Journal of
Environment
(JE)

Exploring Bio Augmentation as a Sustainable Approach for COD Reduction in Palm Oil Refinery

CARI Journals

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 3, pp 1 – 7, 2023
www.carijournals.org

Exploring Bio Augmentation as a Sustainable Approach for COD Reduction in Palm Oil Refinery

Himanshu Ramesh Lamba[1*], Emanuel M Tapu[2], Juan Carlos Verardo[3]

[1*, 3]BiOWiSH Technologies

[2]CV Abatemen Karya Bersama

https://orcid.org/0009-0003-8121-8158

Accepted: 1st Dec 2023 Received in Revised Form: 14th Dec 2023 Published: 28th Dec 2023

Abstract

Purpose: This study aimed to investigate the effectiveness of Bioaugmentation Technology in addressing elevated levels of Chemical Oxygen Demand (COD) and reducing sludge volume in the aeration tank of a Palm Oil Refinery located in Kalimantan Island, Indonesia. In addressing these concerns, the study employed Bioaugmentation Technology, specifically tailored for the treatment of palm oil mill effluent in both aerobic and anaerobic ponds, with the aim of expediting the breakdown of organic compounds.

Methodology: The research focused on evaluating the impact of this technology on organic degradation and sludge reduction in comparison to conventional treatment methods. Conventional Palm Oil Mill Effluent (POME) treatment systems typically utilize large-volume sequential pond arrangements with extended hydraulic retention times (>90 days), resulting in inefficient organic degradation. Conversely, the Bioaugmentation Technology utilized in this study emerged as a natural, non-toxic, and easily implementable solution to operational challenges faced by these systems.

Findings: The technology facilitated the rapid breakdown of organic compounds, leading to a reduction in COD and subsequently, a decrease in sludge volume. Based on the observed positive outcomes, it is recommended to consider Bioaugmentation Technology as a viable and efficient solution for POME wastewater treatment in palm oil refineries.

Unique contributor to theory, policy and practice: Its capacity to enhance organic degradation, reduce sludge volume, and improve overall treatment plant efficiency suggests its potential as a valuable complementary technology to existing treatment methods in similar operational conditions.

Keywords: *Bioaugmentation, POME, COD, Sludge, Effluent*

I. INTRODUCTION

Palm oil is rapidly growing, remarkably in equatorial climate nations. Its adaptability in various products has led to a strong demand for palm oil.[1] The expansion of the oil palm agribusiness has led to the release of significant volumes of liquid waste known as palm oil mill effluent (POME).[2] It is approximated that for every ton of crude palm oil (CPO) produced through industrial processing, around 2.5–3.8 tons of POME waste is generated (Cheng et al., 2019).[3] Considering the global production of 71.47 million tons of crude palm oil in 2018, this implies the generation of 178.68 to 268.01 million tons of POME, much of which is discharged into the environment without proper treatment. The presence of untreated POME has numerous adverse effects on aquatic life, water quality, groundwater, soil, and human health (Jasni et al., 2020; Zulfahmi et al., 2021)[4]. With its thick brownish viscous appearance, unpleasant odor, and high colloidal suspension, POME is considered one of the major hazardous pollutants (Syahin et al., 2020)[5]. An examination of the current state of POME treatment and utilization systems in certain palm oil industries is crucial for understanding their environmental implications and advantages. This study aims to evaluate sustainable POME treatment and utilization system.[6]

The effluent generated from palm oil milling, known as Palm Oil Mill Effluent (POME), is released into different water bodies. This leads to various environmental issues such as higher levels of COD and BOD, oil and grease, total nitrogen, and other pollutants. Hence, it is essential to implement efficient treatment methods to eliminate these pollutants before disposal.[7]

To deal with POME effluent, strategies should be implemented in both effective and efficient ways. The selected reactor-treatment system must consider energy consumption issue, feasibility of the implementation while targeting the highest efficiency as possible. Ganapathy et al. (2019) suggest that aerobic treatment of POME could be an alternative solution to overcome these issues effectively as it requires shorter retention time, can treat pollutants effectively, and increases the potential of possibly using treated POME to be used as fertilizer.[8] Presenting bioaugmentation process within the aerobic treatment of POME as a complimentary technology may help to improve the output of effluent discharge and make it more suitable for the environmental health. The goal of this study was to assess the cost-effectiveness of implementing bioaugmentation for POME treatment without altering the existing treatment plant infrastructure.

II. TREATMENT PLANT DESIGN

The Palm oil refining process at this site generates about 200 m^3/day of POME wastewater with chemical oxygen demand (COD) levels ranging from 1000 to 1200 mg/L.

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 3, pp 1 – 7, 2023
www.carijournals.org

Figure 1: POME Water Treatment Plant Process Flow Diagram

The primary treatment for physical treatment process includes Oil Trap Tank and DAF (Dissolved Air Flotation). Oil trap tank is designed to separate specific pollutants such as solid fat, oil, and grease through the density differentiation between water and oil content. The conventional techniques remove oil and grease using skimming tanks and oil and grease traps in treatment plants, but the main disadvantage of these methods is their low efficiency of removal.[9] Dissolved Air Flotation (DAF) with the better efficiency is included to separate the remaining solid pollutant content. In order to provide the consistent removal process, equalization tank is designed before the DAF tank preventing the loading fluctuation thus aiding the treatment efficiency.

It was noticed that after the DAF process, the COD levels were still fluctuating in the range of 350-400 mg/l and could max up to 1000 mg/l during the peak season. Biological reactor follows after the primary treatment which includes Moving Bed Biofilm Reactor (MBBR) and Activated sludge tank in order to meet the targeted COD level. The efficiency of the MBBR process is conditioned by operational conditions such as the Filling Ratio (FR), and Dissolved Oxygen (DO).[10] Activated sludge on the other hand uses the live microorganisms to degrade the complex organic compounds. Both biological reactors provided 2.5 days total of retention time. In order to provide a healthy living environment for bacterial growth, the pH condition must be ideal as well as Dissolved Oxygen (DO) level and temperature. As the ideal conditions for biological reactor vary according to the existing health of the biology in the system, the environmental conditions inside the bioreactor, including temperature, pH, dissolved oxygen levels and agitation rate, must be carefully optimized, closely monitored, and precisely controlled.[11]

The ideal sludge level known as Sludge Volume Index (SVI) should be controlled within the activated sludge reactor and designed to be able to reduce the targeted COD level while maintaining the energy consumptions in effective and efficient ways. An operational target SVI often used for operation is <150 mL/g, although each WWTP has unique SVI values for safe operation, varying from <100 mL/g to >300 mL/g, depending on the hydraulic considerations and the capacity and performance of the secondary clarifier.[12] Prior to the bioaugmentation program, it was noted that the SV30 was about 950 ml/L or close to 300 mL/g SVI standard as the highest range. If the SVI is above 250 ml/g, the sludge settles very slowly, and does not compact well.[13] Maintaining such high SV30 level also causes heavy energy maintenance to achieve the desired

DO levels for the bacterial growth. Increasing the DO implies the waste of electricity consumption for aeration, which generally accounts for 40–50% of the entire electricity consumption in a WWTP. [14]

It was also reported that the biological reactors were operating at a very low efficiency of about 20-30%. The COD for the influent ranged between 350-400 mg/l whereas the the effluent range was on average between 250-300 mg/l.

III. BIOAUGMENTATION:

The bioaugmentation technology used for this study is a proprietary composite biocatalyst that enhances a broad range of hydrolytic, oxidative, and reductive biochemical reactions. It contains a novel consortium of metabolically cooperative microorganisms with endogenous and exogenous enzymes, and small molecule co-factors which support both biocatalytic and metabolic activity. They are composed of all-natural materials and non-genetically modified. As supported by Boopathy (2000), 'the use of mixed cultures in biodegradation studies has numerous advantages which include higher tolerance to perturbations such as changes in nutrient, pH, temperature, and pollutant concentrations'.[14] The main objectives were to observe the impact of the bioaugmentation program on biomass stability within the biological reactor and to improve the performance efficiency by reducing COD levels.

IV. APPLICATION METHODOLOGY

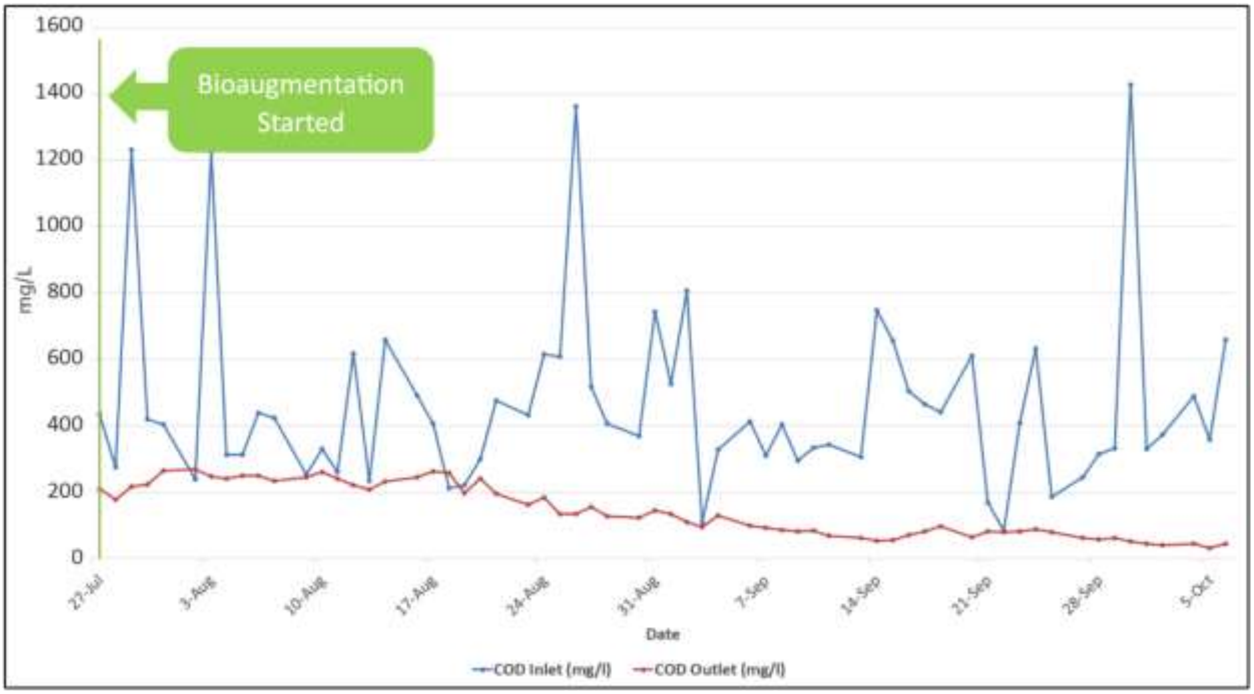
Based on the site survey, MBBR and Activated Sludge tank were selected for Bioaugmentation as both treatment tanks provided ideal conditions for bioaugmentation. Bioaugmentation was performed on a daily basis. Dosing rates were decided based on the daily flow of influent, available retention time in the biological reactors and wastewater parameters. Dosing rates were kept significantly higher in the first few weeks followed by a low maintenance dose for the remaining duration of the study. For Dosing, the recommended quantity of Bioaugmentation technology was dissolved in the water and dosed directly in the moving bed biofilm reactor (MBBR) and aeration tank. Influent and effluent COD levels were monitored on a daily basis throughout the bioaugmentation program. DO levels, pH, and temperature variables were controlled as per the daily management practices during the bioaugmentation program.

V. RESULTS:

Within the first month of the Bioaugmentation implementation, the aeration tank outlet showed stable COD levels below 200 mg/L. In the past, the site had always experienced fluctuations in the COD outlet levels, reaching up to 300 mg/L. However, during the bioaugmentation program, the site did not experience any instability in the COD outlet levels. In the second month, COD levels were observed below 100 mg/L, and starting the third month, COD levels were stable below 50 mg/L. The introduction of the bioaugmentation program significantly helped in improving the efficiency of biological reactors in the treatment process.

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 3, pp 1 – 7, 2023
www.carijournals.org

Figure 2: COD Levels Inlet and Outlet



The site also experienced significant improvement in the daily SV30 measurement within the aeration tank from 950 mL/L in the first month to 600 mL/L. In the third month of the bioaugmentation program, the plant was able to achieve their target SVI of 150mL/g.

Parameter	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 8	Week 10	Week 11	Week 12	Week 13
Inlet COD (mg/L)	553	506	377	400	408	653	502	352	511	353	358	591	509
Outlet COD (mg/L)	230	244	235	239	183	135	123	83	64	80	70	43	38

Table 1: COD Levels - Before and After Bioaugmentation

VII. CONCLUSION

The Bioaugmentation Program to this palm oil refinery proved to be highly effective. COD levels were reduced from 230mg/l to 38mg/l in 13 weeks implementing Bioaugmentation program. This 83% reduction in the outlet COD levels proved to be highly significant. Reduction in sludge volume was observed rapidly within the first two months of bioaugmentation, resulting in improved stability. Through these results, the plant could provide cost effective-efficient ways to treat the POME wastewater and meet the effluent standard discharge limits which is safe for the environment. This study proved to be so successful that the site management decided to continue with Bioaugmentation regularly to achieve stable results.

VIII. RECOMMENDATIONS

After analyzing the outcomes of this study, it is advisable to consider bioaugmentation as a highly cost-effective approach for addressing POME wastewater treatment. This method proves effective in systems employing a combination of various biological reactors to specifically target elevated COD levels.

REFERENCES

[1] M. S. Saad, M. D. H. Wirzal, and Z. A. Putra, "Review on current approach for treatment of palm oil mill effluent: Integrated system," *Journal of Environmental Management*, vol. 286, p. 112209, May 2021, doi: https://doi.org/10.1016/j.jenvman.2021.112209.

[2] M. Wajdi et al., "Effect of Initial PH Adjustment on Acetogenic Treatment of Palm Oil Mill Effluent," Annals of the Romanian Society for Cell Biology, pp. 5459–5466, Mar. 2021, Accessed: Dec. 24, 2023. [Online]. Available: https://annalsofrscb.ro/index.php/journal/article/view/2050

[3] Yoke Wang Cheng, Zhan Sheng Lee, Chi Cheng Chong, M. R. Khan, Kim Hoong Ng, and SK Safdar Hossain, "Hydrogen-rich syngas production via steam reforming of palm oil mill effluent (POME) – A thermodynamics analysis," International Journal of Hydrogen Energy, vol. 44, no. 37, pp. 20711–20724, Aug. 2019, doi: https://doi.org/10.1016/j.ijhydene.2018.05.119.

[4] Jannatulhawa Jasni et al., "Comparative toxicity effect of organic and inorganic substances in palm oil mill effluent (POME) using native microalgae species," Journal of Water Process Engineering, vol. 34, pp. 101165–101165, Apr. 2020, doi: https://doi.org/10.1016/j.jwpe.2020.101165.

[5] S. M S, "DECOLOURISATION OF PALM OIL MILL EFFLUENT (POME) TREATMENT TECHNOLOGIES: A REVIEW," Journal of Oil Palm Research, Feb. 2020, doi: https://doi.org/10.21894/jopr.2020.0008.

[6] U. Hasanudin, R. Sugiharto, A. Haryanto, T. Setiadi, and K. Fujie, "Palm oil mill effluent treatment and utilization to ensure the sustainability of palm oil industries," Water Science and Technology, vol. 72, no. 7, pp. 1089–1095, Jun. 2015, doi: https://doi.org/10.2166/wst.2015.311.

[7] A. Ratnasari et al., "Advances in pretreatment technology for handling the palm oil mill effluent: Challenges and prospects," Bioresource Technology, vol. 344, p. 126239, Jan. 2022, doi: https://doi.org/10.1016/j.biortech.2021.126239.

[8] B. Ganapathy, A. Yahya, and N. Ibrahim, "Bioremediation of palm oil mill effluent (POME) using indigenous Meyerozyma guilliermondii," Environmental Science and Pollution Research, vol. 26, no. 11, pp. 11113–11125, Feb. 2019, doi: https://doi.org/10.1007/s11356-019-04334-8.

[9] A. El-Gawad and H. S, "Oil and Grease Removal from Industrial Wastewater Using New Utility Approach," Advances in Environmental Chemistry, Jul. 08, 2014. https://www.hindawi.com/journals/aec/2014/916878/

[10] A. D. Santos, R. C. Martins, R. M. Quinta-Ferreira, and L. M. Castro, "Moving bed biofilm reactor (MBBR) for dairy wastewater treatment," Energy Reports, vol. 6, pp. 340–344, Dec. 2020, doi: https://doi.org/10.1016/j.egyr.2020.11.158.

[11] "Temperature Control and Heat Exchange in Bioreactors," News-Medical.net, Aug. 31, 2023. https://www.news-medical.net/whitepaper/20230831/Temperature-Control-and-Heat-Exchange-in-Bioreactors.aspx

[12] P. Wongburi and J. K. Park, "Prediction of Sludge Volume Index in a Wastewater Treatment Plant Using Recurrent Neural Network," Sustainability, vol. 14, no. 10, p. 6276, Jan. 2022, doi: https://doi.org/10.3390/su14106276.

[13] "How to Calculate and Control Sludge Volume Index (SVI)," chemtech-us.com, Jun. 25, 2020. https://chemtech-us.com/articles/how-to-calculate-and-control-sludge-volume-index-svi/#:~:text=If%20the%20SVI%20is%2080 (accessed Dec. 16, 2023).

[14] C. O. Nwuche, H. Aoyagi, and J. C. Ogbonna, "Treatment of Palm Oil Mill Effluent by a Microbial Consortium Developed from Compost Soils," International Scholarly Research Notices, vol. 2014, pp. 1–8, Oct. 2014, doi: https://doi.org/10.1155/2014/762070.