Asian Journal of Microbiology and Biotechnology

Volume 9, Issue 1, Page 60-67, 2024; Article no.AJMAB.12005
ISSN: 2456-8341

Ecological Significance of Dynamism of Physiologic Variance on Properties of Palm Oil Mill Effluents

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Authors' contributions

This work was carried out in collaboration among all authors. Author ECO conceived and designed the experiments, performed the experiment and processed the data, analyzed the data and wrote the manuscript. Author OCM carried out the experiment and analysed the results. Author AKC co-supervised the research and revised the manuscript. Author DPU analyzed the research design and methodology, interpreted the data. Author OEH guided the experimental design, supervised the research, performed the experiment interpreted the data, revised the manuscript and processed the data. All authors read and approved the final manuscript.

Article Information

DOI: 10.56557/AJMAB/2024/v9i18627

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.ikprress.org/review-history/12005

Original Research Article

Received: 21/01/2024
Accepted: 25/03/2024
Published: 04/04/2024

ABSTRACT

Properties a given waste is essential for rationale comprehension of plausible way(s) for its remediation. In the present study, POME from oil milling centre at Anambra state showed high heterotrophic activity of microorganisms. Total viable counts of the organisms isolated from the

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waste water were 5.4 x 10^3 CFU/ml and 4.4 x 10^3 CFU/ml at day 0 and day 7 of the incubation respectively. These observations showed a significant variation from the control experiment at these recorded days of incubations which shows total viable cell counts (TVC) of 4.6 x 10^3 and 2.9 x 10^4 CFU/ml respectively. Total coliform counts (TCC) of the organisms isolated from the dairy waste water were 1.3 x 10^3 and 1.8 x 10^3 CFU/ml for the day 0 and day 7 incubation periods respectively while the TCC from the control experiment were: 8.0 x 10^2 and 3.2 x 10^2 CFU/ml for day 0 and day 7 incubation periods respectively. POME sample from Awka, Anambra state was subjected to various physicochemical profiling and was further optimized at different conditions to exert various variability. Biochemical oxygen demand (BOD_5) is one of the important physical parameter widely used in assessment of quality of aqueous surroundings. Physicochemical properties of waste water from the milling centre showed the following: pH (5.0), temperature (41ºC), conductivity (610); water dissolved minerals such as Cl^-, K^+, PO_3, $Mg2^+$, Ca^{2+} were all determined. Initial dissolved oxygen concentration (mg/l) of the waste water was determined using a probe connected to a meter with initial value of 39.4 mg/l. Biochemical oxygen demand (BOD_5) was determined after five incubation days at room temperature in separate bottles optimized at varying pH of 4.0-9.0 in a range of 1.0 units. BOD_5 decreases with increased pH values in all the tested samples incubated for 5 days. pH 5.0 gave a significant reduction of the oxygen exertion (1400 mg/ml) while pH 4.0, 6.0, 7.0 showed an oxygen exertion (BOD_5) of 1978, 2778, and 2965 mg/ml respectively. Samples incubated at 8.0 and 9.0 showed oxygen exertion of 2945 and 2899 mg/ml respectively. Other contents of the dairy waste water such as total organic carbon (TOC), total organic matter contents (TOM) were all determined respectively. Samples was also collected from mapped area 0.5 km away from the waste water reservoir and used as the reference standard. Proceeding results from the present research study showed the compromised statues of our aquatic environment and also in a wider look gave a great insight of effective modalities in water treatment; as increasing population of myriads of processing industries in our country today pose great challenge to the competence of our aquatic body.

Keywords: BOD_5; pH; aquatic bodies; physicochemical; oxygen exertion.

1. INTRODUCTION

Ecosystem is a self-supporting unit with biotic and abiotic plausible [1]. Organisms live in the surface water, with aerobic species congregating near the water surface and anaerobic microbes increasing with depth of the water level due to decrease in oxygen concentrations and reduced water conditions [2]. Waste water is one of the crucial sources of pollution in terrestrial and water body [3]. The industry including those of inorganic and organic bias in utility is of economic importance in terms of their impact on the environment. Palm oil mill effluent are waste accruing from processing of raw palm to finished red oil (Okwaye *et al.,* 2013). The wastewater from this processing industry and other domestic sources are generally polarize and may contain toxic pollutants. It contains acids, bases, toxic materials, and matter high in biological oxygen demand, color, and low in suspended solids [3]. The palm oil industry has turned out to play an essential role in agricultural industries within sub-saharan with Nigeria not left out in the progressive development; which produce a great amount of oily liquid wastewater globally referred to as palm oil mill effluent (POME) [4]. Nowadays, the palm oil business is developing rapidly and transforming into an imperative agriculture-based industry in these two countries. The numbers of palm oil factories have increased generally, at starting with 10 plants in 1960 moved to 1600 operating mills in 2018 in Nigeria. At least 44 million tons of POME was produced and are expanding each year in Nigeria, especially as a result of the activity of the legislature to advance the palm oil industry [5].

While the palm oil industry has been perceived emphatically for its commitment toward monetary development and quick improvement, it has additionally added to environmental pollution because of the creation of huge amounts of by-products during the process of oil extraction [5]. POME contains a great amount of acidic content, temperature, Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) [6]. At the point when it is released into streams it can defile drinking water for the human and animal community. The crude effluent contains 90-95% water and incorporates residual oil, soil particles and suspended solids. A modern oil palm plant produces about 2.5 t of effluent per ton of palm oil, or 0.5 ton of effluent per ton of new fresh fruit

[7]. Palm oil plant effluent is an exceptionally a polluted substance and much exploration has been devoted to methods for reducing its danger to the human environment.

2. MATERIALS AND METHODS

2.1 Materials

All the reagents, equipment used in the present study were of analytical grade and products of BDh, May and Baker, Sigma Alrich. The equipment is calibrated at each use.

2.2 Methods

2.2.1 Waste water collection

Palm oil mill effluents were collected from a milling center located at Awka south L.G.A of Anambra state (7^{o}9'N 6^{o}50'E) Nigeria. The sample was collected from the industry resurge tank at about 7.00 am of the morning using four sample bottles of 100 ml calibration. The collection was done at the four corners of the surge reservoir tank. The collected POME were homogenously pooled together into a clean asceptic ice packed container and transferred to the laboratory.

2.2.2 POME analysis

POME from the industry reservoir site prior to microbial isolations was subjected to various physicochemical profiling analysis as described in journal of ATSDR, (2010).
The following tests were carried out:

2.2.3 Physico-chemical analyses

Conductivity, pH, Chloride, Sulphate, total solid (TS), total dissolved solid (TDS), total suspended solid (TSS), were determined using standard laboratory methods as reported by Onojake et al. [8]. Water hardness (Ca and Mg), turbidity were also determined as described by APHA [89. Total Organic Carbon (TOC), Total organic matter (TOM) was also determined in the laboratory using titrimetric method by Walkey and Black [10].

2.2.4 Estimation of Total organic carbon (TOC) and Total organic matter (TOM)

This was done as described by Onojake et al. [8], briefly ten ml (10 ml) of waste water samples was measured out and poured into 500ml volumetric flask. 10ml of $K_2Cr_2O_7$ and 20ml of conc. H_2SO_4were added. 100ml of distilled water (1:1), 10ml of H_3PO_4 and five drops of diphenylamine indicator were added before titrating with 0.5N ferrous ammonium sulphate $(NH_4)_2SO_4Fe$.

A blank titration was thereafter carried out and the % TOC was calculated as:

%TOC = TVB - TVS/ Weight of sample
TOM = TOC X 1.752

Where TVB and TVS are titre value of the blank and the test sample.

Further water properties such as dissolved oxygen concentration and biochemical oxygen demand exertion (BOD_5) using the dissolve oxygen probe connected to a meter. BOD was determined from the dissolved oxygen concentration after five days of incubation as described in the protocol by APHA, 1992. BOD sample bottles were used during the study; pH of the waste water was varied using 1% HCl (v/v) (4.0- 6.0) and 0.1 mol. of NaOH (8.0-9.0) (w/v).

$$BOD_5 = Do_1 - Do_5$$
$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$
$$6H^+ + O^-{}_2 = 2H_2O + 2H^+$$

Where Do_1 is the initial dissolved oxygen concentration
Do_5 is the final dissolved oxygen concentration

Determination of TS, TDS and TSS

Total solids = mg. total solids $\frac{\times}{}$ 1000
mL of sample
TDS= conductivity * 0.65
TSS = TS - TDS

2.2.5 Microbial isolations

Microbial analysis of the waste water was determined using standard microbiology and biochemical techniques as described by Ezeonu et al. [11]. Morphology identification, microscopic mounting and biochemical test were carried out as well.

Coliform counting was determined after plating on a standard bacteria medium as follows:

TCFU/g = colony observed x dilution factor x volume used

3. RESULTS

Table 1. The microbial populations of the POME at varying days of incubations

Heterotrophic Counts (CFU/ml)	Control	POME
Total Viable Counts (TVC) (10^{-2})	4.6 X 10^3	5.4 X 10^3
Total Coliform Counts (TCC) (10^{-2})	8.0 x10^2	1.3 x10^3
Day 0		

Table 2. The microbial populations of the POME at varying days of incubations

Heterotrophic Counts (CFU/ml)	Control	POME
Total Viable Counts (10^{-2})	2.9 x 10^4	4.4 X 10^3
Total Coliform Counts (10^{-2})	3.2 x 10^2	1.8 x 10^3
Day 7		

Table 3. Physicochemical properties of the POME against the Standard

Physiochemical parameters	Control experiment	Water sample
Ph	7.2	5.02
Dissolved oxygen	46.98	39.4
BOD	8.22	14 (factor of 100 folds)
TDS	258.70	469.95
TSS	40.06	55.70
TS	298.76	525.65
Water Conductivity	398	723
Chloride ion (Mg/l)	393±0.18	1151.614±0.36
Phosphate (Mg/l)	1.86±0.02	1.53±0.02
Magnesium (Mg/l)	4.27±0.09	11.27±0.21
Potassium (Mg/l)	7.42±0.22	12.52±0.45
Calcium (Mg/g)	14.23±0.1	22.34±0.17
Turbidity (NTU)	28.77	53.50
Colour	Clear/transparent	Colloidal
Total Organic Carbon (TOC)	2.85±0.02	57.64±0.1
Total Organic Matter	4.99±0.01	100.99±0.12
Water temperature	24.5^{0}C	33.0^{0}C

Fig. 1 below show the impact of temperature on dissolved oxygen concentration (DO) of the POME compared with the standard.

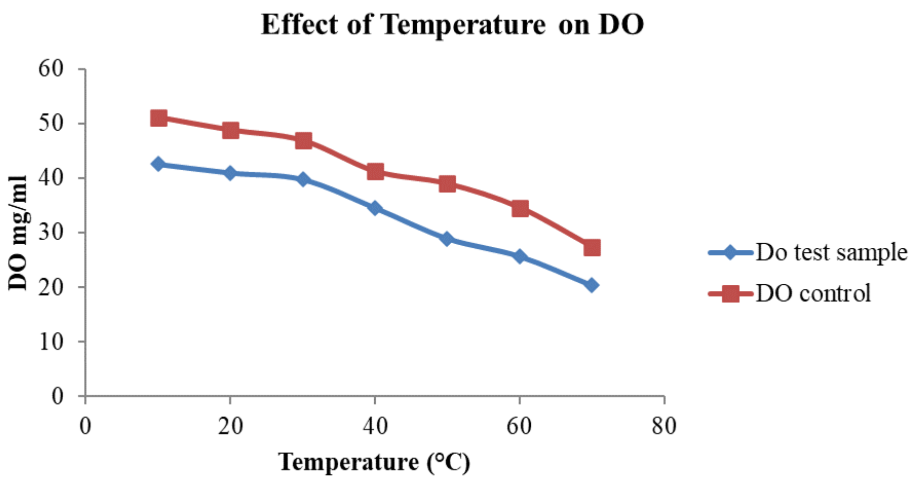

Fig. 1. Effect of temperature on dissolved oxygen (DO) concentration in both the POME and the standard

Fig. 2 below shows the impact of pH ranging from 4.0-9.0 on biochemical oxygen demand (BOD_5) exertion of the POME modeled for five days.

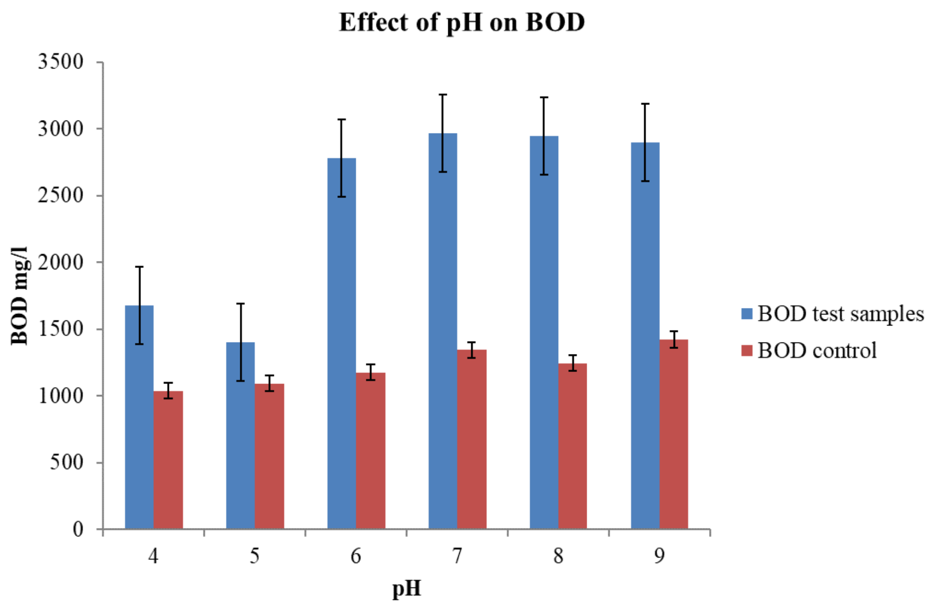

Fig. 2. Effect of pH on Biochemical oxygen demand exertion in both the POME and the standard

Fig. 3 below shows the effect of temperature optimized from 20-70°C on total dissolved solid particles in the dairy waste water and that of the standard.

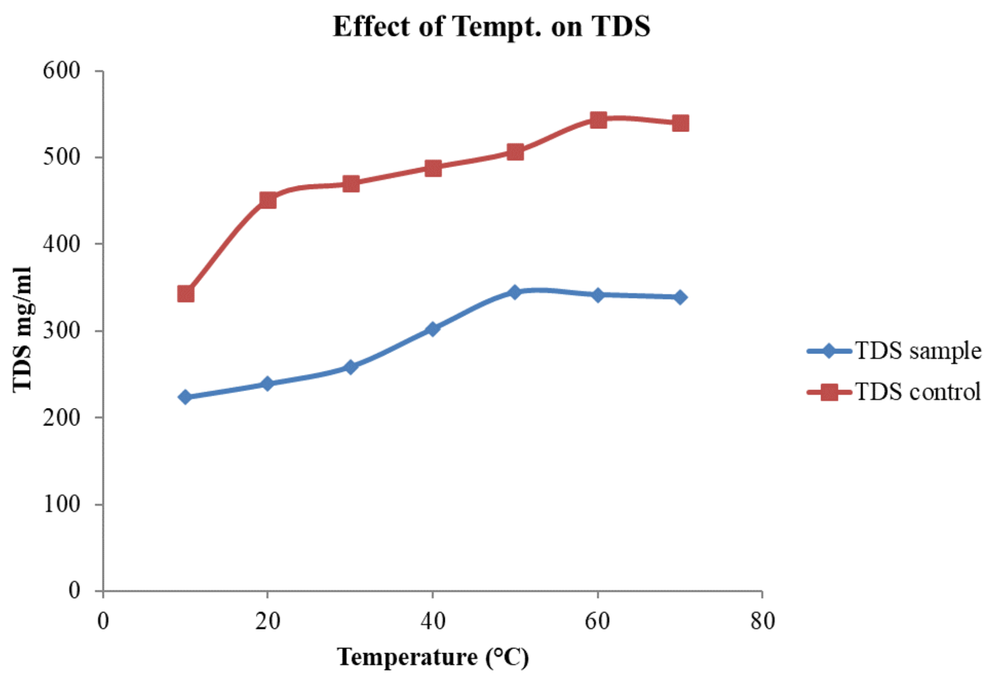

Fig. 3. Effect of temperature (deg. Celsius) on total dissolved solids in both the POME and of the reference standard

4. DISCUSSION

Sustainability of the ecosystem especially the water bodies is a collective approach of competent biotic and abiotic factors. Biochemical oxygen represents an important constitutive factor of aquatic surrounding; compromising the standard of this factor result to a lethal effect on inhabitants of the aquatic bodies. The present study undertakes the impact of physiologic pH on biochemical oxygen demand counts of palm oil mill effluent from palm oil milling centre. POME from oil milling centre at Anambra state showed high heterotrophic activity of microorganisms incubated for seven (7) days against the control experiment. Total viable counts of the organisms isolated from the waste water were 5.4 x 10^3 CFU/ml and 4.4 x 10^3 CFU/ml at day 0 and day 7 of the incubation respectively. These observations showed a significant variation from the control experiment at these recorded days of incubations which shows total viable cell counts (TVC) of 4.6 x 10^3 and 2.9 x 10^4 CFU/ml respectively. Total coliform counts (TCC) of the organisms isolated from the dairy waste water were 1.3 x 10^3 and 1.8 x 10^3 CFU/ml for the day 0 and day 7 incubation periods respectively while the TCC from the control experiment were: 8.0 x 10^2 and 3.2 x 10^2 CFU/ml for day 0 and day 7 incubation periods respectively. Vallero, 2010 suggested a seasonal fluctuation of organisms with respect to days and other impacted physiologic factors. Increase in the coliform counts of the organisms from the waste water could be attributed to the nature of recalcitrant found present in the surge tank of the dairy industry; also as suggested by center for disease control (2008) pathogenic organisms increase in any system due to favourable conditions for cross specie interactions and organismal budding from the inhabitant hosts.

Physicochemical properties amongst all biochemical oxygen represent an important constitutive factor of aquatic surrounding; compromising the standard of this factor result to a lethal effect on inhabitants of the aquatic bodies. The present study undertakes the impact of physiologic pH on certain selected physicochemical properties palm oil waste water from a milling site at Awka, Anambra state. Vallero, 2010 suggested a seasonal fluctuation of organisms with respect to days and other impacted physiologic factors. Increase in the coliform counts of the organisms from the waste water could be attributed to the nature of recalcitrant found present in the surge tank of the milling industry; also as suggested by center for disease control (2008) pathogenic organisms increase in any system due to favourable conditions for cross specie interactions and organismal budding from the inhabitant hosts.

Results obtained from the waste water after physicochemical analysis showed that the waste water contains relatively higher hydrogen ion concentration (H^+) showing an acidic range profiling on pH scale. This can be attributed to the nature of the contaminant in the water such as oxidized sugars and metabolites of fermentations such as lactic acid, glycerol and gluconic acids which can lower the pH of the waste water as stated in the proceedings of the ATSDR, 2005. Other contents of the waste water upon analysis showed higher concentration of potassium (12.52 mg/l), Magnesium (11.27 mg/l), chloride ions (1151.614mg/l) and relatively lower PO_3 (1.53mg/l) ions compared to the control. The presence of Potassium, magnesium and chloride ions in higher concentrations (Mg/l) against the control revealed the level of influx of pollutants from the dairy processing firm. Chikere et al. [12] in their study at Eleme Rivers reported a similar correlation of ions in the Bonny river. Their result revealed a higher concentration of the mineral ions in the following order 2.28, 1.84, 5.22 and 1789.22 mg/g respectively for K, nitrate, magnesium and chloride ions.

Total organic carbon content and total organic matter (TOM) content of the waste water were observed at 53.50 and 100.99 mg/l respectively in the tested sample. This showed a strong significant different from the control experiment which showed TOC and TOM of 2.85 and 4.44 mg/l respectively. Mbachu et al. [13] reported a sharp variation in their research on microbial diversities in a spent engine polluted site at Mgbuka, Onitsha Anambra state with Total organic carbon content and total organic matter contents showing the highest in concentrations of 116.06 and 203.34 mg/kg respectively [14,15].

Effect of temperature on dissolved oxygen (DO) concentration of the dairy waste water as shown in Fig. 1, depicts temperature dependent oxygen solvation in the dairy waste water. Gas availability in liquid medium is said to be dependent on the enthalpy state of the medium as most gas become kinetic competent at high temperature and such escape from the surface of the medium. Fig. 1 showed that much oxygen quotient in mg/l was found at the lower temperature range of the waste water while the concentration of the oxygen decreases as the incubation temperature increases with 80°C showing the least of the DO concentration (27.39 and 20.33)on both the control and test samples respectively.

Effect of pH on the biochemical oxygen demand counts (BOD_5) of the waste water showed a pH dependent solvation of atmospheric oxygen in the water body. From the figure (Fig. 2) oxygen exertion was found more on the waste water at the alkaline range while oxygen availability was much for biochemical activities at the lower pH (acidic range). Co-existence of hydrogen ions and oxygen can be traced to mutual scrambling of ion pairs as reported by Price and stones.

Total dissolved solid (TDS) of the waste water which reveals the physical conductivity of the aquatic body to the dissolved solid contents. Fig. 3 showed increase of total dissolve solid (TDS) particles in the effluent as the temperature increases. This indicates a proportionate increase in conductivity of ions in the waste water sample. Temperature is said to have impact on the adiabatic state of matters, most feeble solid particles lose their basic crystalline shape when exerted upon by high energy inform of heat.

5. CONCLUSION

The present study has shown the dynamism and interaction of physical physiologic factors on physicochemical properties and states of water bodies. This presents in a nutshell an ease way of safe-guarding our ecosystem especially the aquatic environment through manipulation of certain empirical for adequate sustainability of our environment.

FUNDING INFORMATION

This work was solely funded by the research group of Dr. Ezenwelu Chijioke, O.

ETHICS

Authors declared no ethical issues that may arise after the publication of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.ikprress.org/review-history/12005