman 2013; Ahmad *et al.,* 2002). Over the past years, there was a growing interest in the potential polluting impact of POME on the environmental (Okolie et al, 2019).

Nigeria is among the world's leading producers of palm oil (Ohimain *et al.,* 2012). The palm oil industry is a major agro-based enterprise especially in the southern part of the country where palm oil trees are found (Nwaugo *et al.,* 2008).

This study was aimed to examines the impact of palm oil mill effluents on surface water quality in Ogbadibo Local Government of Benue state. The study was specifically focused on the assessment of the impact of palm oil mill effluent on surface water quality in the Ogele Stream of Ogbadibo Local Government Area of Benue State, Nigeria. Ogele is the largest stream in the community that serves as a source of domestic water for some of the population in the community. The stream serves as a major drainage channel receiving domestic wastes as well as effluents discharged from the palm oil mills in the area. The study will contribute towards availing the understanding of the impacts of POME on water bodies.

MATERIAL AND METHODS

Samples Collections

Water samples were collected using simple surface-grab methods from the section of the Ogele stream that directly received the discharge of palm oil mills effluent. The stream was divided into three (3) sampling points, Upstream, midstream, and downstream. At each point three (3) samples were collected using a sterilized plastic sampling bottles in triplicate. Sample bottles were thoroughly rinsed with stream water three times at each point of sampling before submerging the bottle into a depth of about 0.5 M below the running water. pH and temperature were taken immediately. Samples were stored in an icebox and transported to the laboratory for analysis. Each sample was divided into two (2) portions, one of the portions was acidified to 1 % HNO_3 and refrigerated at 4°C prior to metal analysis.

Laboratory Analysis of Physico-Chemical and Bacteriological Parameters

The pH value, temperature, and TDS were determined directly using Multifunctional pH, Eh (mV), °C, EC, TDS Meter (LOHAND Model Number: PH-2603, Hangzhou lohand biological company limited). The pH meter was calibrated with a buffer solution of 4 and 9. After calibration, the electrode was directly immersed into the sample bottles and allowed to stabilize the reading from the instrument was recorded. Electrical Conductivity (EC) was measured with a conductivity meter JENWAY 40710 model HI 9032 The instrument was calibrated using a standard solution of conductivities 500 µs/cm and 1500 µs/cm. Values were taken in micro siemens per centimeter.

Turbidity was measured with a microprocessor turbidimeter. Total Suspended Solids (TSS) was determined using a simple filter paper gravimetric method. Briefly, the water sample was filtered through a pre-weighed filter paper. The residue retained on the filter was dried in an oven at 103 to 105 °C until the constant weight was attained. The increase in weight of the filter represents the total suspended solids.

Biochemical Oxygen Demand (BOD) was calculated using five days' incubation method, while Chemical Oxygen Demand (COD) was determined titrimetric/dichromate oxidation method described by Ohimain (2012). The Total Bacterial Count (TBC) was determined using the spread plate method using nutrient Agar. Heavy metals (Cr, Pb, Mn, Cu, Mg, and Fe) were determined using Atomic Absorption Spectrophotometer after acidification of the samples with 1 % HNO_3

Statistical Analysis

Minitab (Version 19) was used for statistical analysis. The observations were presented as means and standard errors of the mean (SEM) of three replicates. Mean differences between sampling points were tested by one-way ANOVA with Fisher's exact post hoc test for the least significant difference (LSD) at $p \leq 0.05$.

RESULT AND DISCUSSION

The results of Physico-chemical and bacteriological parameters are presented in table 1. The maximum and minimum obtained values of temperature of the stream sampling points are 24.33 and 26.67 °C with was within the normal range by WHO.

pH is critical in water and soil environments, it controls several chemical behaviors by affecting their solubility, alkalinity, and hardness (Wang *et al.*, 2002; Bolaji *et al.*, 2015). pH is an important indicator of water quality to support life (Fakayode *et al.*, 2005; Donald *et al.*, 2019). The pH values measured were neutral (7.23 and 7.13) for both upstream and midstream, and near neutral (6.2) for downstream reveals the water is neutral. All of the pH values were within the normal range. Similar studies by Ohimain *et al.*, (2012) and O'thong *et al.*, (2008) reported pH values of 5.6 and 6.25, respectively. pH is one of the most influencing parameters in chemical reactions within the water. Many organisms are sensitive to pH changes, it affects their metabolic activities (Chen and lin 1995; Wang *et al.*, 2002). It was observed at pH below 6.5 some organisms experience decline in growth and reproduction (Donald *et al.*, 2019). The observed pH in this study is within the normal range to support most of the aquatic life.

The content of electrical conductivity (EC) of water is a direct function of its dissolved mineral matter content. The higher the contamination of inorganic compounds in the water, the higher the EC of water, as they dissociate more in water than organic compounds. Although the observed EC in this study is within the limit, the higher value indicates the dissolution of inorganic compounds.

The maximum and minimum turbidity of 31.9 and 29.6 NTU was observed at upstream and downstream. The turbidity was significantly higher in all the sampling points when compared with the WHO limit, with a significant decrease observed between upstream, midstream, and downstream. Moreover, particulate matter affects the turbidity in water bodies.

The maximum total dissolved solids content was 226.67 mg/L obtained downstream, no significant difference was observed between the total dissolved solids of midstream and upstream. Likewise, the level of total suspended solids was higher downstream with 2.59 mg/l but decreased at the midstream and upstream with a value of 1.84 and 1.82 mg/l respectively. An elevated level of total suspended solids affects the water temperatures and dissolved oxygen levels and light penetration (Bilotta and Braziera, 2008). Lower dissolved oxygen concentrations will negatively affect aquatic organisms (Chapman and Kimstach, 1996). Similarly, Lower TSS will decrease primary productivity in phytoplankton and macrophytes, increase the rate of drift in invertebrates (Donald *et al.*, 2019).

The BOD of wastewater expresses the amount of oxygen used by biodegradable organic substances. In this study, the measured BOD is substantially insignificant typical of palm oil mill effluent. Biochemical oxygen demand (BOD) is an important indicator of the pollution status of a freshwater body (Bhatti and Latif, 2011). The BOD of POME reported in the literature is high compared to what is obtained in this study (Awotoye et al. 2011; Ohimain *et al.*, 2012). The obtained BOD values show that the water samples contain little organic waste.

Chemical Oxygen Demand (COD) is the measure of chemically oxidizing organic waste present in water. The estimation of COD is of great significance for waters having unfavorable conditions for the growth of microorganisms (Wang *et al.*, 2002). The maximum COD observed in this study was 112 mg/L downstream. High COD suggests recalcitrance of chemicals that have escaped biodegradation. These chemicals may be persistent and may cause severe environmental problems like bioaccumulation (Bolaji *et al.*, 2015). Similar to BOD, the COD obtained in this study was relatively low when compared to the maximum COD of POME reported by Ohimain et al (2012). The higher BOD and COD reported in the literature as mostly for the palm oil mill effluent, not for the affected water bodies.

POME contains various heavy metals at a huge level. The discharge effluent containing this volume of heavy metals into the waterways may cause serious problems for public health and the food chain (Shavandi *et al.*, 2012). In this study, heavy metals that include 0.1 – 0.43 mg/L Cr, 0.33 – 0.57 mg/L Pb, 0.37 – 0.53 mg/L Mn, and 1.05 – 1.97 mg/L Mg all exceed the threshold limit of WHO. The presence of heavy metals in palm oil mills effluent had been established in previous studies. heavy metals such as Zn, Cu, and Fe are reported to be present in POME at concentrations of 2.3, 0.85, and 46.5 mg/L (Hashiguchi *et al.*, 2020). Similarly, Ohimain *et al.*, (2012) reported the presence of heavy metals in pome with a maximum concentration of 1.67 Cr, 1.61 Cu, 0.023 Cd, and 13.81 Fe. The presence of heavy metals in pome and water impacted with pome may have many sources. Among them is the treated empty bunches with are rich in major nutrients and contained reasonable amounts of trace elements (Igwe *et al.*, 2007).

The maximum total bacterial count (TBC) of 69.33 cfu/ml was observed downstream. The upstream and midstream values were 44.67 and 46.61cfu/ml respectively. All the values of TBC were above the limit of 10 cfu/ml.

CONCLUSION

With the growing increase in oil palm production in the country, POME discharge is expected to be on the rise in Nigeria. As a pollutant, it causes contamination of water bodies. Thus, while benefiting from palm oil production, the adverse environmental impact from the palm oil industry in water bodies and to the inhabitant of the surrounding environment cannot be ignored. The finding of this study revealed that the ogele stream is fit to support aquatic life but not recommended for domestic consumption. Future Research is recommended at intervals to enable the proper monitoring of the waterbody for domestic usability.

REFERENCES

Ahmad, A. L., Ibrahim, N., Ismail, S., Bhatia, S., (2002). Coagulation-Sedimentation-Extraction Pre-treatment Method for the Removal of Suspended Solids and Residual Oil from Palm Oil Mill Effluent (POME). *IIUM Engineering Journal* 3(1), 25-33.

Ahmad, A. L., Ismail, S., Bhatia, S., (2003). Water Recycling from Palm Oil Mill Effluent (POME) using Membrane Technology. *Desalination* 157 (1-3), 87-95.

APHA, 1998. Standard Methods for Examination of Water and Wastewater. 19th edition, American Public Health Association, Washington in DC. Brock T. D. and Madigan M. T. (1988) Biology of Microorganisms. 5th edition. Prentice Hall International Inc., pp: 641-644.

Awotoye, O. O., Dada, A. C. & Arawomo, G. A. O. (2011). Impact of palm oil processing effluent discharge on the quality of receiving soil and river in Southwestern, Nigeria. *Journal of Applied Science Research,* 7(2), 111-118.

Bhatti M. T., Latif M. (2011). Assessment of Water Quality of a River using an Indexing Approach during the Low-Flow Season. Irrigation. Drain., 60:103-114. Doi: 10.1002/ird.549.

Bilotta, G. S. and Braziera, R. E. (2008). Understanding the influence of suspended solids on water quality and aquatic biota. *Wat. Res.*, 42; 2849 – 2861.

Bolaji, E. J., Opeyemi, I. E., & Eniola, O. O. (2015) Impact of Palm Oil Mill Effluent on Physico-Chemical Parameters of a Southwestern River, Ekiti State, Nigeria. *Mercy Derkyi Esi Awuah Daniel Obeng-Ofori Nana Sarfo Agyemang Derkyi Fred Owusu-Ansah*, 638.

Boukori Y., Bawa I., and M, Djaneye B. G. (1999). Characterization of some Togo Surface Waters. *Bull. Chem. Soc. Ethiopia*. 13(1): 11-21.

Chapman D. And Kimstach V. (1996). Chapter 3 - Selection of water quality variables. In: Chapman, D. (ed.) Water Quality Assessment - A Guide to the use of Biota, Sediments and Water in Environmental Monitoring (2nd Edition). (pp. 74 – 132). (London and New York: Taylor and Francis).

Chen, J. C. and Lin, C. Y. (1995). Responses of oxygen consumption, Ammonia-N excretion and Urea-N excretion of *Penaeus chinensis* exposed to ambient ammonia at different salinity and pH levels. *Aquaculture,* 136, 243-255.

Donald, A. E., Chizuruoke, D. M., & Gladys, O. O. (2019). Quality assessment of vegetable oil effluent discharged into a southeastern Nigeria river. *African Journal of Environment and Natural Science Research*, *2*(1), 1-11.

Eletta O. A. A. (2007). Determination of some trace metal levels in Asa river using AAS and XRF techniques. International journal of physical sciences. 2 (3): 056-060.

Fakayode S. O. (2005). Impact Assessment of Industrial Effluents in Water Quality of the Receiving Alaro River in Ibadan, Nigeria. *Ajeam-Ragee,* 10:1-13.

Hashiguchi, Y., Zakaria, M. R., Maeda, T., Yusoff, M. Z. M., Hassan, M. A., & Shirai, Y. (2020). Toxicity identification and evaluation of palm oil mill effluent and its effects on the planktonic crustacean Daphnia magna. *Science of The Total Environment*, *710*, 136277.

Igwe, J. C., and Onyegbado, C. C. (2007). A review of palm oil mill effluent (POME) water treatment. *Global Journal of Environmental Research*, *1*(2), 54-62.

Ma.,A.N., (2000). Environmental Management for the Oil Palm Industry. Palm Oil Dev., 30: 1-10.

Madaki, Y. S., and Seng, L. (2013). Pollution control: how feasible is zero discharge concepts in Malaysia palm oil mills. *American Journal of Engineering Research*, *2*(10), 239- 252.

Ngan M. A., Zajima Y., Asahi M., and Junit H. (1996). A novel treatment process for palm oil mill effluent. PORIM TECHNOLOGY, October 1996.

Nwaugo V. O., Chinyere G. C. and Inyang C. U. (2008). Effects of palm oil mill effluents (POME) on soil bacterial flora and enzyme activities in Egbama. Plant Product *Research Journal 12*: 10 – 13

O'Thong S., Prasertsan P., Intrasungkha N., Dhamwichukorn S. and Birkeland N. (2008). Optimization of simultaneous thermophilic fermentative hydrogen production and COD reduction from palm oil mill effluent by thermo anaerobic bacterium-rich sludge. *International Journal of Hydrogen Energy* 33: 1221 - 1231.

Ohimain, E. I., Seiyaboh, E. I., Izah, S. C., Oghenegueke, V. E., and Perewarebo, T. G. (2012). Some selected physico-chemical and heavy metal properties of palm oil mill effluents. *Greener Journal of Physical Sciences*, *2*(4), 131-137.

Ohimain. E. I., Izah .S. C.,and Jenakumo. N. (2013). Physico-chemical and microbial screening of palm oil mill effluents for amylase production. *Greener J. of Biol. Sci*., 3(8): 314 – 325.

Okolie, H., Ekwuribe, E., Obasi, C. C, Obidiebube, E. A. and Obasi, S. N. (2019). Evaluation of Palm Oil Mill Effluent (POME) Impact on Soil Chemical Properties and Weed Cover in Awka–Rain Forest Zone of Nigeria. *Canadian Journal of Agriculture and Crops,* 4(2): 93- 100.

Othman, M. R., Hassan, M. A., Shirai, Y., Baharuddin, A. S., Ali, A. A. M., and Idris, J. (2014). Treatment of effluents from palm oil mill process to achieve river water quality for reuse as recycled water in a zero-emission system. *Journal of Cleaner Production*, *67*, 58-61.

Shavandi, M. A., Haddadian, Z. M. H. S., Ismail, M. H. S., Abdullah, N., and Abidin, Z. Z. (2012). Removal of Fe (III), Mn (II) and Zn (II) from palm oil mill effluent (POME) by natural zeolite. *Journal of the Taiwan Institute of Chemical Engineers*, *43*(5), 750-759.

Wang, W., Wang, A., Chen, L., Liu, Y. and Sun, R. (2002). Effects of pH on survival, phosphorus concentration, adenylate energy charge and Na+, K+ ATPase activities of *Penaeus chinensis* Osbeck Juveniles *Aquatic Toxicol*. 60,75-83

WHO/UNICEF (2012). Progress on Drinking Water Sanitation. 2012 Update WHO, Geneva and UNICEF, New York.

Wu, T. Y., Mohammad, A. W., Jahim, J. M., and Anuar, N. (2009). A holistic approach to managing palm oil mill effluent (POME): Biotechnological advances in the sustainable reuse of POME. *Biotechnology Advances*, *27*(1), 40-52.

African Journal of Environment and Natural Science Research
ISSN: 2689-9434
Volume 4, Issue 1, 2021 (pp. 45-52)
www.abjournals.org

APPENDIX

Table 1: Physical, chemical and biological parameters in the surface water samples collected. Values were mean and standard error of the mean (n=3).

Parameters	Sampling points Up-stream	Mid-stream	Down-stream	WHO limit	ANOVA F-value	p-value
Temperature (°C)	26.67(±0.14)[a]	26.67(±0.14)[a]	24.33(±0.27)[b]	Ambient °C	49.33	***
pH	7.23(±0.03)[a]	7.13(±0.10)[a]	6.2(±0.09)[b]	6.5 – 8.5	33.73	***
EC (µs/cm)	196.67(±2.33)[a]	199.67(±2.33)[a]	183(±0.94)[b]	1000 µs/cm	10.64	*
TDS (mg/L)	211(±0.94)[a]	214(±0.64)[a]	226.67(±1.91)[b]	1500 mg/L	30.26	**
TSS (mg/L)	1.85(±0.01)[a]	1.84(±0.11)[a]	2.59(±0.04)[b]	500 mg/L	190.79	***
Turbidity (NTU)	31.9(±0.24)[a]	31.8(±0.00)[a]	29.6(±0.00)[b]	5 NTU	60.84	***
BOD (mg/L)	3.26(±0.01)[a]	3.25(±0.05)[a]	3.35(±0.02)[a]	-	2.49	ns
COD (mg/L)	60.33(±0.98)[a]	61.35(±0.72)[a]	112(±1.25)[b]	-	589.98	***
Chromium (mg/L)	0.43(±0.05)[a]	0.37(±0.05)[a]	0.1(±0.00)[b]	0.05 mg/L	10.5	**
Lead (mg/L)	0.57(±0.03)[a]	0.54(±0.04)[a]	0.33(±0.03)[b]	0.01 mg/L	16.33	*
Manganese (mg/L)	0.37(±0.03)[a]	0.35(±0.04)[a]	0.53(±0.05)[b]	0.1 mg/L	4.17	ns
Copper (mg/L)	0.1(±0.00)[a]	0.1(±0.00)[a]	0.1(0.00)[a]	1.5mg/L	0.00	ns
Magnesium (mg/L)	1.05(±0.03)[a]	1.07(±0.05)[a]	1.97(±0.03)[b]	0.5mg/L	199.76	***
Iron (mg/L)	0.12(0.01)[a]	0.1(±0.00)[a]	0.27(±0.03)[b]	0.3 mg/L	20.13	**
TBC (cfu/ml)	44.67(±1.66)[a]	46.61(±1.36)[a]	69.33(±1.66)[b]	10 cfu/ml	49.33	***

One-way ANOVA of sampling points, asterisk were level of significance, $*P < 0.05$, $**P < 0.01$, $***P \leq 0.001$, ns, not significant. Values that share a letter are not statistically different. WHO - World Health Organization, EC - Electrical conductivity, TDS - Total Dissolved Solids, TSS - Total Suspended Solids, BOD - Biochemical Oxygen Demand, COD - Chemical Oxygen Demand, TBC - Total Bacteria Count.